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Xam idea Biology

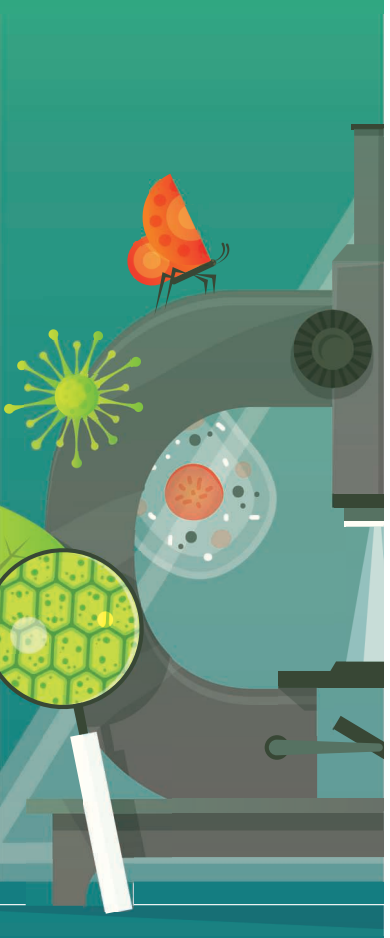
A Complete Course Book Term-I & Term-II

As per special scheme of assessment released by the CBSE dated July 05, 2021 vide Circular No. Acad-51/2021 for the session 2021-22

Compiled by:
Ruchi Yadav
Komal Gera

Term-I: MCQs (Including case- based & assertion reasoning based)
Term-II: Case-based/situation based, open ended-short answer/long answer

Class XII



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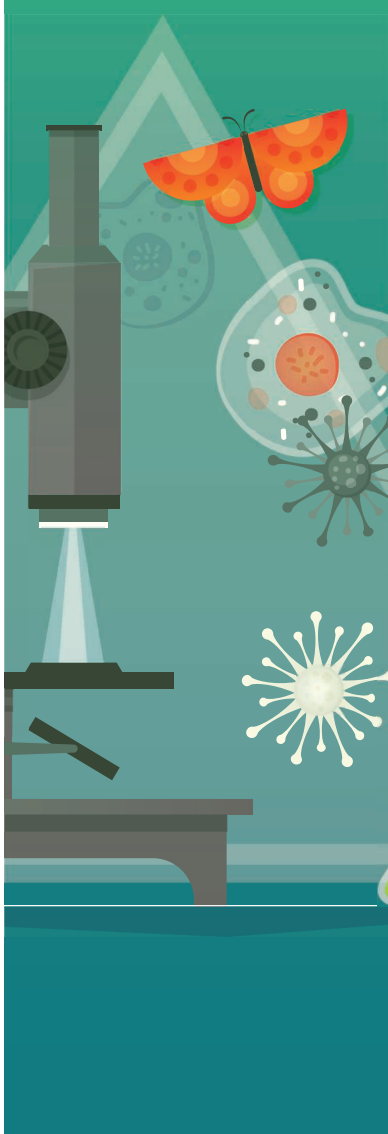


Syllabus

CENTRAL BOARD OF SECONDARY EDUCATION, NEW DELHI

BIOLOGY (Theory)

CLASS–XII (2021-22)

Time : 3 hours | Max. Marks : 70

Unit	Title	No. of Periods	Marks
VI	Reproduction	30	14
VII	Genetics and Evolution	40	18
VIII	Biology and Human Welfare	30	14
IX	Biotechnology and its Applications	30	10
X	Ecology and Environment	30	14
	Total	**160**	**70**

Unit–VI Reproduction

Chapter–1: Reproduction in Organisms

- Reproduction, a characteristic feature of all organisms for continuation of species; Modes of reproduction—asexual and sexual reproduction; Asexual reproduction—binary fission, sporulation, budding, gemmule formation, fragmentation; Vegetative propagation in plants; Events in sexual reproduction.

Chapter–2: Sexual Reproduction in Flowering Plants

- Flower structure; Development of male and female gametophytes; Pollination—types, agencies and examples; Outbreeding devices; Pollen-pistil interaction; Double fertilisation; Post fertilisation events—development of endosperm and embryo, development of seed and formation of fruit; Special modes—apomixis, parthenocarpy, polyembryony; Significance of seed dispersal and fruit formation.

Chapter–3: Human Reproduction

- Male and female reproductive systems; Microscopic anatomy of testis and ovary; Gametogenesis—spermatogenesis and oogenesis; Menstrual cycle; Fertilisation, embryo development upto blastocyst formation, implantation; Pregnancy and placenta formation (elementary idea); Parturition (elementary idea); Lactation (elementary idea).

Chapter–4: Reproductive Health

- Need for reproductive health and prevention of Sexually Transmitted Diseases (STDs); Birth control—need and methods, Medical Termination of Pregnancy (MTP); Amniocentesis; Infertility and assisted reproductive technologies– IVF, ZIFT, GIFT, AI (brief overview).

Unit–VII Genetics and Evolution

Chapter–5: Principles of Inheritance and Variation

- Heredity and Variation, Mendelian inheritance; Deviations from Mendelism—Incomplete dominance, Co-dominance, Multiple alleles and Inheritance of blood groups, Pleiotropy; Elementary idea of polygenic inheritance; Chromosome theory of inheritance; Chromosomes and genes; Linkage and crossing over; Sex determination—in human being, birds, grasshopper and honey bee; Mutation; Pedigree analysis; Sex-linked inheritance—Haemophilia, Colour blindness; Mendelian disorders in humans—sickle cell anaemia, Phenylketonuria, thalassemia; Chromosomal disorders in humans; Down's syndrome, Turner's and Klinefelter's syndromes.

Chapter–6: Molecular Basis of Inheritance

- Structure of DNA and RNA; DNA packaging; Search for genetic material and DNA as genetic material; Structure of DNA and RNA; DNA packaging; DNA replication; Central Dogma; Transcription, genetic code, translation; Gene expression and regulation—*lac* operon; Genome, Human genome project; DNA fingerprinting.

Chapter–7: Evolution

- Origin of life; Biological evolution and evidences for biological evolution (paleontology, comparative anatomy, embryology and molecular evidences); Adaptive radiation; Biological evolution: Lamarck's theory of use and disuse of organs; Darwin's theory of evolution; Mechanism of evolution - variation (mutation and recombination) and natural selection with examples; Types of natural selection; Gene flow and genetic drift; Hardy - Weinberg's principle; Brief account of evolution; Human evolution.

Unit–VIII Biology and Human Welfare

Chapter–8: Human Health and Diseases

- Pathogens; Parasites causing human diseases (malaria, dengue, chikungunya, filariasis, ascariasis, typhoid, pneumonia, common cold, amoebiasis, ringworm) and their control; Basic concepts of immunology—vaccines; Cancer, HIV and AIDS; Adolescence — drug and alcohol abuse.

Chapter–9: Strategies for Enhancement in Food Production

- Animal husbandry, Plant breeding, tissue culture, single cell protein.

Chapter–10: Microbes in Human Welfare

- Microbes in food processing, industrial production, Antibiotics; Production and judicious use; Sewage treatment, energy generation and microbes as bio-control agents and bio-fertilizers.

Unit–IX Biotechnology and its Applications

Chapter–11: Biotechnology: Principles and Processes

- Genetic Engineering (Recombinant DNA technology).

Chapter–12: Biotechnology and its Application

- **Application of biotechnology in health and agriculture:** Genetically modified organisms - Bt crops; RNA interference, Human insulin, gene therapy; Molecular diagnosis; Transgenic animals; biosafety issues, biopiracy and patents

Unit–X Ecology and Environment

Chapter–13: Organisms and Populations

- **Organisms and Environment:** Habitat and niche, abiotic factors, ecological adaptations; Population interactions—mutualism, competition, predation, parasitism, commensalism; Population attributes—growth, birth rate and death rate, age distribution.

Chapter–14: Ecosystem

- **Ecosystems:** Structure and function; Productivity and decomposition; Energy flow; Pyramids of number, biomass, energy; Nutrient cycles (carbon and phosphorous); Ecological succession; Ecological Services—carbon fixation, pollination, seed dispersal, oxygen release (in brief).

Chapter–15: Biodiversity and its Conservation

- Biodiversity—Concept, levels, patterns, importance; Loss of biodiversity; Biodiversity conservation; Hotspots, endangered organisms, extinction, Red Data Book, Sacred Groves, biosphere reserves, national parks, wildlife, sanctuaries and Ramsar sites.

Chapter–16: Environmental Issues

- Air pollution and its control; Water pollution and its control; Agrochemicals and their effects; Solid waste management; Radioactive waste management; Greenhouse effect and climate change impact and mitigation; Ozone layer depletion; Deforestation; case study exemplifying success story addressing environmental issue(s).

The changes for classes XI-XII (2021-22) internal year-end/Board Examination are as under:		
Year-end Examination/Board Examination (Theory)	(2020-21) Existing	(2021-22) Modified
Composition	❖ Objective type Questions including Multiple Choice Question-20% ❖ Case-based/Source- based Integrated Questions-10% ❖ Short Answer/ Long Answer Questions- Remaining 70%	❖ Competency Based Questions will be 20% These can be in the form of Multiple-Choice Questions, Case- Based Questions, Source Based Integrated Questions or any other types ❖ Objective Questions will be 20 % ❖ Remaining 60% Short Answer/ Long Answer Questions- (as per existing pattern)

Assessment Areas (Theory) 2021-22

BIOLOGY (044)

CLASS-XII

Time: 3 hours **Maximum Marks: 70 marks**

Typology of Questions → / Competencies ↓		Section A VSA (1 marks)	Section B Case-based Questions	Section C SA (2 marks)	Section D LA-I (3 marks)	Section E LA-II (5 marks)	Total	%
Demonstrate Knowledge and Understanding	Remembering	4 (1) =4	–	1 (2) =2	1 (3) =3	1 (5) =5	14	20%
	Understanding	7 (1) =7	1 (5) =5	3 (2) =6	1 (3) =3	–	21	30%
Application of Knowledge / Concepts		1 (1) =1	1(5) = 5	2 (2) =4	2 (3) = 6	1 (5) = 5	21	30%
Formulate, Analyse, Evaluate and Create		2 (1) =2	1 (4) = 4	–	1 (3) = 3	1 (5) = 5	14	20%
Total		14(14) =14	3 (14)	6 (2) = 12	5 (3) = 15	3 (5) = 15	31 (70)	100

Note:

- All questions would be compulsory. However, an internal choice of approximately 33% would be provided.
- **Section- 'A'** would have 10 MCQs (including matching type MCQs) and 04 Assertion Reasoning type questions of one mark each.
- **Section 'B'** would have 3 source-based/case-based /passage-based/integrated assessment questions: 2 questions of 5 marks each and 1 question of 4 marks with sub parts of the values 1/2/3 marks each.
- **Section 'C'** would have 6 Short Answer (SA) type questions carrying 2 marks each.
- **Section 'D'** would have 5 Long Answer-I (LA-I) type questions carrying 3 marks each.
- **Section 'E'** would have 3 Long Answer-II (LA-II) type questions carrying 5 marks each. Internal Choice would be provided in 3 questions of Section 'C', in 2 questions of Section 'D' and in all three questions of Section 'E'.

Suggestive verbs for various competencies

- **Demonstrate, Knowledge and Understanding**

  State, name, list, identify, define, suggest, describe, outline, summarize, etc.
- **Application of Knowledge/Concepts**

  Calculate, illustrate, show, adapt, explain, distinguish, etc.
- **Analyze, Evaluate and Create**

  Interpret, analyse, compare, contrast, examine, evaluate, discuss, construct, etc.

Part-A

basic concepts

NCERT Textbook Questions

Multiple Choice Questions

Assertion-Reason Questions

Case-based/Source-based Question

Very Short Answer Questions

Short Answer Questions

Long Answer Questions–I

Long Answer Questions–II

Self-Assessment Test

Chapter –1

Reproduction in Organisms

basic concepts

1. Reproduction

- Reproduction is essential
  - (*i*) for multiplication and maintaining the identity of a species;
  - (*ii*) to introduce variation among the individuals of a species;
  - (*iii*) to maintain and to inherit the genetic constitution or genetic make-up.

Function/Importance

- Reproduction is necessary for the continuity of the species.
- Sexual reproduction is responsible for variation in a population and its inheritance to future generations.

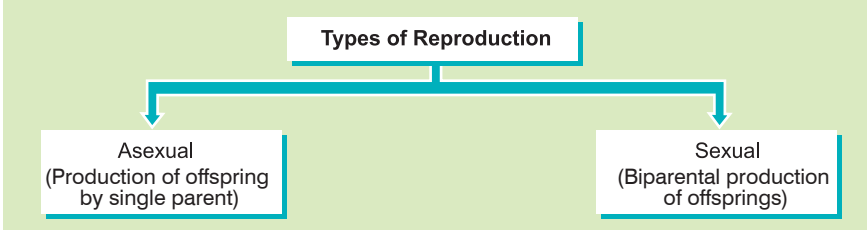
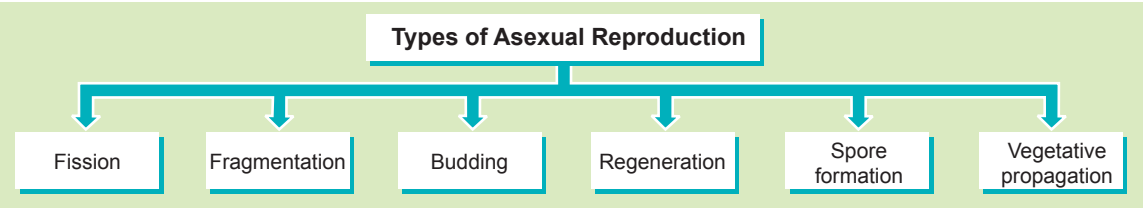


Table 1.1 Differences between asexual reproduction and sexual reproduction

S. No.	Asexual reproduction	Sexual reproduction
(*i*)	Asexual reproduction does not involve formation or fusion of gametes.	Sexual reproduction involves formation and fusion of gametes.
(*ii*)	The offsprings formed by asexual reproduction are genetically identical to the parent and are referred to as clones.	The offsprings are neither identical to the parents nor to each other hence, it leads to variation in a population.
(*iii*)	It is a simple and fast process.	It is an elaborate, complex and slow process.
(*iv*)	It involves only mitosis.	It involves meiosis.
(*v*)	It is always uniparental (single parent).	It is usually biparental (two parents).
(*vi*)	It helps in maintaining same characters for generations.	It plays a vital role in evolution process.
(*vii*)	It is common among single-celled organisms, and in plants and animals with relatively simple organisation.	It is common in higher animals with complex organisation.

2. Asexual Reproduction

- Uniparental, with or without gamete formation.
- It is a condition where an offspring receives two copies of a chromosome or part of chromosome from one parent and no copies from the other parent.
- Offsprings are exact copies or clones of each other and the parent.
- Mitosis is the essential mode of asexual reproduction.



(*i*) Fission: The splitting of parental cell into two or more daughter cells.

(*a*) Binary fission: The splitting of a parental cell into two equal daughter cells, each of which rapidly grows into an adult, is called binary fission. It occurs in single-celled animals like bacteria and protozoans (*e.g.*, *Amoeba*, *Paramecium*). It can be simple or irregular, longitudinal, oblique or transverse, depending on the plane of division.

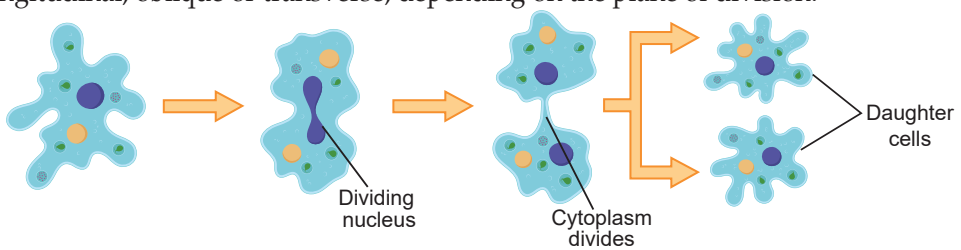


Fig. 1.1 Binary fission in *Amoeba*

(*b*) Multiple fission: The splitting of a parent cell into numerous daughter cells, each of which grow into an adult is called multiple fission, *e.g.*, *Plasmodium*, *Amoeba*.

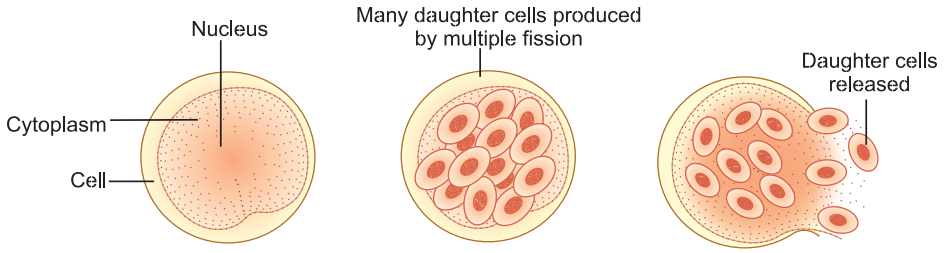


Fig. 1.2 Multiple fission in *Plasmodium*

- **Sporulation:** During unfavourable conditions, organisms like *Amoeba* cover themselves with a three-layered hard covering or cyst. This is called **encystation**. On return of favourable conditions, it divides by multiple fission within the cyst and produces many *Amoebae*. This is called sporulation. The cyst bursts open and spores are liberated to develop into adults.

(*ii*) Fragmentation: It is a mode of asexual reproduction in which the parental body breaks into two or more fragments and each fragment grows into a new individual, *e.g.*, *Spirogyra*, *sponges*.

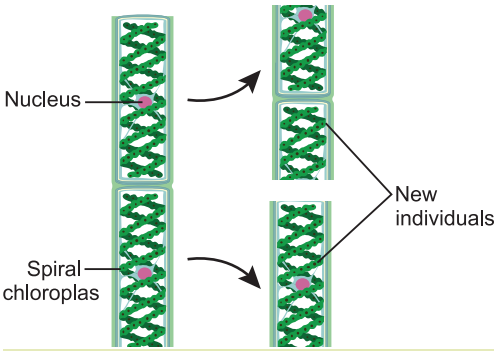


Fig. 1.3 Fragmentation in *Spirogyra*

(iii) Budding: It is a mode of asexual reproduction in which one or more outgrowths (buds) are produced which initially remain attached to the parent cell and eventually get separated from it to grow into a new individual, *e.g.*, yeast, *Hydra*.

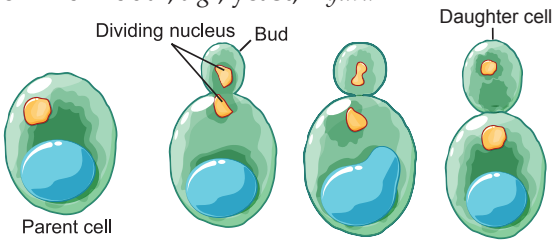


Fig. 1.4 Budding in yeast

(iv) Regeneration: It is a mode of asexual reproduction in which the lost part of an organism is repaired/reproduced by proliferation of cells, *e.g.*, *Planaria*.

(v) Spore formation:

- **Zoospores:** These are endogenously produced unicellular, naked and motile spores with one or two flagella. Zoospores are produced in a sac-like structure called **zoosporangium**, *e.g.*, *Chlamydomonas*.
- **Conidia:** Asexual non-motile spores cut off externally either singly (*e.g.*, *Phytophthora*) or in chains (*e.g.*, *Penicillium*) from the tip of a special hyphae called **conidiophore**.
- **Gemmules:** Internal asexual reproductive units or buds are called gemmules, *e.g.*, sponges. These develop within the parental body and are released during germination.

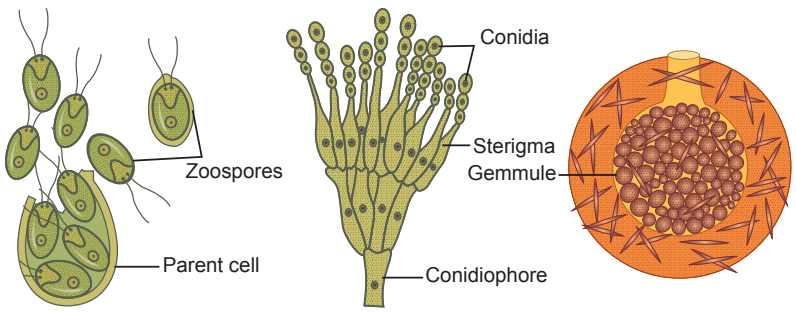


Fig. 1.5 Spore formation

(vi) Vegetative propagation: It is a mode of reproduction in which new plants are formed from vegetative parts (vegetative propagules) of the plant like root, stem, etc. It is very common in higher angiosperms.

Following are some units of vegetative propagation:

- Bulbil — *Agave*
- Bulbs — Onion, Garlic
- Eyes on tuber — Potato
- Leaf buds — *Bryophyllum*
- Offset — Hyacinth and *Pistia*
- Rhizome — Ginger
- Runner — *Oxalis*
- Sucker — Mint

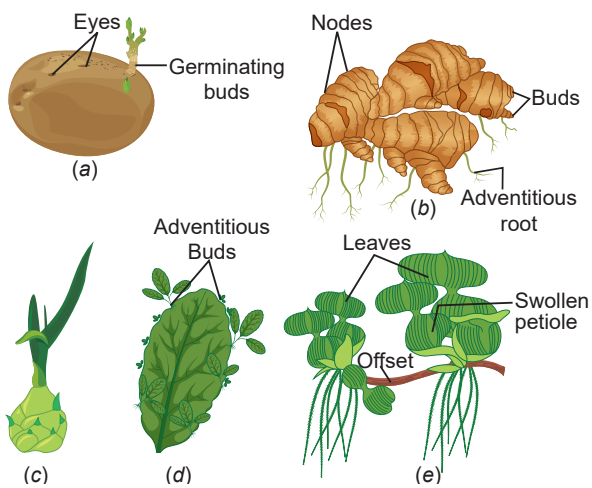


Fig. 1.6 Vegetative propagules in angiosperms: (*a*) Potato tuber; (*b*) Rhizome of ginger; (*c*) Bulbil of *Agave*; (*d*) Leaf buds of *Bryophyllum*; (*e*) Offset of water hyacinth

Advantages of Vegetative Propagation: The important advantages of vegetative propagation are as follows:

(*a*) The new plants produced by this process are the exact replica of the parent plants.

(*b*) Fruit trees produced from cutting or grafting start growing rapidly and bear fruits earlier than the plants produced from seeds. However, the latter plants are reduced in quality of flowers and fruits.

(*c*) The plants grown by vegetative propagation usually need less attention in the early years of growth.

Disadvantages of Vegetative Propagation: The important disadvantages of vegetative propagation are as follows:

(*a*) Selection of characters is not possible.

(*b*) Diseases from parents is passed onto the offsprings.

(*c*) No variations are introduced in the offsprings.

3. Events in Sexual Reproduction

- Events in sexual reproduction may be grouped into three distinct stages as follows:
  (*i*) Pre-fertilisation (*ii*) Fertilisation (also known as syngamy) (*iii*) Post-fertilisation

(i) Pre-fertilisation

- This includes formation of gametes **(gametogenesis)** and their transfer.

(a) Gametogenesis

- It involves formation of two haploid reproductive units called gametes.
- The formation of male gamete or male reproductive unit is called **spermatogenesis.**
- The formation of female gamete or female reproductive unit is called **oogenesis**.
- When male and female gametes are similar in appearance and it is not possible to differentiate between them, they are called **homogametes** or **isogametes**.
- When the male and female gametes are morphologically distinct, they are called **heterogametes**.
- Among heterogametes, the male reproductive unit is called **antherozoid** or **sperm** and female reproductive unit is called **egg** or **ovum**.
- A single organism bearing both male and female sex gametes is called **homothallic** or **monoecious**, *e.g.*, coconut, *Chara*.
- Organisms in which different individuals carry male and female gametes are called **heterothallic** or **dioecious**, *e.g.*, papaya, *Marchantia*.
- Unisexual male flowers bearing stamens are called **staminate** flowers.
- Unisexual female flowers bearing pistils are called **pistillate** flowers.
- The animals bearing both the sexes are called **hermaphrodites**, *e.g.*, earthworm, sponge, tapeworm and leech.

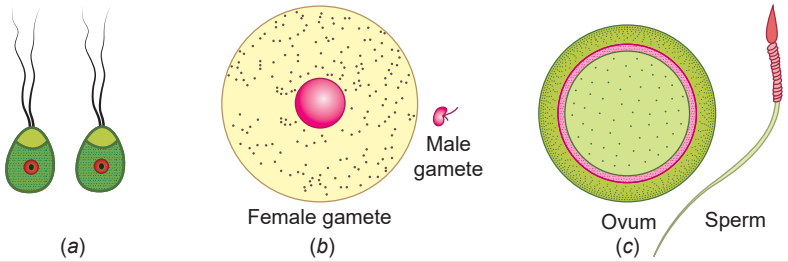


Fig. 1.7 Types of gametes: (*a*) Isogametes of *Cladophora* (an alga); (*b*) Heterogametes of *Fucus* (an alga); (*c*) Heterogametes of *Homo sapiens* (human beings)

Cell division during gamete formation

- Gametes are always haploid.
- Haploid organisms produce gametes by mitotic division. Diploid organisms undergo meiosis in specialised cells called **meiocytes** (gamete mother cell) to form gametes.
- At the end of both divisions, only one set of chromosomes get incorporated into each gamete.

(b) Gamete transfer

- After gamete formation, male and female gametes must be physically brought together to facilitate fusion **(fertilisation)**.
- Male gametes are usually motile, whereas female gametes are static.
- In lower plants like some algae and fungi, both male and female gametes are motile.
- In simple plants like algae, bryophytes and pteridophytes, water acts as the medium for gamete transfer.
- In angiosperms, the pollen grains are transferred from anther of one flower to the stigma of another flower by pollinating agents and the process is called **pollination**.

(ii) Fertilisation or syngamy

- It is the fusion of male and female gametes to form a diploid cell called **zygote**.
- The phenomenon of development of female gamete directly into an individual without fertilisation is called **parthenogenesis**, *e.g.*, rotifers, honeybees, lizards and birds.
- Fertilisation is of two types, *i.e.*, external fertilisation and internal fertilisation.

Table 1.2 Differences between external fertilisation and internal fertilisation

S. No.	External fertilisation	Internal fertilisation
(*i*)	When fusion of gametes occurs outside the body of an organism, it is called external fertilisation.	When fusion of gametes occurs inside the body of an organism, it is called internal fertilisation.
(*ii*)	Large number of both male and female gametes are released into the surrounding medium (*e.g.*, water) in order to enhance chances of syngamy.	The number of sperms produced are very large and number of eggs produced are less.
(*iii*)	The offsprings are extremely vulnerable to predators, threatening their survival.	The offsprings are well protected comparatively.
(*iv*)	Examples: Bony fishes, frogs and majority of algae.	Examples: Birds, mammals, etc.

(iii) Post-fertilisation events

These are the events that takes place after the formation of zygote. It includes development of zygote and embryo after fertilisation.

(a) Zygote development

- In external fertilisation, these zygote is formed in the external medium, whereas in internal fertilisation, zygote is formed inside the body of the organism.
- Further development of zygote depends upon the life cycle and environment.
- Zygote ensures continuity of species between organisms of one generation and the next.
- In algae and fungi, the zygote develops a thick wall to resist dessication and damage.
- In haplontic life cycle, the zygote undergoes reductional division (meiosis) to form a haploid organism.
- In diplontic life cycle, the zygote undergoes mitotic division to form a diploid organism.

(b) Embryogenesis

- The processes of development of embryo from the zygote is called **embryogenesis**.
- During embryogenesis, zygote undergoes
  (*i*) cell division (mitosis) to increase cell number, and
  (*ii*) cell differentiation to form specialised tissues and organs.
- Based on whether the zygote develops outside or inside the body of female parent, animals can be classified into **oviparous** and **viviparous**, respectively.

Table 1.3 Differences between oviparous animals and viviparous animals

S. No.	Oviparous animals	Viviparous animals
(*i*)	Oviparous animals lay fertilised eggs.	Viviparous animals give birth to young ones.
(*ii*)	The fertilised eggs have calcareous shell and young ones hatch out after a period of incubation.	The fertilised egg (zygote) has no shell and develops into a young one inside the body of the female organism.
(*iii*)	Chances of survival of young one is less as the female lays egg in the environment surrounding.	Chances of survival of young one is more because of proper embryonic care and protection inside the mother's body.
(*iv*)	For example, reptiles, birds, etc.	For example, majority of mammals including humans.

- In flowering plants, the zygote is formed inside the ovule, where the zygote develops into an embryo.
- The fertilised ovule develops into **seed** and ovary develops into **fruit**.
- The seed after dispersal in favourable condition germinates to produce new plants.
- The outermost protective covering of fruit is called **pericarp** or fruit wall.

NCERT Textbook Questions

Q. 1. Why is reproduction essential for organisms?

Ans. Refer to Basic Concepts Point 1 (Function/Importance).

Q. 2. Which is a better mode of reproduction: sexual or asexual? Why?

Ans. Sexual mode of reproduction is better because it is biparental reproduction and introduces variation among offsprings and their parents (in a population) due to crossing over and recombination during gamete formation by meiosis and thus helps in better adaptation to changing environment.

Q. 3. Why is the offspring formed by asexual reproduction referred to as clone? ***[CBSE (AI) 2010]***

Ans. In asexual reproduction, the offspring are morphologically and genetically identical to the parent and to each other. Hence they are called clones.

Q. 4. Offspring formed due to sexual reproduction have better chances of survival. Why? Is this statement always true?

Ans. Offspring formed due to sexual reproduction have better chances of survival because:

(*i*) the offspring retains its hybrid vigour which may adapt better with the changing environment.

(*ii*) genetic variation is introduced among the offspring, which increases the range of tolerance or biological tolerance.

(*iii*) sexual reproduction occurs in adverse conditions in lower plant kingdom, so sexual spores survive in adverse conditions.

Sexual reproduction may not always show better chances of survival because the offspring may be inferior to the parents.

Q. 5. How does the progeny formed from asexual reproduction differ from those formed by sexual reproduction?

Ans.

Table 1.4 Differences between progenies from asexual and sexual reproduction

S. No.	Progeny from asexual reproduction	Progeny from sexual reproduction
(*i*)	The progenies have similar genetic make up.	The progenies have different genetic makeup.
(*ii*)	The progenies are not only identical to one another but are exact copies of their parents, *i.e.*, clone of the parent.	The progenies are different from each other and dissimilar to the parent.
(*iii*)	Variation is absent.	Variation is a common phenomenon.
(*iv*)	Variation may occur due to mutation.	Variation occurs due to mutation, crossing over and recombination.
(*v*)	Progenies are less adaptable to changes in environment.	Progenies are more adaptable to changes in environment.

Q. 6. Distinguish between asexual and sexual reproduction. Why is vegetative reproduction also considered as a type of asexual reproduction?

Ans. For differences, refer to Table 1.1.

Vegetative reproduction is considered as a type of asexual reproduction because

(*i*) it is uniparental reproduction,

(*ii*) there is no involvement of gametes or sex cells, and

(*iii*) cell division is mitotic and no reductional division takes place,

(*iv*) vegetative propagules are somatic cells.

(*v*) there is no variation among the progenies.

Q. 7. What is vegetative propagation? Give two suitable examples.

Ans. In plants, the vegetative propagules (runner, rhizome, sucker, etc.) are capable of producing new offsprings by the process called vegetative propagation. As the formation of these vegetative propagules does not involve both the parents, the process involved is asexual.

Examples: (*i*) Adventitious buds in the notches along the leaf margins of *Bryophyllum* grow to form new plants.

(*ii*) Potato tuber having buds when grown, develops into a new plant.

Q. 8. Define (*i*) Juvenile phase, (*ii*) Reproductive phase, (*iii*) Senescent phase.

Ans. **(*i*) Juvenile phase:** It is the pre-reproductive phase in which all organisms require a certain growth and maturity in the life before reproducing sexually.

(*ii*) Reproductive phase is the phase in the life cycle, where an organism possess all the capacity and potential to reproduce sexually. It is the end of juvenile phase or vegetative phase.

(*iii*) Senescent phase is the post-reproductive phase in the life cycle where an organism slowly loses the rate of metabolism, reproductive potential and shows deterioration of the physiological activity of the body.

Q. 9. Higher organisms have resorted to sexual reproduction in spite of its complexity. Why?

Ans. Higher organisms have resorted to sexual reproduction to

(*i*) get over the unfavourable condition,

(*ii*) introduce variation to enable better adaptive capacity, biological tolerance and competitive edge,

(*iii*) restore high gene pool in a population,

(*iv*) restore vigour and vitality of the race, and

(*v*) get proper parental care during vulnerable stage.

Q. 10. Explain why meiosis and gametogenesis are always interlinked.

Ans. Gametogenesis (formation of male and female gametes) is associated with reduction in chromosome number thus, the gamete formed contains half the chromosome set of the parental cell. So, gametogenesis is interlinked with meiosis because meiosis reduces the chromosome number to half, *i.e.*, from 2n to 'n'.

Q. 11. Identify each part in a flowering plant and write whether it is haploid (n) or diploid (2n).

(*i*) Ovary	**(*ii*) Anther**	**(*iii*) Egg**
(*iv*) Pollen	**(*v*) Male gamete**	**(*vi*) Zygote.**

Ans.

(*i*) Diploid (2n)	(*ii*) Diploid (2n)	(*iii*) Haploid (n)
(*iv*) Haploid (n)	(*v*) Haploid (n)	(*vi*) Diploid (2n)

Q. 12. Define external fertilisation. Mention its disadvantages.

Ans. The fusion of compatible gametes outside the body of the parent is called external fertilisation, *e.g.*, in frog.

Disadvantages of external fertilisation:

(*i*) It requires a medium for fusion of gametes.

(*ii*) The young ones are often exposed to the predators and no parental care is provided.

Q. 13. Differentiate between a zoospore and a zygote.

Ans.

Table 1.5 Differences between zoospore and zygote

S. No.	Zoospore	Zygote
(*i*)	These are endogenously, asexually produced, unicellular, naked and motile spores having one or two flagella.	Zygote is a diploid cell formed by fusion of male and female gametes.
(*ii*)	It may be haploid or diploid.	It is always diploid.
(*iii*)	Zoospore takes part in dispersal.	Zygote does not have significant role in dispersal.

Q. 14. Differentiate between gametogenesis from embryogenesis.

Ans.

Table 1.6 Differences between gametogenesis and embryogenesis

S. No.	Gametogenesis	Embryogenesis
(*i*)	It is the formation of gametes from meiocytes (gamete mother cells).	It is the formation of embryo from zygote.
(*ii*)	This is a pre-fertilisation event.	This is a post-fertilisation event.
(*iii*)	The cell division during gametogenesis is meiotic in diploid organisms.	The cell division during embryogenesis is mitotic in diploid organisms.
(*iv*)	It occurs inside reproductive organs.	It occurs outside or inside the female body.
(*v*)	It produces haploid gamete.	It gives rise to diploid embryo.

Q. 15. Describe the post-fertilisation changes in a flower.

Ans. The post-fertilisation changes that take place in a flower are as follows:

(*i*) The formation of zygote (inside ovule) which later develops into an embryo and primary endosperm cell which in turn develops into endosperm (provides nourishment to the growing embryo).

(*ii*) While the sepals, petals and stamens are shed, the pistil remains intact.

(*iii*) The fertilised ovule develops into seeds.

(*iv*) The ovary matures into a fruit that later develops a thick, protective wall called pericarp.

(*v*) Seeds after dispersal, germinate under favourable conditions, which later develop into a new plant.

Q. 16. What is a bisexual flower? Collect five bisexual flowers from your neighbourhood and with the help of your teacher find out their common and scientific names.

Ans. A flower which possess both the male and female reproductive structures, *i.e.*, both stamen and carpel is called a bisexual flower.

Table 1.7 List of some common bisexual flowers

S. No.	Common name	Scientific name
(*i*)	China rose	*Hibiscus rosa-sinensis*
(*ii*)	Chandni	*Tabernaemontana divaricata*
(*iii*)	Makoi	*Solanum nigrum*
(*iv*)	Sunflower	*Helianthus annuus*
(*v*)	Mustard	*Brassica campestris*

Q. 17. Examine a few flowers of any Cucurbit plant and try to identify the staminate and pistillate flowers. Do you know any other plant that bears unisexual flowers?

Ans. A staminate or male flower has only stamens and no carpel. A pistillate flower has only carpel and no stamens. Plants that bear unisexual flowers are papaya and date palm.

Q. 18. Why are offspring of oviparous animals at a greater risk as compared to offspring of viviparous animals?

Ans. In viviparous animals, the young one develops inside the body of the female organism. As a result of this, the young one gets better protection and nourishment for proper development. In

case of oviparous animals, they lay eggs and the young ones develop inside the calcareous shell, outside the body of the female. So, the young ones are not effectively protected and nourished and are vulnerable to predators. So, they are at a greater risk as compared to the offsprings of the viviparous animals.

Multiple Choice Questions [1mark]

Choose and write the correct option in the following questions.

1. Meiosis takes place in

(*a*) gemmule (*b*) megaspore (*c*) meiocyte (*d*) conidia

2. Vegetative propagation in mint occurs by

(*a*) stolon (*b*) offset (*c*) runner (*d*) sucker

3. A few statements describing certain features of reproduction are given below. *[NCERT Exemplar]*

(*i*) Gametic fusion takes place **(*ii*) Transfer of genetic material takes place**

(*iii*) Reduction division takes place **(*iv*) Progeny have some resemblance with parents**

Select the options that are true for both asexual and sexual reproduction from the options given below:

(*a*) (*i*) and (*ii*) (*b*) (*ii*) and (*iii*) (*c*) (*ii*) and (*iv*) (*d*) (*i*) and (*iii*)

4. The term 'clone' cannot be applied to offspring formed by sexual reproduction because *[NCERT Exemplar]*

(*a*) offspring do not possess exact copies of parental DNA

(*b*) DNA of only one parent is copied and passed on to the offspring

(*c*) offspring are formed at different times

(*d*) DNA of parent and offspring are completely different.

5. *Amoeba* and yeast reproduce asexually by fission and budding respectively, because they are *[NCERT Exemplar]*

(*a*) microscopic organisms (*b*) heterotrophic organisms

(*c*) unicellular organisms (*d*) uninucleate organisms

6. A few statements with regard to sexual reproduction are given below. *[NCERT Exemplar]*

(*i*) Sexual reproduction does not always require two individuals

(*ii*) Sexual reproduction generally involves gametic fusion

(*iii*) Meiosis never occurs during sexual reproduction

(*iv*) External fertilisation is a rule during sexual reproduction

Choose the correct statements from the options below.

(*a*) (*i*) and (*iv*) (*b*) (*i*) and (*ii*) (*c*) (*ii*) and (*iii*) (*d*) (*i*) and (*iv*)

7. In *Bryophyllum* adventitious buds arise from

(*a*) leaves (*b*) root (*c*) stems (*d*) flowers

8. A multicellular, filamentous alga exhibits a type of sexual life cycle in which the meiotic division occurs after the formation of zygote. The adult filament of this alga has *[NCERT Exemplar]*

(*a*) haploid vegetative cells and diploid gametangia

(*b*) diploid vegetative cells and diploid gametangia

(*c*) diploid vegetative cells and haploid gametangia

(*d*) haploid vegetative cells and haploid gametangia.

9. The male gametes of rice plant have 12 chromosomes in their nucleus. The chromosome number in the female gamete, zygote and the cells of the seedling will be, respectively *[NCERT Exemplar]*

(*a*) 12, 24, 12 (*b*) 24, 12, 12 (*c*) 12, 24, 24 (*d*) 24, 12, 24.

10. Given below are a few statements related to external fertilisation. Choose the correct statements. *[NCERT Exemplar]*

(*i*) The male and female gametes are formed and released simultaneously.

(*ii*) Only a few gametes are released into the medium.

(*iii*) Water is the medium in a majority of organisms exhibiting external fertilisation.

(*iv*) Offspring formed as a result of external fertilisation have better chance of survival than those formed inside an organism.

(*a*) (*iii*) and (*iv*) (*b*) (*i*) and (*iii*) (*c*) (*ii*) and (*iv*) (*d*) (*i*) and (*iv*)

11. The most common asexual reproductive structure of algae and fungi are

(*a*) agygospore (*b*) zoospore (*c*) buds (*d*) conidia

12. The period of growth from birth till attainment of sexual maturity is called

(*a*) Asexual phase (*b*) Immature phase (*c*) Maturation phase (*d*) Juvenile phase

13. The statements given below describe certain features that are observed in the pistil of flowers. *[NCERT Exemplar]*

(*i*) Pistil may have many carpels **(*ii*) Each carpel may have more than one ovule**

(*iii*) Each carpel has only one ovule **(*iv*) Pistil have only one carpel**

Choose the statements that are true from the options below.

(*a*) (*i*) and (*ii*) (*b*) (*i*) and (*iii*) (*c*) (*ii*) and (*iv*) (*d*) (*iii*) and (*iv*)

14. Which of the following situations correctly describe the similarity between an angiosperm egg and a human egg? *[NCERT Exemplar]*

(*i*) Eggs of both are formed only once in a lifetime

(*ii*) Both the angiosperm egg and human egg are stationary

(*iii*) Both the angiosperm egg and human egg are mobile

(*iv*) Syngamy in both results in the formation of zygote

Choose the correct answer from the options given below.

(*a*) (*ii*) and (*iv*) (*b*) (*iv*) only (*c*) (*iii*) and (*iv*) (*d*) (*i*) and (*iv*)

15. Homothallism represents

(*a*) asexual condition (*b*) unisexual condition

(*c*) bisexual condition (*d*) none of these

16. Appearance of vegetative propagules from the nodes of plants such as sugarcane and ginger is mainly because. *[NCERT Exemplar]*

(*a*) nodes are shorter than internodes (*b*) nodes have meristematic cells

(*c*) nodes are located near the soil (*d*) nodes have non-photosynthetic cells

17. Which of the following statements, support the view that elaborate sexual reproductive process appeared much later in the organic evolution. *[NCERT Exemplar]*

(*i*) Lower groups of organisms have simpler body design

(*ii*) Asexual reproduction is common in lower groups

(*iii*) Asexual reproduction is common in higher groups of organisms

(*iv*) The high incidence of sexual reproduction in angiosperms and vertebrates

Choose the correct answer from the options given below:

(*a*) (*i*) and (*iii*) (*b*) (*i*) and (*iii*) (*c*) (*ii*) and (*iv*) (*d*) (*ii*) and (*iii*)

18. Offspring formed by sexual reproduction exhibit more variation than those formed by asexual reproduction because *[NCERT Exemplar]*

(*a*) sexual reproduction is a lengthy process

(*b*) gametes of parents have qualitatively different genetic composition

(*c*) genetic material comes from parents of two different species

(*d*) greater amount of DNA is involved in sexual reproduction.

19. Choose the correct statement from amongst the following. [*NCERT Exemplar*]

(*a*) Dioecious (hermaphrodite) organisms are seen only in animals

(*b*) Dioecious organisms are seen only in plants

(*c*) Dioecious organisms are seen in both plants and animals

(*d*) Dioecious organisms are seen only in vertebrates

20. There is no natural death in single celled organisms like *Amoeba* and bacteria because [*NCERT Exemplar*]

(*a*) they cannot reproduce sexually

(*b*) they reproduce by binary fission

(*c*) parental body is distributed among the offspring

(*d*) they are microscopic

21. A gamete from a diploid parent is haploid, then from a haploid parent will be

(*a*) Ooploid (*b*) Haploid

(*c*) $1/4n$ (*d*) Tetraploid

22. During formation of zygote

(*a*) fertilisation of male gamete occurs (*b*) fertilisation of both gametes occurs

(*c*) fertilisation of female gamete occurs (*d*) either (*a*) or (*c*)

23. There are various types of reproduction. The type of reproduction adopted by an organism depends on [*NCERT Exemplar*]

(*a*) the habitat and morphology of the organism

(*b*) morphology of the organism

(*c*) morphology and physiology of the organism

(*d*) the organism's habitat, physiology and genetic makeup

24. Identify the incorrect statement. [*NCERT Exemplar*]

(*a*) In asexual reproduction, the offspring produced are morphologically and genetically identical to the parent

(*b*) Zoospores are sexual reproductive structures

(*c*) In asexual reproduction, a single parent produces offspring with or without the formation of gametes

(*d*) Conidia are asexual structures in Penicillium

25. Which of the following is a post-fertilisation event in flowering plants? [*NCERT Exemplar*]

(*a*) Transfer of pollen grains (*b*) Embryo development

(*c*) Formation of flower (*d*) Formation of pollen grains

Answers

1. (*c*)	**2.** (*d*)	**3.** (*c*)	**4.** (*a*)	**5.** (*c*)	**6.** (*b*)	**7.** (*a*)	**8.** (*d*)	**9.** (*c*)	**10.** (*b*)
11. (*b*)	**12.** (*d*)	**13.** (*a*)	**14.** (*b*)	**15.** (*c*)	**16.** (*b*)	**17.** (*c*)	**18.** (*b*)	**19.** (*c*)	**20.** (*c*)
21. (*b*)	**22.** (*c*)	**23.** (*d*)	**24.** (*b*)	**25.** (*b*)					

Assertion-Reason Questions

In the following questions a statement of assertion followed by a statement of reason is given. Choose the correct answer out of the following choices.

(a) Assertion and reason both are correct statements and reason is correct explanation for assertion.

(b) Assertion and reason both are correct statements but reason is not correct explanation for assertion.

(c) Assertion is correct statement but reason is wrong statement.

(d) Assertion is wrong statement but reason is correct statement.

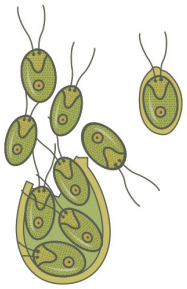
1. **Assertion :** In angiosperms, the ovule develops into a seed after fertilisation.
   Reason : Fertilisation is not essential for the development of fruit.
2. **Assertion :** Zygote is the only cell that gives a vital link between two generations of an organism.
   Reason : The two gametes fuse to form a single zygote.
3. **Assertion :** The offsprings of asexual reproduction are clones.
   Reason : There is no fertilisation in asexual reproduction.
4. **Assertion :** Earthworm is monoecious.
   Reason : Hermaphrodites bear both the sexes.
5. **Assertion :** Grafting is not usually possible in monocots.
   Reason : Successful grafting requires that cambia of both Stock and Scion fuse to form new vascular tissues.
6. **Assertion :** Large number of both male and female gametes enhance chances of syngamy.
   Reason : In lizards female gametes develops directly into an individual.
7. **Assertion :** Binary fission occurs in single-celled animals.
   Reason : Offsprings show variation.
8. **Assertion :** Parthenogenesis is a kind of variation of sexual reproduction.
   Reason : In parthenogenesis, a young one develops from an ovum but without fertilisation.
9. **Assertion :** Viviparous animals give better protection to their offsprings.
   Reason : They lay their eggs in safer places in the environment.
10. **Assertion :** Chances of survival of young one is more.
    Reason : Mother's body provides proper embryonic care and protection.

Answers

1. (*b*) **2.** (*b*) **3.** (*a*) **4.** (*d*) **5.** (*a*) **6.** (*b*) **7.** (*c*) **8.** (*a*) **9.** (*c*) **10.** (*a*)

Case-based/Source-based Question

1. Study the diagram given below and answer the questions that follow:



(*i*) Name an alga that reproduces asexually through zoospores. Why are these reproductive units so called?

(*ii*) Mention a characteristic feature and a function of zoospores in some algae.

(*iii*) How does *Penicillium* reproduce asexually?

Ans. (*i*) *Chlamydomonas* reproduces through zoospores. The reproductive units are called zoospores because they are motile.

(*ii*) Zoospores are microscopic motile structures. These are special structures by which algae reproduce asexually.

(*iii*) *Penicillium* reproduces asexually by spore formation called conidia on conidiophores.

2. Given below is the diagram of a ginger rhizome. Answer the questions given below based on the diagram.

(*i*) Why do vegetative propagules in sugarcane and ginger appear from the nodes?

(*ii*) Name the vegetative propagules in (*a*) Potato, and (*b*) *Pistia*.

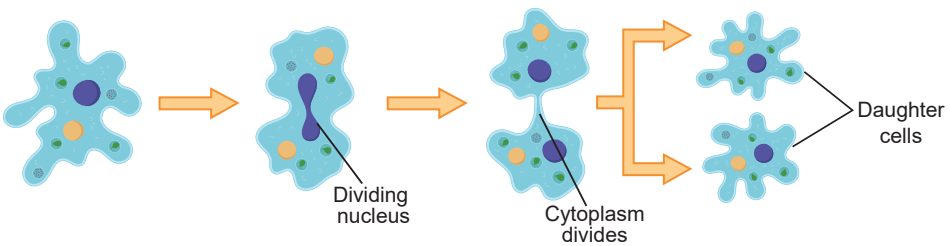
(*iii*) How does potato multiply?

Ans. (*i*) This is because the nodes have meristematic cells.

(*ii*) The vegetative propagules of potato is tuber and that of *Pistia* is offsets.

(*iii*) Potato multiplies by buds (eyes) of the tuber (vegetative propagation).

3. Observe the diagram showing binary fission in *Amoeba* and answer the questions that follow.



(*i*) Mention two inherent characteristics of *Amoeba* and yeast that enable them to reproduce asexually.

(*ii*) How is the continuity of species maintained generation after generations?

(*iii*) Why are no variations seen in clones? State two reasons.

Ans. (*i*) (*a*) They are unicellular organisms.

(*b*) They have a very simple body structure.

(*ii*) Continuity of species is maintained generation after generations by the process of reproduction.

(*iii*) (*a*) Clones are produced from one parent only by mitosis.

(*b*) No fusion of gametes or syngamy takes place. Also, there is no recombination.

Very Short Answer Questions [1 mark]

Q. 1. In yeast and *Amoeba* the parent cell divides to give rise to two new individual cells. How does the cell division differ in these two organisms? ***[CBSE (F) 2010]*** ***[HOTS]***

Ans. In *Amoeba*, binary fission takes place whereas in yeast cell division occurs by budding.

Q. 2. Name an organism where cell division is itself a mode of reproduction. ***[CBSE (AI) 2013]***

Ans. Protists/Monerans/*Amoeba*/*Paramecium* (any unicellular organism).

Q. 3. Meiosis is an essential event in the sexual life cycle of any organism. Give two reasons. ***[CBSE (F) 2015]***

Ans. (*i*) Meiosis helps in the formation of gametes by reductional division and maintains constant number of chromosomes.

(*ii*) Meiosis brings variation in offsprings by recombination of genes.

Q. 4. Write the two pre-fertilisation events from the list given below: [*HOTS*]
Syngamy, Gametogenesis, Embryogenesis, Pollination

Ans. Gametogenesis, Embryogenesis, Pollination.

Q. 5. State the fate of a pair of autosomes during gamete formation. [*CBSE Delhi 2017*]

Ans. During gamete formation a pair of autosomes segregate from each other.

Q. 6. Mention the site where syngamy occurs in amphibians and reptiles, respectively. [*CBSE (AI) 2010*]

Ans. In amphibians, external fertilisation occurs hence, syngamy occurs in the medium of water. In reptiles, internal fertilisation occurs hence, syngamy occurs within the body of female parent.

Q. 7. Name the group of organisms that produce non-motile gametes. How do they reach the female gamete for fertilisation? [*CBSE (F) 2011*]

Ans. Angiosperms produce non-motile gametes. They reach the female gamete with the help of air or water.

Q. 8. Cucurbits and papaya plants bear staminate and pistillate flowers. Mention the categories they are put under separately on the basis of the type of flowers they bear. [*CBSE Delhi 2012*]

Ans. Cucurbit is a monoecious plant having staminate and pistillate flowers on the same plant. Papaya has staminate and pistillate flowers on separate plants and hence it is dioecious.

Q. 9. Name two animals that exhibit oestrus cycle. [*CBSE (F) 2016*]

Ans. Cow, sheep and rat (*Any two*).

Q. 10. Rearrange the following events of sexual reproduction in the sequence in which they occur in a flowering plant: embryogenesis, fertilisation, gametogenesis, pollination. [*NCERT Exemplar*] [*HOTS*]

Ans. Gametogenesis, pollination, fertilisation, embryogenesis.

Q. 11. Is Marchantia monoecious or dioecious? Where are the sex organs borne in this plant? [*HOTS*]

Ans. Marchantia is dioecious. The male sex organs, antheridia, are borne on the antheridiophores and female sex organs, called as archegonia are borne on archegoniophores.

Q. 12. How is it possible in *Oxalis* and *Viola* plants to produce assured seed-sets even in the absence of pollinators? [*CBSE (F) 2012*]

Ans. By presence of cleistogamous flowers, hence anthers and stigma lie close to each other ensuring self-pollination.

Q. 13. Mention the unique feature with respect to flowering and fruiting in bamboo species. [*CBSE Delhi 2012*]

Ans. Bamboo species flower once in its life time generally after 50–100 years of vegetative growth. It produces large number of fruits and then dies.

Q. 14. Mention the unique flowering phenomenon exhibited by *Strobilanthus kunthiana* (Neelakuranji). [*CBSE Delhi 2012*]

Ans. *Strobilanthus kunthiana* flowers once in 12 years.

Q. 15. Name the phenomenon and one bird where the female gamete directly develops into a new organism. [*CBSE (AI) 2013*]

Ans. The phenomenon is called parthenogenesis. Turkey is the name of the bird.

Q. 16. Why is banana considered a good example of parthenocarpy? [*CBSE (AI)* 2012] [*HOTS*]

Ans. In banana, formation of fruit occurs without fertilisation, and thus there is no formation of seeds. So, it is considered a good example of parthenocarpy.

Q. 17. Give reasons for the following:
Some organisms like honey-bees are called parthenogenetic animals. [*CBSE (AI) 2012*] [*HOTS*]

Ans. Since drones/males develop from unfertilised eggs so they are called as parthenogenetic animals.

Q. 18. At what state does the meiosis occur in an organism exhibiting haploidic life cycle and mention the fate of the products thus produced. [*CBSE Delhi 2019*]

Ans. Organisms exhibiting haploidic life cycle undergo meiosis during zygote formation. The products thus formed are haploid gametophyte.

Short Answer Questions [2 marks]

Q. 1. Name the units of vegetative propagation in water hyacinth. Explain giving reasons why it has become the most invasive aquatic weed. ***[CBSE (F) 2013]***

Ans. Offsets are the unit of vegetative propagation in water hyacinth. Since the formation of hyacinth offsets does not involve two parents, the process involved is asexual, therefore they spread quickly.

Q. 2. Name the vegetative propagules in the following:

(*a*) *Agave* **(*b*) *Bryophyllum*** ***[CBSE (AI) 2014]***

Ans. (*a*) *Agave*—Bulbil (*b*) *Bryophyllum*—leaf buds/adventitous buds.

Q. 3. Name the relationship between the first two words and suggest a suitable word ***[HOTS]***

(*a*) *Doob* grass : Runner : : Potato : .....

(*b*) Endogamy : Self-fertilisation : : Exogamy : .....

Ans. (*a*) Tuber (*b*) Cross-fertilisation.

Q. 4. Explain the significance of meiocytes in a diploid organism. ***[CBSE Delhi 2016]***

Ans. In a diploid organism, meiocytes undergo meiosis to form haploid gametes. These help to restore diploidy ($2n$) through zygote formation or syngamy.

Q. 5. The cell division involved in gamete formation is not of the same type in different organisms. Justify. ***[CBSE (AI) 2011]***

Ans. The parents may be haploid or diploid but the gametes always have to be haploid. Diploid parents undergo meiosis to produce haploid gametes, whereas haploid parents undergo mitosis to produce haploid gametes.

Q. 6. A list of three flowering plants is given below. Which ones out of them are (*i*) monoecious and (*ii*) bearing pistillate flowers?

List: Date palm, Cucurbits and Pea. ***[CBSE (F) 2011]***

Ans. (*i*) Monoecious plant—Cucurbits

(*ii*) Bearing pistillate flowers—Date palm, Cucurbits.

Q. 7. Angiosperms bearing unisexual flowers are said to be either monoecious or dioecious. Explain with the help of one example each. ***[CBSE Delhi 2016]***

Ans. In some flowering plants, both male and female flowers may be present on the same individual (monoecious) or on separate individuals (dioecious). Some examples of monoecious plants are Cucurbits and coconuts and of dioecious plants are papaya and date palm.

Q. 8. A single pea plant in your kitchen garden produces pods with viable seeds, but the individual papaya plant does not. Explain. ***[CBSE (AI) 2016]***

Ans. Flowers of pea plants are bisexual, hence can be self pollinated and produce pods with viable seeds.

Papaya is a dioecious plant bearing male and female flower on separate plants. It is unable to produce viable seeds as there is no cross-pollination. It could be a male plant which is unable to produce fruit and seeds.

Q. 9. The number of taxa exhibiting asexual reproduction is drastically reduced in the higher plants (angiosperms) and higher animals (vertebrates) as compared with lower groups of plants and animals. Analyse the possible reasons for this situation. ***[NCERT Exemplar]***

Ans. Both angiosperms and vertebrates have a more complex structural organisation. They have evolved very efficient mechanism of sexual reproduction. Since asexual reproduction does not create new genetic pools in the offspring and consequently hampers their adaptability to external conditions, these groups have resorted to reproduction by the sexual method.

Q. 10. Which of the following are monoecious and dioecious organisms:

(*a*) Earthworm **(*b*) Chawra**

(*c*) *Marchantia* **(*d*) Cockroach.** ***[NCERT Exemplar]*** ***[HOTS]***

Ans. (*a*) Monoecious (*b*) Monoecious

(*c*) Dioecious (*d*) Dioecious.

Q. 11. Zygote forms the major link between one generation and those of the next generation organism. What is the fate of zygote in organisms which show: [*HOTS*]

(*i*) haplontic life cycle and (*ii*) diplontic life cycle?

Ans. (*i*) Zygote of haplontic life cycle divides meiotically to form new organisms.

(*ii*) Zygote of diplontic life cycle divides mitotically during embryogenesis to form embryo and then individual.

Q. 12. Mention two important characteristics in the sexual reproduction of frogs and bony fishes. [*HOTS*]

Ans. Both these release the mature gametes simultaneously. They also release a large number of gametes in the water to enhance the chances of syngamy (external fertilisation).

Q. 13. Out of many papaya plants growing in your garden, only a few bear fruits. Give reason. [*CBSE (AI) 2016*]

Ans. Papaya plant is dioecious, *i.e.*, male and female flowers are borne on separate plants. Only plants bearing female flowers will bear fruits.

Q. 14. How does the floral pattern of Mediterranean orchid *Ophrys* guarantee cross-pollination? [*CBSE Delhi 2010*]

Ans. The orchid bears flowers which resemble the female wasp in colour, smell, as well as appearance. The male pollinators mistake them as their female counterparts. Therefore, in the process of their pseudocopulation they pollinate the flower.

Q. 15. Explain the importance of syngamy and meiosis in a sexual life cycle of an organism. [*CBSE Delhi 2016*]

Ans. In the sexual life cycle of an organism, meiosis results in formation of haploid gametes which fuse together by syngamy and the diploid nature of the organism is restored in the zygote.

Q. 16. A moss plant produces a large number of antherozoids but relatively only a few egg cells. Why?

OR **[*CBSE Delhi 2010*]**

Why do moss plants produce very large number of male gametes? Provide one reason. What are these gametes called? [*CBSE (AI) 2015*]

Ans. Antherozoids are motile male gametes which have to swim on the water surface to fertilise the immotile female gametes, *i.e.*, egg. Since, during its transfer many antherozoids get destroyed, a large number of them are produced.

Q. 17. A liverwort plant is unable to complete its lifecycle in a dry environment. State two reasons. [*CBSE (F) 2013, (AI) 2015*]

Ans. For sexual reproduction to take place in mosses and liverworts the motile male gametes, antherozoids, have to swim on the water surface to fertilise the immotile female gametes, egg. In dry conditions, the antherozoids do not reach the egg and hence fertilisation cannot occur. So, the life cycle remains incomplete.

Q. 18. Mosses and frogs both need water as a medium for fertilisation. Where does syngamy occur and how is it ensured in both these organisms? [*CBSE 2019 (57/2/1)*]

OR

Write the basis of categorising animals as oviparous or viviparous, giving one example of each.

Ans. In frogs, external fertilisation takes place in water. The frogs release large number of motile gametes. There is synchronised maturation of ova and sperms.

In moss, internal fertilisation takes place. The male gametes are motile and are produced in large numbers.

OR

Oviparous animals are egg laying (fertilised or unfertilised). For example, reptiles, birds. Viviparous animals give birth to young ones. For example, majority of mammals; humans.

Q. 19. Why do algae and fungi shift to sexual mode of reproduction just before the onset of adverse conditions? [*CBSE Delhi 2014*]

Ans. Algae and fungi shift to sexual mode of reproduction for survival during unfavourable conditions. Fusion of gametes helps to pool their resources for survival. The zygote develops a thick wall that is resistant to dessication and damage which undergoes a period of rest before germination.

Q. 20. If the chromosome numbers in meiocytes of human beings, rat, elephant, rice, butterfly and onion are 46, 42, 56, 24, 380 and 32, respectively. What will be the chromosome numbers in gametes of these species? [*HOTS*]

Ans. The chromosome numbers in the gametes of these species will be

Human beings = 23, rat = 21, elephant = 28, rice = 12, butterfly = 190 and onion = 16.

Q. 21. Why dogs and cats have oestrus cycle but human beings have menstrual cycle, though all are mammals? [*HOTS*]

Ans. Dogs and cats are seasonal breeders . They have heat period during which ovulation takes place. Humans, on the other hand, have this cycle monthly.

Q. 22. With which type of reproduction do we associate the reduction division? Analyse the reasons for it. [*NCERT Exemplar*]

Ans. Reduction division is associated with sexual reproduction because the diploid organisms undergo meiosis to form haploid gametes.

Q. 23. Name any two organisms and the phenomenon involved where the female gamete undergoes development to form new organisms without fertilisation. [*CBSE (F) 2014*]

Ans. The phenomenon of development of female gamete directly into an individual without fertilisation is called parthenogenesis, *e.g.*, rotifers, honeybees, lizards and birds.

Q. 24. (*a*) State the difference between meiocyte and gamete with respect to chromosome number.
(*b*) Why is a whiptail lizard referred to as parthenogenetic? [*CBSE Delhi 2012*]

Ans. (*a*) Meiocytes contain diploid sets of chromosomes whereas gametes contain haploid sets of chromosomes.

(*b*) Whiptail lizard reproduces without fertilisation, *i.e.*, an unfertilised egg develops into a new individual. Therefore, they are referred to as parthenogenetic.

Q. 25. It is said apomixis is a type of asexual reproduction. Justify. [*CBSE Delhi 2019*]

Ans. Apomixis is a type of asexual reproduction because :

(*i*) Apomixis is the formation of seeds or embryo without fusion of gametes or fertilisation.

(*ii*) Diploid egg cell is formed without reductional division and develops into the embryo without fertilisation.

(*iii*) Some cells of the nucellus start dividing and develop into embryo.

Long Answer Questions–I [3 marks]

Q. 1. Differentiate between an annual and a biennial plant. Provide one example of each. [*CBSE Delhi 2017*]

Ans.

Table 1.8 Differences between annual plants and biennial plants

S. No.	Annual plants	Biennial plants
(*i*)	These plants require a single season to complete their whole life cycle.	These plants require two seasons to complete their whole life cycle.
(*ii*)	They grow, set seeds and die within one year.	In the first year, they grow a healthy root system and short stem, *i.e.*, show vegetative growth and become dormant in winters. In second year, they grow quickly, flower, set seeds and die.
(*iii*)	For example, rice, wheat, etc.	For example, onion, carrot, etc.

Q. 2. Diagrammatically represent the asexual reproduction in yeast.

Ans. Refer to Fig. 1.4.

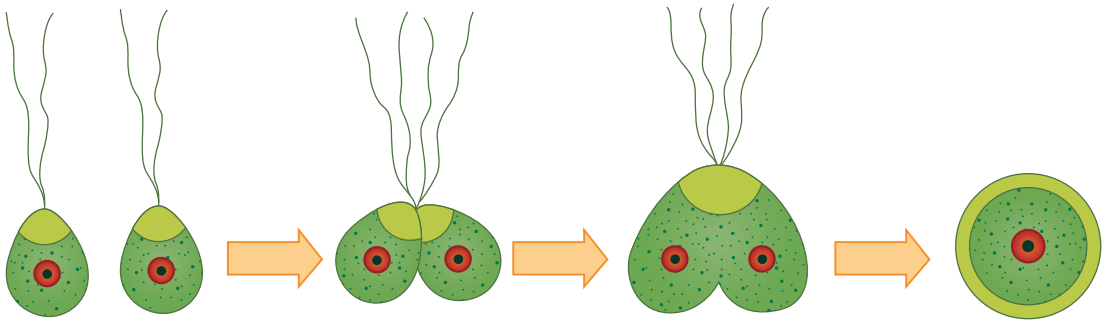
Q. 3. Although sexual reproduction is a long drawn, energy-intensive complex form of reproduction, many groups of organism in Kingdom Animalia and Plantae prefer this mode of reproduction. Give at least three reasons for this. *[NCERT Exemplar]*

Ans. (*a*) Sexual reproduction brings about variation in the offspring.

(*b*) Since gamete formation is preceded by meiosis, genetic recombination occurring during crossing over (meiosis-I), leads to a great deal of variation in the DNA of gametes.

(*c*) The organism has better chance of survival in a changing environment.

Q. 4.



(*a*) (*b*) (*c*) (*d*)

(*i*) State the type of gametes shown in the diagram.

(*ii*) Identify the process taking place and the resultant structure.

(*iii*) Name an organism that reproduces in this manner.

(*iv*) Label (*c*) and (*d*). *[CBSE Sample Paper 2015, 2017]* *[HOTS]*

Ans. (*i*) Isogametes.

(*ii*) Fertilisation is taking place and zygote is the resultant structure.

(*iii*) *Cladophora*/*Chlamydomonas*.

(*iv*) (*c*) represents zygote; (*d*) represents new individual.

Q. 5. Pollen banks are playing a very important role in promoting plant breeding programme the world over. How are pollens preserved in the pollen banks? Explain. How are such banks benefitting our farmer? Write any two ways. *[CBSE Delhi 2019]*

Ans. Cryopreservation/preserved in liquid nitrogen (–196°C).

(*i*) Availability of pollen of different genetic strains (for wider use).

(*ii*) Cryopreservation increases viability of pollens (which can be used in crop breeding programmes).

(*iii*) Can be preserved/stored for longer duration.

(*iv*) Conserve large number of species.

(*v*) To prevent complete extinction of any species.

(*vi*) Maintain biodiversity. (*Any two*)

Long Answer Questions–II [5 marks]

Q. 1. What are vegetative propagules? Name any four of them along with an example for each.

Ans. The units of asexual vegetative structures of plants which are capable of giving rise to new individuals/plants are called vegetative propagules.

Example:

(*i*) Rhizome of ginger, (*ii*) bulbil of *Agave*,

(*iii*) leaf buds of *Bryophyllum*, (*iv*) bulbs of onion.

Q. 2. Enumerate the differences between asexual and sexual reproduction. Describe the types of asexual reproduction exhibited by unicellular organisms. *[NCERT Exemplar]*

Ans. For differences, refer to Table 1.1.

For types of asexual reproduction exhibited by unicellular organisms, refer to Basic Concepts Point 2(*i*).

Q. 3. Explain the stages in sexual reproduction of an organism. Mention what major events occur in each of them.

Ans. Refer to Basic Concepts Point 3.

Q. 4. Do all the gametes formed from a parent organism have the same genetic composition? Analyse the situation with the background of gametogenesis and provide suitable explanation. ***[NCERT Exemplar]***

Ans. Gametes do not have the same genetic composition formed by the parent organism.

Refer to Basic Concepts Point 3(*i*).

Q. 5. Differentiate between (*a*) oestrus and menstrual cycles; (*b*) ovipary and vivipary. Cite an example for each type. ***[NCERT Exemplar]***

Ans. (*a*)

Table 1.9 Differences between oestrus cycle and menstrual cycles

S. No.	Oestrus cycle	Menstrual cycle
(*i*)	It involves no uterine bleeding.	It ends with uterine bleeding.
(*ii*)	It continues until death.	It continues till menopause.
(*iii*)	Occurs in non-primates. *e.g.*, sheeps, cows	Occurs in apes and humans.

(*b*) Refer to Table 1.3

Self-Assessment Test

Time allowed: 1 Hour **Max. marks: 30**

1. Choose and write the correct option in the following questions. **(3×1 = 3)**

(i) The number of chromosomes in the shoot tip cells of a maize plant is 20. The number of chromosomes in the microspore mother cells of the same plant shall be:

(a) 20 (b) 10

(c) 40 (d) 15

(ii) Product of sexual reproduction generally generate

(a) longer viability of seeds (b) prolonged dormancy

(c) large biomass (d) new genetic combination leading to variation

(iii) In ginger, vegetative propagation occurs through

(a) bulbis (b) runners

(c) rhizome (d) offsets

2. In the following questions a statement of assertion followed by a statement of reason is given. Choose the correct answer out of the following choices. **(3×1 = 3)**

(a) Assertion and reason both are correct statements and reason is correct explanation for assertion.

(b) Assertion and reason both are correct statements but reason is not correct explanation for assertion.

(c) Assertion is correct statement but reason is wrong statement.

(d) Assertion is wrong statement but reason is correct statement.

(*i*) Assertion : In budding new individuals are formed by mitosis.

Reason : It is a common method of asexual reproduction.

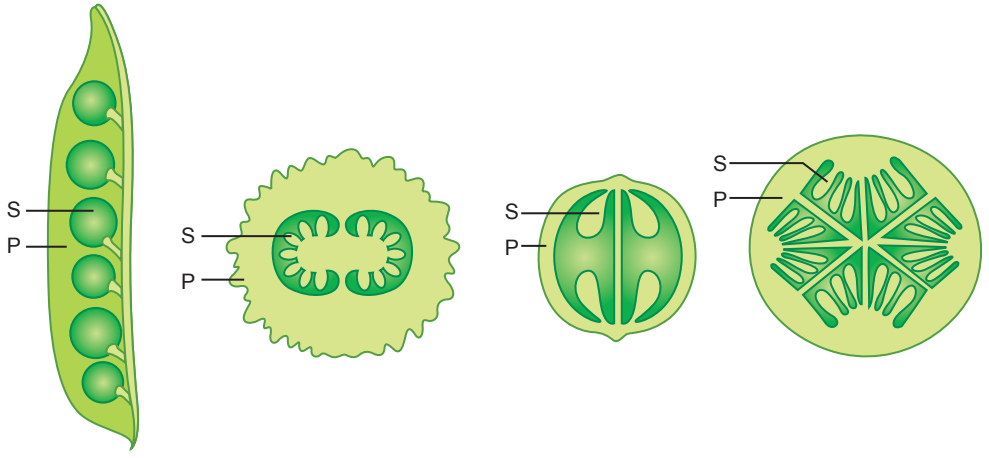
(*ii*) Assertion : Parthenogenesis involves only one parent.

Reason : It is a type of asexual reproduction.

(*iii*) **Assertion :** Vegetative propagation occurs in all unicellular organisms.

Reason : Vegetative parts develop into independent plants only under suitable environmental conditions.

3. Banana produces fruits but is propagated only by vegetative means. Why is it so? **(1)**
4. What is pericarp? **(1)**
5. Why are papaya and date palm plants said to be dioecious whereas Cucurbits and coconut palms monoecious, in spite of all of them bearing unisexual flowers? ***[CBSE (F) 2010]*** **(2)**
6. State the difference between external and internal fertilisation. **(2)**
7. In haploid organisms that undergo sexual reproduction, name the stage in the life cycle when meiosis occurs. Give reasons for your answer. **(2)**
8. In a developing embryo, analyse the consequences if cell divisions are not followed by cell differentiation. ***[NCERT Exemplar]*** **(2)**
9. Answer the following questions: **(3)**
   (i) Name two plants having diploid body.
   (ii) Name the type of cell division that takes place in the zygote of an organism exhibiting haplontic life cycle. ***[CBSE Delhi 2011]***
   (ii) Why does organisms exhibiting external fertilisation show great synchrony between the sexes and release a large number of gametes into surrounding medium. ***[CBSE Sample Paper 2018]***
10. Analyse the diagrams of few kinds of fruits showing seeds (S) and protective pericarp(P). Answer the questions that follow based on the analysis. **(3×1 = 3)**



   (i) From which part does fruit, seed and embryo develop?
   (ii) Suggest a possible explanation why the seeds in a pea are arranged in a row, whereas those in tomato are scattered in the juicy pulp.
   (iii) Name the phase that all organisms have to pass through before they can reproduce sexually.
11. Draw the sketches of a zoospore and a conidium. Mention two dissimilarities between them and at least one feature common to both structures. ***[NCERT Exemplar]*** **(3)**
12. What are vegetative propagules? Name any four along with their examples. **(5)**

Answers

1. (*i*)—(*a*), (*ii*)—(*d*), (*iii*)—(*c*) **2.** (*i*)—(*b*), (*ii*)—(*c*), (*iii*)—(*d*)

Chapter –2

Sexual Reproduction in Flowering Plants

basic concepts

1. Parts of Flower

- In a flower, four different sets of whorls or floral members are attached to a central axis called **thalamus**.
- The outermost and the first accessory whorl is of sepals and is called **calyx**.
- The second accessory whorl is of petals and is called **corolla**.
- Next to the corolla, is the male reproductive whorl of stamens called **androecium**.
- The female reproductive whorl is of carpels and is called **gynoecium** or **pistil**.
- Calyx and corolla are the non-essential whorls while androecium and gynoecium are the essential whorls.

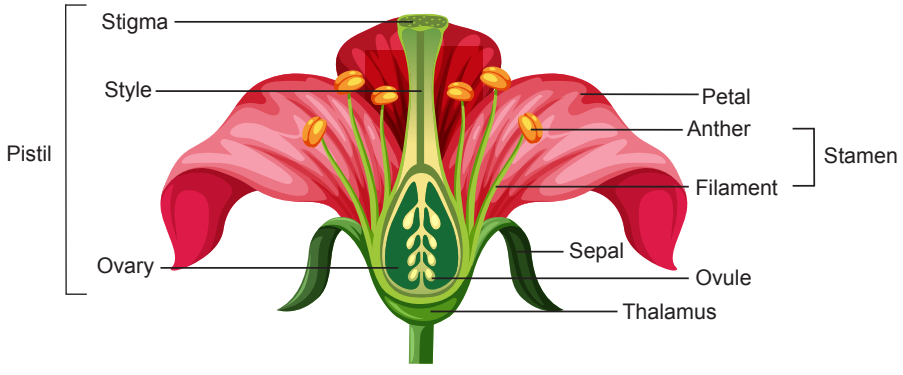


Fig. 2.1 A diagrammatic representation of L.S. of a flower

2. Functions of Floral Members

- **Calyx**
  - (*i*) Its main function is to protect the flower in bud condition. It is smaller than the petals in size.
  - (*ii*) When green, it is photosynthetic in nature.
  - (*iii*) When coloured, it attracts insects for pollination.

- **Corolla**
  - (*i*) It provides colour and scent to attract pollinators.
  - (*ii*) Sometimes the base of corolla bears some secretory glands and secretes nectar.
  - (*iii*) They also provide protection to the plant.
- **Androecium:** Its main function is the production of microspores, *i.e.*, pollen grains containing male gametes within the anther lobe.
- **Gynoecium:** The function of gynoecium is the production of megaspores eggs, fruits and seeds.

3. Male Reproductive Unit

- **Stamen** is the male reproductive unit and consists of the following two parts:
  - (*i*) A long and slender stalk called **filament**.
  - (*ii*) A bilobed terminal structure called **anther**.

Structure of Anther

- It is composed of two anther sacs or lobes separated by a tissue called connective tissue.
- The anther is bilobed and each lobe or sac consists of two theca separated by a septum.
- The anther is a tetragonal (four-sided) structure, consisting of four microsporangia, two in each of the lobes.
- Microsporangia develop and get transformed into pollen sacs.

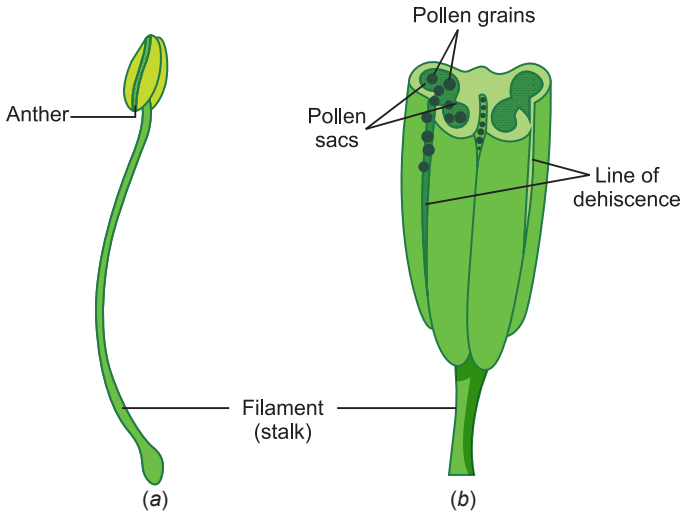


Fig. 2.2 (*a*) A typical stamen; (*b*) Transverse section of an anther

Structure of Microsporangium

- A typical microsporangium appears circular and is surrounded by four walls:
  - (*i*) **Epidermis:** It is the outermost single layer of cell which is protective in nature.
  - (*ii*) **Endothecium:** It is the second layer with thick cells, help in dehiscence and is protective in nature.
  - (*iii*) **Middle layer:** It is the third layer composed of 1–3 layers of cells, help in dehiscence and is protective in nature.
  - (*iv*) **Tapetum:** It is the fourth and innermost layer of cell with dense cytoplasm and many nuclei. It provides nourishment to the developing pollen grains.
- The centre of each microsporangium is filled with closely arranged similar cells called **sporogenous cells**.

- At maturity, pollen sac is formed by fusion of two microsporangium in each lobe.
- A mature anther dehisces by slits and liberate the pollen grains.

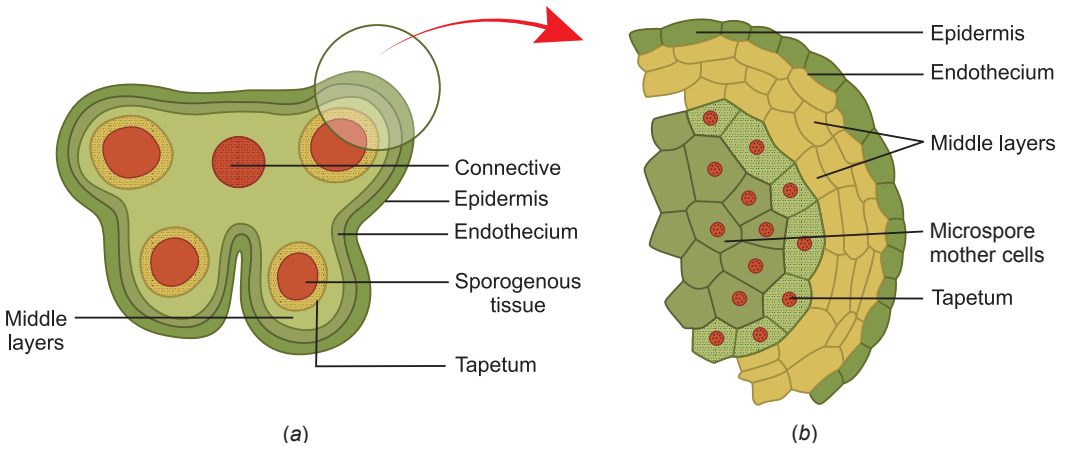


Fig. 2.3 (*a*) Transverse section of a young anther;
(*b*) Enlarged view of one microsporangium showing wall layers

Microsporogenesis

- The process of formation of microspore from a pollen mother cell by meiosis is called **microsporogenesis**.

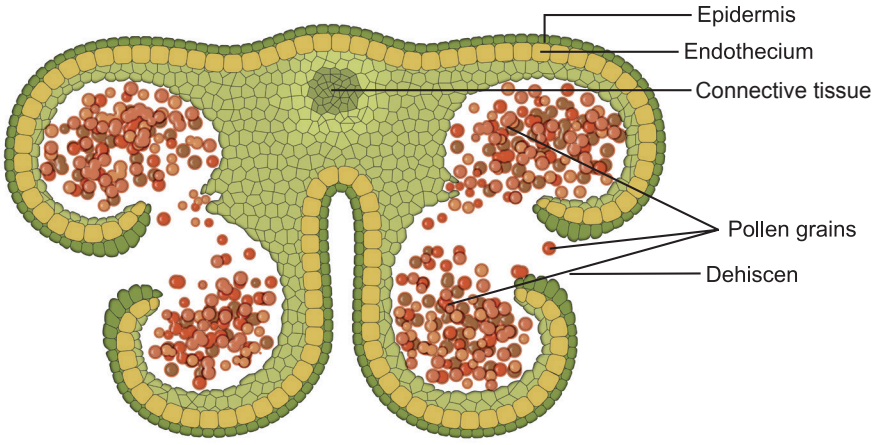


Fig. 2.4 T.S. of mature dehisced anther with pollen grains

- Each cell of the sporogenous tissue in a microsporangium acts as a potential **pollen mother cell (PMC)** or **microspore mother cell**.
- PMC undergoes meiotic divisions to form cluster of four cells called **microspore tetrad**.
- On maturity, the anther dehydrates and the microspores separate from each other to form **pollen grains** with two layered wall—outer hard exine and inner intine.

Pollen Grains

- Pollen grains are generally spherical in structure.
- They possess two prominent wall layers—outer exine and inner intine.

- The **exine** is a hard layer made of sporopollenin which is one of the most resistant organic material present in nature. It can withstand high temperature and strong acids and alkalis. Even enzymes cannot degrade sporepollenin and hence pollens are preserved as fossils.
- The inner thin layer of **intine** is made up of cellulose and pectin.
- The exine has aperture where sporopollenin is absent, called **germ pores**.
- The newly differentiated pollen grain has a central nucleus and dense cytoplasm.
- Pollen grain is the first cell of a male gametophyte.
- The protoplast increases in size and mitotically divides into two unequal cells—(*a*) bigger vegetative cell which is rich in food reserve and large irregularly shaped nucleus, and (*b*) smaller spindle-shaped generative cell with dense cytoplasm and a nucleus. This is called the **2-celled stage**.
- In majority angiosperms, pollens are released in this 2-celled stage, whereas in other species, the generative cell divides into 2 male gametes and thus pollen is said to be in **3-celled stage**.

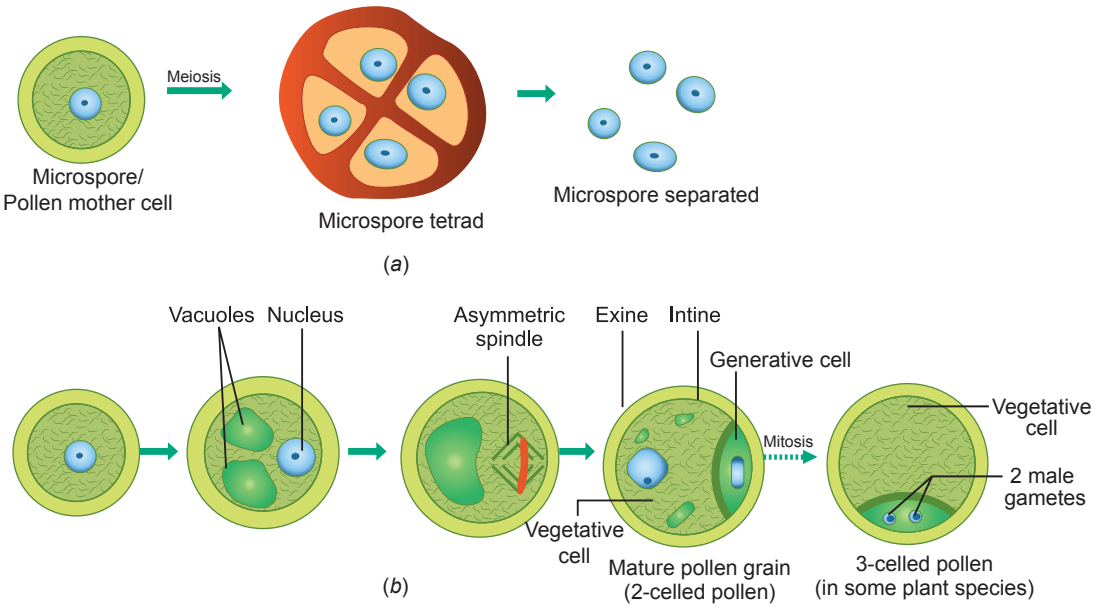


Fig. 2.5 (*a*) Enlarged view of a pollen grain tetrad;
(*b*) Stages of a microspore maturing into a pollen grain

Importance of pollen grains

- They contain male gametes for sexual reproduction.
- These are nutrient-rich and thus are taken as food supplements.
- Pollens can be stored for years in liquid nitrogen at –196°C, to be used later in crop breeding programmes.
- They may cause allergies and bronchial afflictions in some people leading to asthma, bronchitis, etc.

4. Female Reproductive Unit

- The pistil or gynoecium represents the female reproductive unit of a flower.
- The gynoecium may have single pistil (called **monocarpellary**), more than two pistils (called **multicarpellary**), fused pistils (called **syncarpous**) or free pistils (called **apocarpous**).

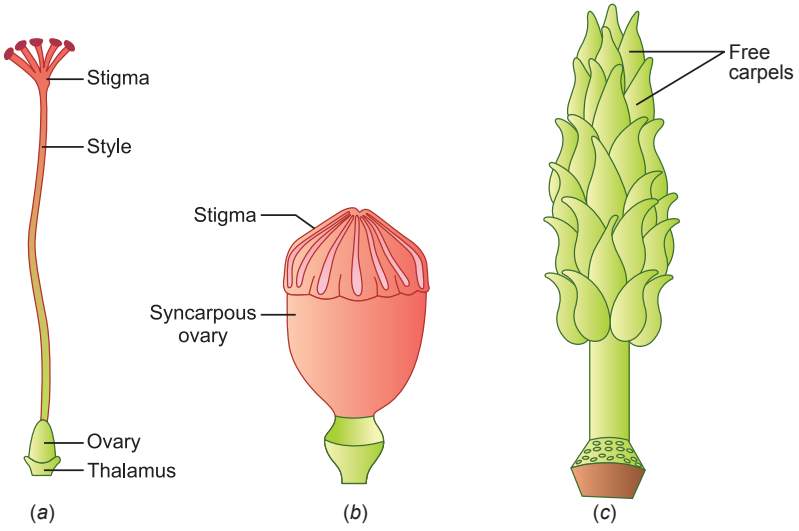


Fig. 2.6 (a) Pistil of *Hibiscus*; (b) Multicarpellary, syncarpous pistil of *Papaver*; (c) A multicarpellary, apocarpous gynoecium of *Michelia*

Table 2.1: Parts of pistil and their functions

S. No.	Parts	Functions
(*i*)	**Stigma**	It receives the pollen grains. It has sticky surface and pollen grains get stuck to it during pollination.
(*ii*)	**Style**	It is an elongated slender part beneath the stigma, that connects the stigma with ovary. It holds the stigma to receive the pollen grains. It is through the style that the pollen tube grows and reaches the ovule.
(*iii*)	**Ovary**	It is the basal swollen part of pistil that contains ovules and eggs.

- Inside the ovary there is a compartment called ovarian cavity or locule separated by septum.
- Placenta is the tissue in ovarian cavity from where ovule or **megasporangium** arise.

Structure of Megasporangium (Ovule)

- The ovule is stalked and is attached to the placenta by means of a stalk called **funicle**.
- The junction between an ovule and a funicle is called **hilum**. Sometimes, the funicle extends beyond the hilum to form a ridge called **raphae**.
- The ovule is surrounded by one or two protective multicellular **integuments**.
- Integument encircles the ovule entirely except at the tip, resulting in a small opening called **micropyle**.
- The basal part of an ovule opposite to micropyle is called **chalaza**.
- The cells with high or abundant reserve food material enclosed within integument is called **nucellus**.
- The female gametophyte located within the nucellus is called an **embryo sac**.

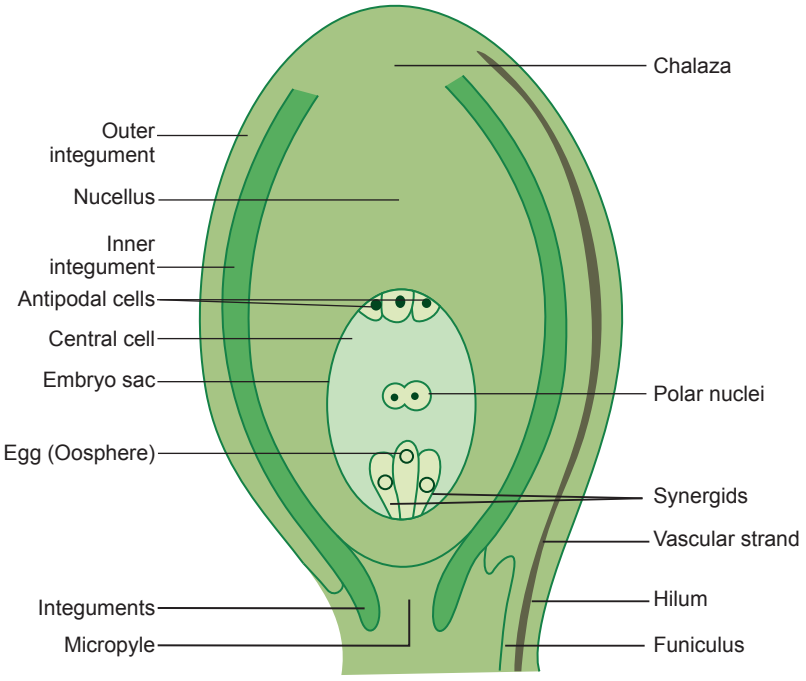


Fig. 2.7 A diagrammatic view of a typical anatropous ovule

Megasporogenesis

- The process of formation of haploid megaspores from the diploid megaspore mother cell (MMC) is called **megasporogenesis**.
- In the micropylar region, the nucellus contains cells with dense cytoplasm and prominent nucleus which is differentiated into a single MMC.
- MMC is diploid and undergoes meiosis.
- MMC first divides transversely into two cells called **dyad**.
- These two cells again divide transversely, as a result a linear row of four haploid cells is produced which is called **megaspore tetrad** or **linear tetrad**.
- Out of these four megaspores, only one remains functional while the other three degenerate.
- The one functional megaspore develops into the female gametophyte or **embryo sac**. This is called **monosporic development**.

Megagametogenesis

- The formation of female gametophyte (embryo sac) is called **megagametogenesis**.
  - (*i*) Megaspore is the first cell of the female gametophyte.
  - (*ii*) The megaspore increases in size and its nucleus divides mitotically into two nuclei which move apart to opposite poles. Thus, a 2-nucleate embryo sac is formed.
  - (*iii*) The two daughter nuclei undergo another mitotic division giving rise to the 4-nucleate stage.
  - (*iv*) The third mitotic division gives rise to 8-nucleate 7-celled embryo sac.
  - (*v*) The central cell contains 2 nuclei known as polar nuclei.
  - (*vi*) The three nuclei at the micropylar region form the **egg apparatus**.
  - (*vii*) In the egg apparatus, the middle cell is the largest and is called **oosphere/egg/ovum**, while other two naked cells adjoining the egg cell are called **synergids**.

(*viii*) The three nuclei at the chalazal end are surrounded by cytoplasm and cellular wall. These are called **antipodal cells**.

(*ix*) Female gametophyte is 7 celled, 8 nucleate as it consist of 7 cells but 8 nuclei (2 nuclei in polar cell).

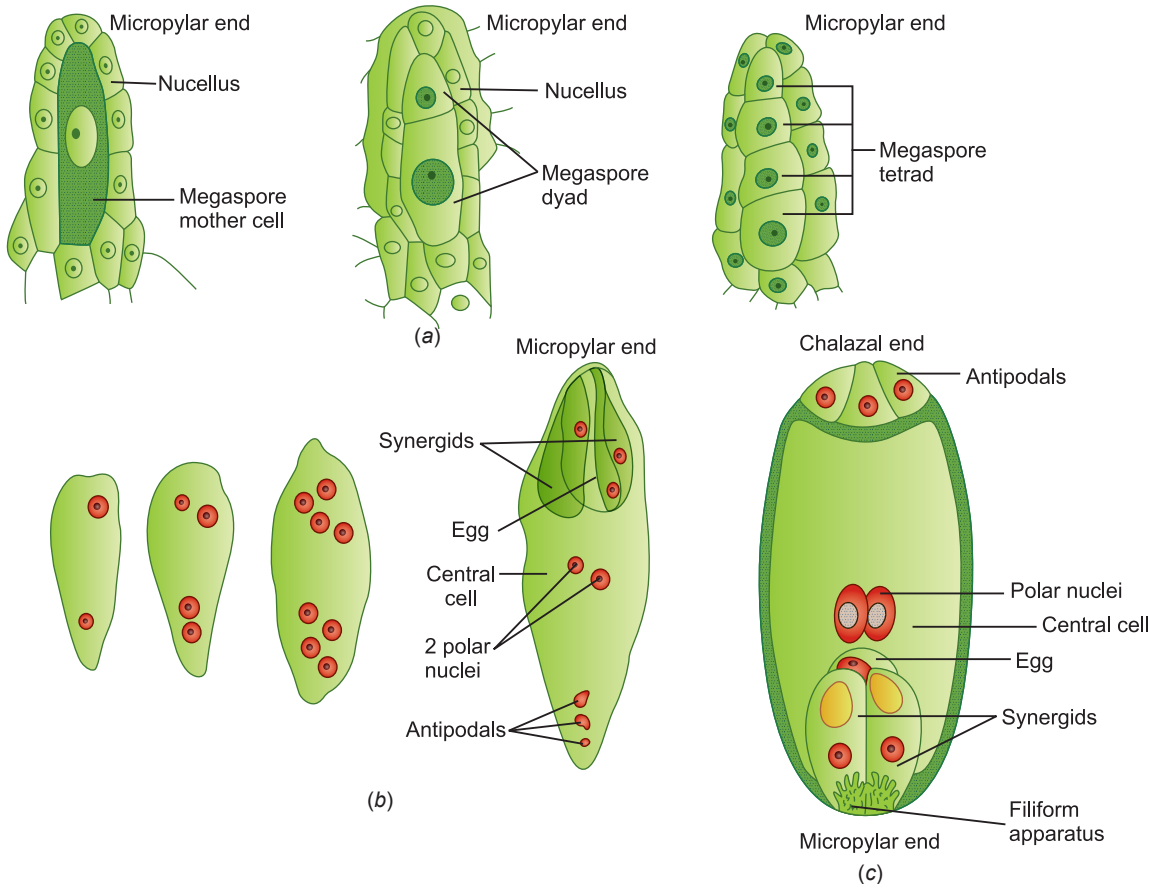


Fig. 2.8 (*a*) Parts of the ovule showing a large megaspore mother cell, a dyad and a tetrad of megaspores; (*b*) 2, 4 and 8-nucleate stages of embryo sac and a mature embryo sac; (*c*) A diagrammatic representation of the mature embryo sac

5. Pollination

- The transfer of pollen grains from anther and their deposition over stigma of the pistil is termed as **pollination**. Depending upon sources of pollen grains, pollination is of three types.

Pollination

Autogamy
1. The transfer of pollen grains is from anther to stigma of the same flower, *e.g.*, pea, rice, wheat, etc. It is self-pollination.
2. Brings pollen with similar genetic constitution on stigma.

Geitonogamy
1. The transfer of pollen grains is from anther of one flower to the stigma of another flower of same plant, *e.g.*, *Cucurbita*.
2. It is functionally cross-pollination but genetically similar to autogamy.

Xenogamy/Allogamy
1. The transfer of pollen grains is from anther of one flower to the stigma of another flower of different plant, *e.g.*, Papaya, maize.
2. Brings genetically different types of pollen grains to stigma.

Contrivances or Devices for Self-pollination (Autogamy)

- Cross-pollination can be prevented by exhibiting
  - (*i*) **Cleistogamous flowers:** These are bisexual closed flowers which never open and the anthers dehisce inside these closed flowers, *e.g.*, *Commelina* and produce seed set even in absence of pollinators.
  - (*ii*) **Homogamy:** It is the condition of the maturity of anther and stigma at the same time, *i.e.*, synchrony in pollen release and stigma receptivity. *e.g.*, *Catharanthus* (*Vinca*).
  - (*iii*) Close association between anther and stigma, *e.g.*, *Mirabilis*.

Advantages of Self-pollination

- (*i*) Pure breed of parents is maintained.
- (*ii*) Large numbers of pollen grains are not required for pollination.
- (*iii*) Seed production is ensured.
- (*iv*) Plants do not need to develop mechanisms for attracting pollinators.

Disadvantages of Self-pollination

- (*i*) Variations are not introduced in the progeny.
- (*ii*) Vitality of the breed decreases with time.
- (*iii*) Adaptability to changing environment is reduced.

Contrivances or Devices for Cross-pollination (Xenogamy/Allogamy)

- Self-pollination can be prevented by exhibiting
  - **(*i*) Dicliny or Unisexuality:** Male and female flowers are separate. Dioecious condition is seen in papaya.
  - **(*ii*) Dichogamy:** The condition in which the stamens and stigma of a bisexual flower mature at different times. It is of two types:
    - **(*a*) Protandry:** This is the condition where anthers mature earlier than the stigma and release pollens.
    - **(*b*) Protogyny:** This is the condition where the stigma matures earlier than the anther.
  - **(*iii*) Self-sterility or self-incompatibility:** It is a genetic mechanism that prevents self-pollination. Pollen grains of a flower do not germinate on stigma of same flower due to similar sterile genes.
  - **(*iv*) Chasmogamous flowers:** These are open flowers with exposed stamens and stigma which facilitate cross-pollination.

Advantages of cross-pollination:

- (*i*) Variation in the progeny is introduced through recombination.
- (*ii*) The progenies have better adaptability to changing environment.
- (*iii*) Plants develop new traits like disease resistance.
- (*iv*) The defective characters are eliminated over the generations.

Disadvantages of cross-pollination:

- (*i*) Large numbers of pollen grains need to produced of which most are lost during the process of pollination.
- (*ii*) There is always a chance that pollination may not occur.
- (*iii*) It is less economical.

Adaptation for Water Pollination/Hydrophily

- The form of pollination in which pollens are distributed by water is called **hydrophily**.
- It is very common in algae, bryophytes, pteridophytes and some angiosperms.
- *Vallisneria* and *Hydrilla* are submerged freshwater hydrophytes in which hydrophily is observed.
- In sea-grasses (*e.g.*, *Zostera*), female flowers are submerged in water to receive pollen grains for pollination inside water. Pollens are long, needle-like and are carried passively by water.

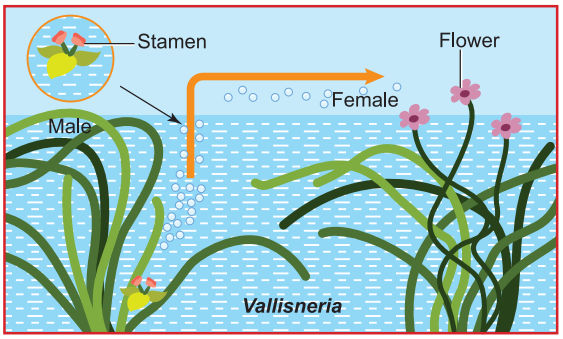


Fig. 2.9 Pollination by water in *Vallisneria*

- In *Vallisneria*, the female flower stalk is long to reach the water surface to receive the pollen grains carried by water currents and the stalks coil up after pollination.
- Pollen grains are protected from wetting by the presence of a mucilaginous covering.
- Flowers are not very colourful and do not produce nectar.

Adaptation for Wind Pollination/Anemophily

- The form of pollination in which wind distributes the pollens is called **anemophily**.
- Pollen grains are light in weight, non-sticky, dry and may be winged as in *Pinus*.
- Stamens are well-exposed for easy dispersal of pollen grains in the wind.
- The stigma is sticky, large and feathery to trap pollen grains floating in the air, *e.g.*, tassels in corn cob.
- Numerous flowers are packed together to form inflorescence.
- Single ovule is present in each ovary. Flowers are not very colourful and do not produce nectar.

Fig. 2.10 A wind-pollinated plant showing compact inflorescence and well-exposed stamens

Fig. 2.11 Insect pollination

Adaptation for Insect Pollination/Entomophily

- The form of pollination in which insects distribute pollens is called **entomophily**.
- Flowers are large, sticky and brightly coloured.
- If small, number of flowers are clustered into inflorescence to make them conspicuous.
- They have honey and nectar glands, which are highly fragrant to attract insects.
- The pollen grain surface is sticky due to exine layer and stigma is sticky due to mucilaginous secretion.
- The flowers offer floral rewards like nectar and pollen grains for pollination to insects.

- In some species, floral rewards provide safe place to lay eggs, *e.g.*, *Amorphophallus*.
- The flower sometimes secrete foul odour to attract insects like flies and beetles.

6. Pollen–Pistil Interaction

- All the events from pollen deposition on the stigma until the entry of the pollen tubes into the ovule are together called **pollen–pistil interactions**.

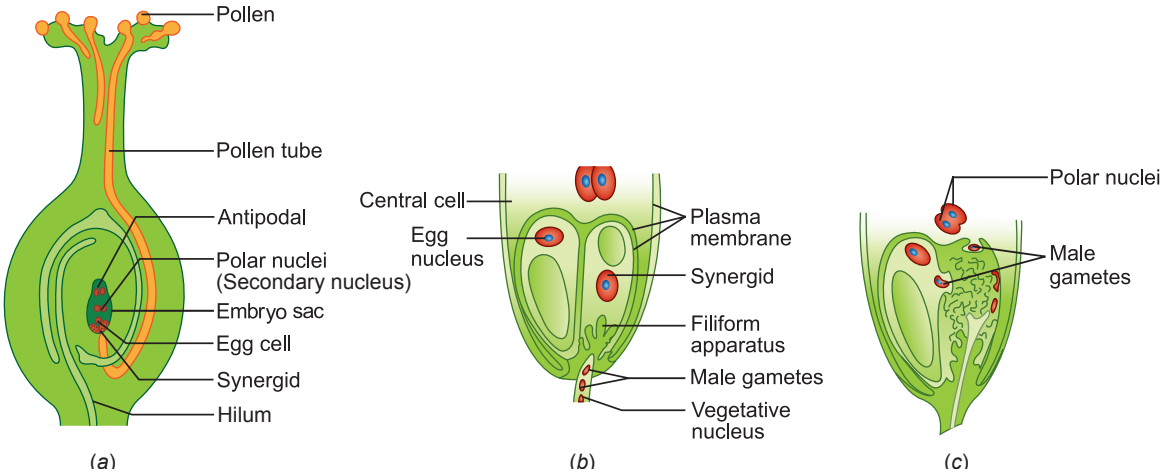


Fig. 2.12 (*a*) L.S. of pistil showing path of pollen tube growth;
(*b*) Enlarged view of an egg apparatus showing entry of pollen tube into a synergid;
(*c*) Discharge of male gametes into a synergid and the movements of the sperms, one into the egg and the other into the central cell

- It is a dynamic process involving pollen recognition by stigma/pistil for compatible pollen.
- Incompatible pollens or sterile pollens are rejected by the pistil and do not allow growth of pollen tube.
- Compatible pollens are encouraged by pistil for growth and development of pollen tubes.
- The pollen tube grows through stigma and style to reach the ovary.
- It then enters the ovule through micropyle and reaches the synergids, guided by filiform apparatus.

7. Artificial Hybridisation

- Commonly used technique in plant breeding programmes to obtain desirable characters.
- Anthers are removed from the bisexual flowers using forceps. This is **emasculation** and is done before the anther dehisces.
- The emasculated flower is covered with a paper bag to prevent contamination from unwanted pollens. This is called **bagging**.
- On attaining maturity, mature pollens from desirable plant are dusted on stigma of bagged flower and rebagged for fruit development.

8. Double Fertilisation/Triple Fusion

- On reaching synergid, pollen tube releases the two male gametes into cytoplasm of synergid.
- One of the male gamete fuses with egg nucleus to form a diploid cell called zygote. This event is called **syngamy**.
- Other male gamete fuses with polar nuclei at the centre to produce a triploid **primary endosperm nucleus (PEN)**. This is termed as **triple fusion**.

- As syngamy and triple fusion take place simultaneously in the embryo sac, it is termed as double fertilisation.
- The central cell after triple fusion forms **primary endosperm cell (PEC)** which later develops into endosperm.
- The zygote later develops into an embryo.

9. Post-fertilisation Events

- The following events after double fertilisation are collectively called post-fertilisation events:
  (*i*) Development of endosperm from primary endosperm nucleus (PEN)
  (*ii*) Development of embryo from zygote
  (*iii*) Development of seeds from ovule
  (*iv*) Development of fruit from ovary

Endosperm Development

- Endosperm develops first, followed by an embryo.
- Endosperm develops from PEN.
- PEN undergoes successive nuclear divisions to give rise to free nuclei and this stage of endosperm development is called **free nuclear endosperm**.
- Subsequently, cell wall is formed on the periphery and endosperm becomes cellular. It is now called cellular endosperm.

Functions

(*i*) The cells of endosperm tissue are triploid and filled with reserve food material to nourish the developing embryo.
(*ii*) The water of tender coconut in the centre is free-nuclear endosperm and white kernel in the outer part is the multicellular endosperm.
(*iii*) The endosperm may be completely consumed by the developing embryo, *e.g.*, pea, beans, or it may persist in mature seed, *e.g.*, coconut.

Embryo Development

- Early development of embryo from the zygote is called embryogeny.
- Embryo develops from zygote at the micropylar end of embryo sac.
- The nutrition for development is provided by endosperm.
- The zygote divides mitotically to form proembryo.
- The different stages of the developing proembryo are globular and heart-shaped embryo, which finally forms mature embryo.

Embryogeny in Dicots

- The zygote undergoes transverse division forming a large basal cell and a small apical or terminal cell.
- The large basal cell enlarges and undergoes transverse division to from a group of 6–10 cells called **suspensor**.
- The first cell of the suspensor towards the micropylar end is called **haustorium**, whereas the last cell of the suspensor towards the chalazal end is called **hypophysis** that later develops into radicle.
- The smaller terminal or apical cell undergoes one vertical division. The two cells formed from terminal cell divide by a transverse division thus forming four embryonal cell (**quadrant stage**).

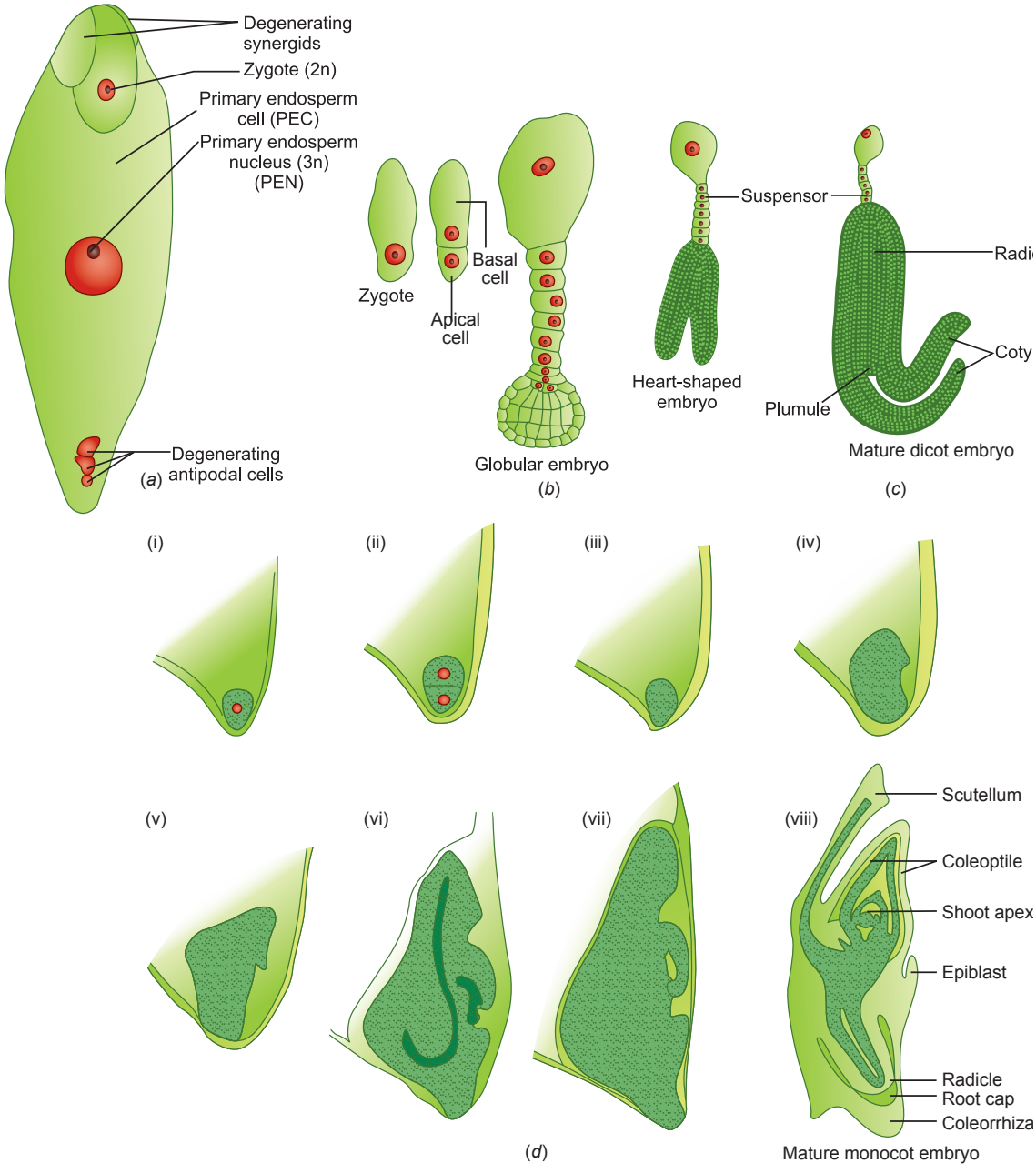


Fig. 2.13 (*a*) Fertilised embryo sac showing zygote and primary endosperm nucleus (PEN);
(*b*) Stages in embryo development in a dicot [shown in reduced size as compared to (*a*)
(*c*) Mature dicot embryo
(*d*) Stages in embryo development in a monocot

- Finally these four cells divide vertically forming 8-celled proembryo (**octate stage**). Four cells at the apex give rise to plumule and another four give rise to hypocotyl except its tip.

Structure of dicotyledonous embryo

(*i*) A typical dicotyledonous embryo consists of an embryonal axis and two cotyledons.

(*ii*) The portion of embryonal axis above the level of cotyledon is called **epicotyl**, which develops into plumule or baby shoot (future shoot).

(*iii*) The cylindrical portion below the level of cotyledon is the **hypocotyl**, which develops into radicle or root tip (future root).

(*iv*) The root tip is often covered with a root cap (**calyptra**).

(*v*) Mango, apple, radish, rose, etc., are some dicot plants.

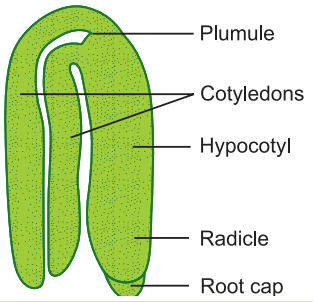


Fig. 2.14 A typical dicot embryo

Structure of monocotyledonous embryo

(*i*) A typical monocotyledonous embryo consists of one cotyledon.

(*ii*) The cotyledon is situated on one side (lateral) of the embryonal axis and is called **scutellum**.

(*iii*) The radicle and root cap are situated at the lower end of embryonal axis in an undifferentiated sheath called **coleorhiza**.

(*iv*) The shoot apex and few leaf primordia are enclosed in a hollow foliar structure in epicotyl region called **coleoptile**.

(*v*) The portion of the embryonal axis above the level of attachment of scutellum is called **epicotyl**.

(*vi*) Grass, banana, bamboo, palm, etc., are some monocot plants.

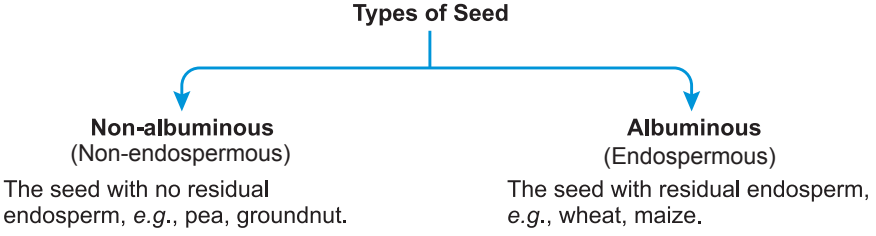
Seed Development

- Seed is a fertilised ovule which is the final product of sexual reproduction.
- It consists of the following:

(*i*) Seed coat(s): 1–2 in number, having an opening called micropyle. Outer integument forms outer seed coat (**testa**) and inner integument forms inner seed coat (**tegmen**).

(*ii*) Cotyledons: 1–2 in number and rich in reserve food material.

(*iii*) Embryonal axis



- Sometimes in the seed, nucellus may persist. This is called **perisperm**, *e.g.*, in black pepper.
- With maturity, the water content of seed decreases and finally enters a state of inactivity called **dormancy**.

Advantages of seeds

(*i*) Seeds posses better adaptive strategies for dispersal to form a new colony.

(*ii*) The reserve food of seed support the growth of seedling till they become nutritionally independent.

(*iii*) The hard seed coats (testa + tegmen) provide protection against injury.

(*iv*) They provide genetic recombination and variation as they are the product of sexual reproduction.

(*v*) Seeds are stored to be consumed throughout the year, to overcome drought and natural calamities.

(*vi*) Depending upon the mobility of seeds, they are used to raise crop in favourable season.

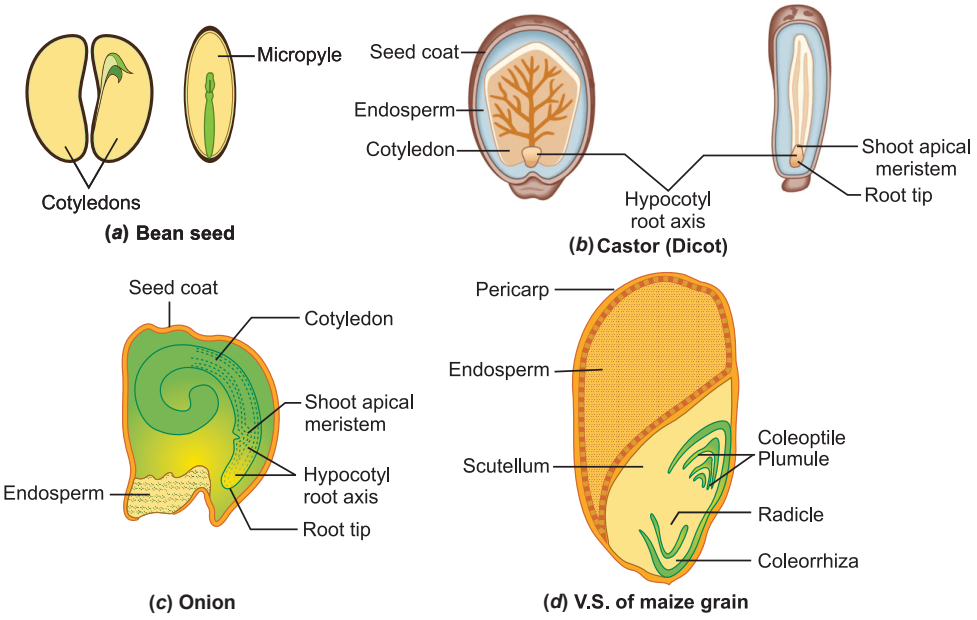
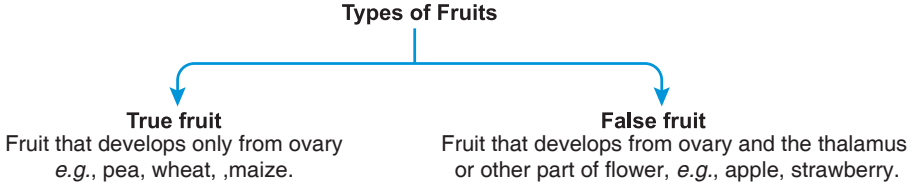


Fig. 2.15 Structure of some seeds

Fruit Development

- The ovary matures to form **fruit** and the ovarian wall develops into the fruit wall called **pericarp**.
- Fruits can be
  - (*i*) Fleshy, *e.g.*, orange, mango, etc.
  - (*ii*) Dry, *e.g.*, mustard, groundnut, etc.



- Fruits consist of three parts: (*a*) outer skin called epicarp, (*b*) middle flesh called mesocarp, (*c*) innermost part called endocarp

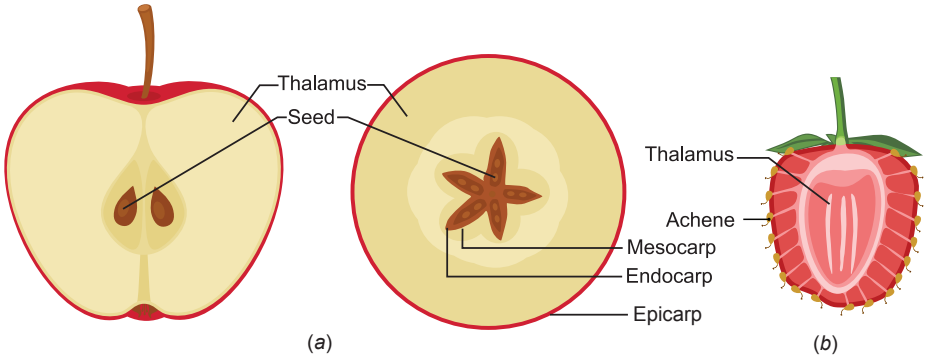


Fig. 2.16 False fruits of apple and strawberry

Parthenocarpic Fruit

- Fruits that are formed without fertilisation are called parthenocarpic fruits. These do not have seeds, *e.g.*, banana. Parthenocarpy can also be induced artificially by growth hormones.

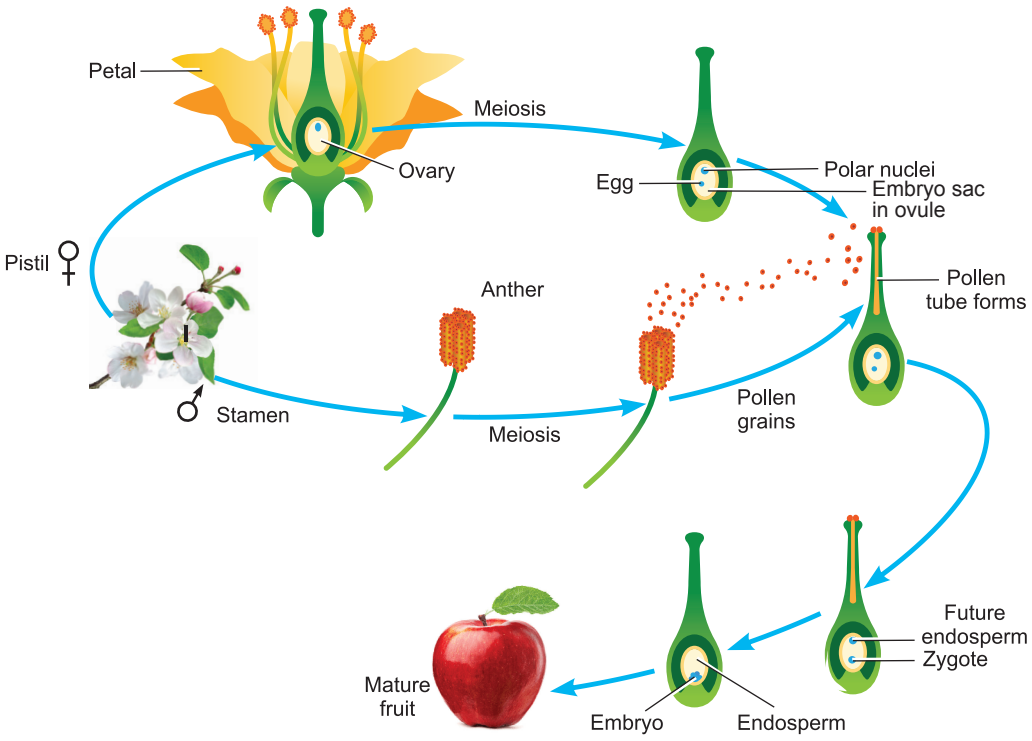


Fig. 2.17 Summary of fruit formation that includes germination of a seed, vegetative growth and the production of flowers that eventually bear fruit, which contains seeds

11. Special Mechanisms of Reproduction

(i) Apomixis

- The phenomenon of asexual reproduction that imitates sexual reproduction by formation of seed without fertilisation is called **apomixis** or **agamospermy**.
- Ways of development of apomictic seeds:

(*a*) A diploid egg is formed without reduction division and develops into embryo without fertilisation.

(*b*) Some cells of the nucellus, which are diploid in nature, start dividing and without fertilisation develop into embryo, *e.g.*, citrus fruits and mango.

(ii) Polyembryony

- The occurrence of more than one embryo in a seed is called polyembryony, *e.g.*, orange.
- Ways of forming polyembryonic seeds:

(*a*) Development of cells like synergids, cells of nucellus, cells of integument, into embryo.

(*b*) Formation of more than one embryo sac in an ovule.

(*c*) Formation of more than one egg in an embryo sac.

NCERT Textbook Questions

Q. 1. Name the parts of an angiosperm flower in which development of male and female gametophyte take place.

Ans. Development of male and female gametophytes takes place in anther and ovary, respectively.

Q. 2. Differentiate between microsporogenesis and megasporogenesis. Which type of cell division occurs during these events? Name the structures formed at the end of these two events.

Ans. **Table 2.2: Differences between microsporogenesis and megasporogenesis**

S. No.	Microsporogenesis	Megasporogenesis
(*i*)	In this process, haploid microspores are formed from diploid microspore mother cell or pollen mother cell (MMC or PMC).	In this process, haploid megaspores are formed from diploid megaspore mother cell (MMC).
(*ii*)	It occurs inside the microsporangia or pollen sac of an anther.	It occurs inside the nucellus of ovule or megasporangium.
(*iii*)	There are many microspore mother cells in a microsporangium.	There is generally a single megaspore mother cell in a megasporangium.
(*iv*)	The four microspores formed from a single microspore mother cell are generally arranged in a tetrahedral structure.	The four megaspores formed from a megaspore mother cell are arranged in the form of a linear tetrad.
(*v*)	All the four microspores arranged in a tetrahedral tetrad are functional.	Only one megaspore remain functional while the other three degenerates.
(*vi*)	The microspores give rise to male gametophyte.	The functional megaspore gives rise to female gametophyte.

Meiosis occurs during micro- and megasporogenesis. Microspores (pollen grains) are formed at the end of microsporogenesis and female gametophyte (embryo sac) are formed at the end of megasporogenesis.

Q. 3. Arrange the following terms in the correct developmental sequence: pollen grain, sporogenous tissue, microspore tetrad, pollen mother cell, male gametes.

Ans. Sporogenous tissue ⟶ Pollen mother cell ⟶ Microspore tetrad ⟶ Pollen grain ⟶ Male gametes.

Q. 4. With a neat, labelled diagram, describe the parts of a typical angiosperm ovule.

Ans. For diagram, refer to Fig. 2.7.

Refer to Basic Concepts Point 3 (Structure of Megasporangium).

Q. 5. What is meant by monosporic development of a female gametophyte?

Ans. Out of the four megaspores, three degenerate and only one remains functional which develops into a female gametophyte or embryo sac. This is called monosporic development, *i.e.*, when embryo sac develops from one single megaspore it is called monosporic embryo sac.

Q. 6. With a neat diagram and explain the 7-celled, 8-nucleate nature of the female gametophyte.

[CBSE Delhi 2017]

Ans. Female gametophyte or embryo sac is a small oval structure that contains a 3-celled egg apparatus, 3 antipodal cells and one binucleate central cell hence, it is 7-celled and 8-nucleate structure.

(*i*) Egg apparatus: It consists of two synergids and an egg cell towards the micropylar end. The cells of egg apparatus are uninucleate. Synergids towards its micropylar end have cellular thickenings called filiform apparatus that helps in guiding pollen tube into the synergids.

(*ii*) Antipodal cells: Chalazal end of embryo sac contain three cells of various shapes and sizes called antipodal cells.

(*iii*) Central cell: It is the single and largest cell which is bounded by a membrane of embryo sac. It contains two polar nuclei which later fuse to form diploid secondary nucleus. After fertilisation the central cell gets converted into triploid primary endosperm cell (PEC) which forms endosperm.

For diagram, refer to Fig. 2.8(*c*).

Q. 7. What are chasmogamous flowers? Can cross-pollination occur in cleistogamous flowers? Give reasons for your answer.

Ans. Chasmogamous flowers are open flowers with exposed stamens and stigma which facilitate cross-pollination.

No cross-pollination occurs in cleistogamous flowers as these flowers are closed and never open and thus no transfer of pollen from outside to stigma of the flower is possible.

Q. 8. Mention two strategies evolved to prevent self-pollination in flowers.

Ans. The two strategies evolved to prevent self-pollination in flowers are:

(*i*) Maturation of anthers and stigma at different time periods in a bisexual flower prevents self-pollination (dichogamy).

(*ii*) Production of unisexual flowers.

Q. 9. What is self-incompatibility? Why does self-pollination not lead to seed formation in self-incompatible species?

Ans. Self-incompatibility or self sterility is the inability of an intersexual or bisexual plant to produce viable seeds on self-pollination, in spite of producing functional male and female gametes. Since, fertilisation does not take place, no seeds are produced. It is a genetic mechanism that prevents self pollen from fertilizing ovules by inhibiting pollen tube growth in pistil.

Q. 10. What is bagging technique? How is it useful in a plant breeding programme?

Ans. It is the covering of female plant with butter paper germ to avoid their contamination from foreign pollens during breeding programme.

Q. 11. What is triple fusion? Where and how does it take place? Name the nuclei involved in triple fusion.

Ans. Triple fusion is fusion of one male gamete and two polar nuclei (or secondary nucleus; if the two have already fused) in the central cell of embryo sac to form primary endosperm nucleus.

It takes place in the central cell of an embryo sac. Three nuclei are involved in triple fusion, *i.e.*, one male nucleus and two polar nuclei in the central cell.

Q. 12. Why do you think the zygote is dormant for sometime in a fertilised ovule?

Ans. The zygote is dormant for sometime in a fertilised ovule because the embryo which is developed from zygote may obtain nutrition from endosperm.

Q. 13. Differentiate between:

(*a*) hypocotyl and epicotyl **(*b*) coleoptile and coleorhiza**

(*c*) integument and testa **(*d*) perisperm and pericarp.**

Ans. (*a*)

Table 2.3: Differences between hypocotyl and epicotyl

S. No.	Hypocotyl	Epicotyl
(*i*)	The region of the embryonal axis that lies between the radicle and the point of attachment of cotyledons is called hypocotyl.	The region of the embryonal axis that lies between the plumule and cotyledons is called epicotyl.
(*ii*)	Hypocotyl pushes the seed above the soil in epigeal germination.	Epicotyl pushes the plumule above the soil in hypogeal germination.
(*iii*)	It is an important component of embryonic root system.	It is an important component of embryonic shoot system.

(*b*)

Table 2.4: Differences between coleoptile and coleorhiza

S. No.	Coleoptile	Coleorhiza
(*i*)	The shoot apex and few leaf primordia are enclosed in a hollow foliar structure in epicotyl region in monocots and is called coleoptile.	The radicle and root cap are situated at the lower end of embryonal axis are enclosed by undifferentiated sheath called coleorhiza.
(*ii*)	It comes out of the soil.	It remains inside the soil.
(*iii*)	It emerges from the soil, turns green and carries out photosynthesis.	It remains in the soil and is non-green in colour.

(*c*) **Table 2.5: Differences between integument and testa**

S. No.	Integument	Testa
(*i*)	It is the protective covering of the ovule (nucellus).	It is the protective covering of the seed.
(*ii*)	It is thin and living.	It is thick and dead.
(*iii*)	It is part of pre-fertilisation.	It is part of post-fertilisation.

(*d*) **Table 2.6: Differences between perisperm and pericarp**

S. No.	Perisperm	Pericarp
(*i*)	It represents persistent remains of nucellus (of ovule) in the seed.	It represents the wall of fruit formed by the ovarian wall.
(*ii*)	It is a part that belongs to seed.	It is a part that belongs to fruit.
(*iii*)	It is usually dry.	It can be dry or fleshy.

Q. 14. Why is apple called a false fruit? Which part(s) of the flower forms the fruit?

Ans. False fruits are those fruits in which accessory floral parts also contribute to fruit formation. In apple, the thalamus also contributes to fruit formation. Therefore, it is called a false fruit. The fruit develops from the ovary of the flower.

Q. 15. What is meant by emasculation? When and why does a plant breeder employ this technique?

Ans. Emasculation is a practice of removal of stamens/anthers before the anther dehisces from bisexual flowers in female parent. A plant breeder employs this technique in the bud condition before the anthers begin to differentiate. It is required to prevent self-pollination.

Uses in plant breeding:

(*i*) Prevention of contamination and pollination of stigma of female flowers with foreign undesirable pollens.

(*ii*) Prevention of damage by animals.

Q. 16. If one can induce parthenocarpy through the application of growth substances, which fruits would you select to induce parthenocarpy and why?

Ans. Only fleshy fruits like orange, watermelon, lemon, etc., should be selected as parthenocarpic fruits. Here seeds of fruits are irritant during consumption so seeds are removed so as to make the fruits even more valuable. It is easy to make fruit juices, jams, etc. with seedless fruits.

Q. 17. Explain the role of tapetum in the formation of pollen grain wall.

Ans. Tapetum is the innermost wall layer of a microsporangium. It nourishes the developing pollen grains and also help in the formation of wall of pollen grains. The cells of tapetum secrete Ubisch granules that provide sporopollenin and other materials for exine formation.

Q. 18. What is apomixis and what is its importance?

Ans. Apomixis is a type of asexual reproduction that mimics sexual reproduction to form seeds without fertilisation.

In apomictic seeds, parental characters are maintained in the progeny/offspring as there is no meiosis or segregation of characters.

If desired hybrid seeds are made apomictics the farmers can keep on using the hybrid seeds to raise new crops year after year.

Multiple Choice Questions [1mark]

Choose and write the correct option in the following questions.

1. In a cereal grain, the single cotyledon of embryo is represented by

(*a*) coleoptile (*b*) coleorhiza

(*c*) scutellum (*d*) hypocotyl

2. **In a typical complete, bisexual and hypogynous flower the arrangement of floral whorls on the thalamus from the outermost to the innermost is** [*NCERT Exemplar*]

(*a*) calyx, corolla, androecium and gynoecium (*b*) calyx, corolla, gynoecium and androecium

(*c*) gynoecium, androecium, corolla and calyx (*d*) androecium, gynoecium, corolla and calyx

3. **A dicotyledonous plant bears flowers but never produces fruits and seeds. The most probable cause for the above situation is** [*NCERT Exemplar*]

(*a*) plant is dioecious and bears only pistillate flowers

(*b*) plant is dioecious and bears both pistillate and staminate flowers

(*c*) plant is monoecious

(*d*) plant is dioecious and bears only staminate flowers.

4. **In angiosperms, male gametes are formed by the division of**

(*a*) microspore mother cell (*b*) microspore

(*c*) generative cell (*d*) vegetative cell

5. **During microsporogenesis, meiosis occurs in** [*NCERT Exemplar*]

(*a*) endothecium (*b*) microspore mother cells

(*c*) microspore tetrads (*d*) pollen grains.

6. **From among the sets of terms given below, identify those that are associated with the gynoecium.** [*NCERT Exemplar*]

(*a*) Stigma, ovule, embryo sac, placenta (*b*) Thalamus, pistil, style, ovule

(*c*) Ovule, ovary, embryo sac, tapetum (*d*) Ovule, stamen, ovary, embryo sac

7. **Starting from the innermost part, the correct sequence of parts in an ovule are** [*NCERT Exemplar*]

(*a*) egg, nucellus, embryo sac, integument (*b*) egg, embryo sac, nucellus, integument

(*c*) embryo sac, nucellus, integument, egg (*d*) egg, integument, embryo sac, nucellus

8. **From the statements given below choose the option that are true for a typical female gametophyte of a flowering plant.** [*NCERT Exemplar*]

(*i*) It is 8-nucleate and 7-celled at maturity

(*ii*) It is free-nuclear during the development

(*iii*) It is situated inside the integument but outside the nucellus

(*iv*) It has an egg apparatus situated at the chalazal end

(*a*) (*i*) and (*iv*) (*b*) (*ii*) and (*iii*) (*c*) (*i*) and (*ii*) (*d*) (*ii*) and (*iv*)

9. **Autogamy can occur in a chasmogamous flower if** [*NCERT Exemplar*]

(*a*) pollen matures before maturity of ovule

(*b*) ovules mature before maturity of pollen

(*c*) both pollen and ovules mature simultaneously

(*d*) both anther and stigma are of equal lengths.

10. **Dioecy states**

(*a*) unisexuality of a flower (*b*) bisexuality of a flower

(*c*) bisexuality of a plant (*d*) unisexuality of a plant

11. **Choose the correct statement from the following.** [*NCERT Exemplar*]

(*a*) Cleistogamous flowers always exhibit autogamy

(*b*) Chasmogamous flowers always exhibit geitonogamy

(*c*) Cleistogamous flowers exhibit both autogamy and geitonogamy

(*d*) Chasmogamous flowers never exhibit autogamy

12. **Which of the following structures are haploid in nature?**

(*a*) nucellus and antipodals (*b*) Microspore and antipodals

(*c*) Egg cell and antipodals (*d*) Egg and central cell

13. Filiform apparatus performs the function of

(*a*) opening the pollen tube (*b*) guiding the pollen tube to egg

(*c*) entry of pollen tube into synergids (*d*) prevents growth of more than one pollen tube

14. Unisexuality of flowers prevent

(*a*) geitonogamy (*b*) autogamy

(*c*) xenogamy (*d*) both geitonogamy and xenogamy

15. A particular species of plant produces light, non-sticky pollen in large numbers and its stigmas are long and feathery. These modifications facilitate pollination by [*NCERT Exemplar*]

(*a*) insects (*b*) water

(*c*) wind (*d*) animals.

16. From among the situations given below, choose the one that prevents both autogamy and geitonogamy. [*NCERT Exemplar*]

(*a*) Monoecious plant bearing unisexual flowers

(*b*) Dioecious plant bearing only male or female flowers

(*c*) Monoecious plant with bisexual flowers

(*d*) Dioecious plant with bisexual flowers

17. In a fertilised embryo sac, the haploid, diploid and triploid structures are [*NCERT Exemplar*]

(*a*) synergid, zygote and primary endosperm nucleus

(*b*) synergid, antipodal and polar nuclei

(*c*) antipodal, synergid and primary endosperm nucleus

(*d*) synergid, polar nuclei and zygote.

18. In an embryo sac, the cells that degenerate after fertilisation are [*NCERT Exemplar*]

(*a*) synergids and primary endosperm cell (*b*) synergids and antipodals

(*c*) antipodals and primary endosperm cell (*d*) egg and antipodals.

19. Transfer of pollen grains from the anther to the stigma of another flower of same plant is called

(*a*) geitonogamy (*b*) autogamy (*c*) xenogamy (*d*) cross-pollination

20. While planning for an artificial hybridisation programme involving dioecious plants, which of the following steps would not be relevant? [*NCERT Exemplar*]

(*a*) Bagging of female flower (*b*) Dusting of pollen on stigma

(*c*) Emasculation (*d*) Collection of pollen

21. In angiosperms, a functional megaspore develops into

(*a*) embryo sac (*b*) endosperm (*c*) ovule (*d*) pollen grain

22. Scutellum is

(*a*) grass embryo (*b*) grass seed (*c*) grass fruit (*d*) grass cotyledon

23. In the embryos of a typical dicot and a grass, true homologous structures are [*NCERT Exemplar*]

(*a*) coleorhiza and coleoptile (*b*) coleoptile and scutellum

(*c*) cotyledons and scutellum (*d*) hypocotyl and radicle.

24. The phenomenon observed in some plants wherein parts of the sexual apparatus is used for forming embryos without fertilisation is called [*NCERT Exemplar*]

(*a*) parthenocarpy (*b*) apomixis

(*c*) vegetative propagation (*d*) sexual reproduction.

25. In a flower, if the megaspore mother cell forms megaspores without undergoing meiosis and if one of the megaspores develops into an embryo sac, its nuclei would be [*NCERT Exemplar*]

(*a*) haploid (*b*) diploid

(*c*) a few haploid and a few diploid (*d*) with varying ploidy.

26. Function of germ pore is

(*a*) emergence of radicle (*b*) absorption

(*c*) growth of pollen tube (*d*) release of male gamete

Answers

1. (*c*)	**2.** (*a*)	**3.** (*d*)	**4.** (*a*)	**5.** (*b*)	**6.** (*a*)	**7.** (*b*)	**8.** (*c*)	**9.** (*c*)	**10.** (*d*)
11. (*a*)	**12.** (*c*)	**13.** (*b*)	**14.** (*b*)	**15.** (*c*)	**16.** (*b*)	**17.** (*c*)	**18.** (*b*)	**19.** (*a*)	**20.** (*c*)
21. (*a*)	**22.** (*d*)	**23.** (*c*)	**24.** (*b*)	**25.** (*b*)	**26.** (*c*)				

Assertion-Reason Questions

In the following questions a statement of assertion followed by a statement of reason is given. Choose the correct answer out of the following choices.

(a) Assertion and reason both are correct statements and reason is correct explanation for assertion.

(b) Assertion and reason both are correct statements but reason is not correct explanation for assertion.

(c) Assertion is correct statement but reason is wrong statement.

(d) Assertion is wrong statement but reason is correct statement.

1. Assertion : The endosperm of angiosperms is generally triploid (3*n*).
Reason : It develops from primary endosperm nucleus formed by fusion of haploid male gamete and diploid secondary nucleus.

2. Assertion : Dictogamy refers to maturation of male and female sex organs at different times.
Reason : This is a safeguard against cross fertilisation.

3. Assertion : Megaspore mother cell undergoes meiosis to produce four megaspores.
Reason : Megaspore mother cell and megaspores are both haploid.

4. Assertion : Entomophilous plants produce less pollen when compared to anemophilous plants.
Reason : The wastage of pollen is reduced to the minimum in entomophilous plants because of the directional pollination.

5. Assertion : A structure of a typical microsporangium in angiosperms consists of four wall layers—epidermis, endothecium, middle layers and tapetum.
Reason : The function of outer three wall layers is protection and also help in dehiscence of anther to release pollen.

6. Assertion : A pollen grains can withstand harsh conditions.
Reason : The exine of pollen grains is made up of sporopollenin which is resistant to high temperatures, strong acids or alkali as well as enzymatic degradation.

7. Assertion : In plants, apomixis is a type of asexual reproduction that mimics sexual reproduction.
Reason : In apomixis seeds are produced without the fusion of gametes.

8. Assertion : In coconut, the water represents the free nuclear endosperm and the white kernel represents the cellular endosperm.
Reason : PEN undergoes a number of free nuclear divisions which are followed by wall formation.

9. Assertion : In monosporic type of embryo development megaspore is situated towards the micropylar end and remains functional.
Reason : In monosporic development the embryo sac develops from a single functional megaspore.

10. Assertion : Microspore is the first cell of male gametophyte.
Reason : It is diploid in nature.

Answers

1. (*a*)	**2.** (*c*)	**3.** (*c*)	**4.** (*b*)	**5.** (*b*)	**6.** (*a*)	**7.** (*a*)	**8.** (*c*)	**9.** (*d*)	**10.** (*c*)

Case-based/Source-based Question

1. Study the diagram given below and answer the questions that follow:

(*i*) Identify the figure given above.

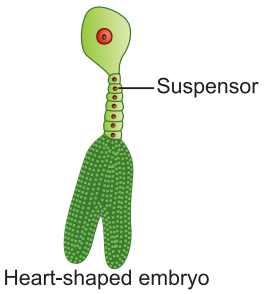
(*ii*) Name the initial cell from which this structure has developed.

(*iii*) Draw the next mature stage and label the parts.

Ans. (*i*) It is a globular embryo of a dicot plant.

(*ii*) Zygote

(*iii*)



2. Fertilisation is essential for production of seed, but in some angiosperms, seeds develop without fertilisation.

(*i*) Give an example of an angiosperm that produces seeds without fertilisation.

(*ii*) Name the process.

(*iii*) Explain the two ways by which seeds develop without fertilisation.

Ans. (*i*) In the members of family Asteraceae, seeds develop without fertilisation.

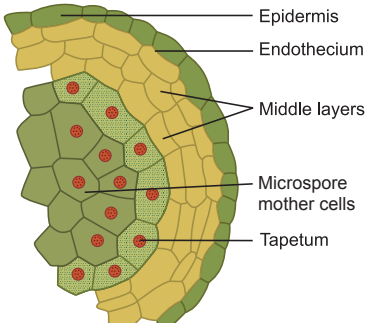
(*ii*) This process is called apomixis.

(*iii*) Two ways by which seeds develop without fertilisation are:

(*a*) In some species, the diploid (2*n*) egg cell is formed without reduction division and develops into embryo without fertilisation.

(*b*) In many varieties of Citrus and mango fruits, some of the nucellar cells surrounding the embryo sac start dividing, protrude into the embryo sac and then develop into embryos.

3. Given below is an enlarged view of one microsporangium of a mature anther.



(*i*) An anther with malfunctioning tapetum often fails to produce viable male gametophytes. Give one reason.

(*ii*) The meiocyte of rice has 24 chromosomes. How many chromosomes are present in its endosperm?

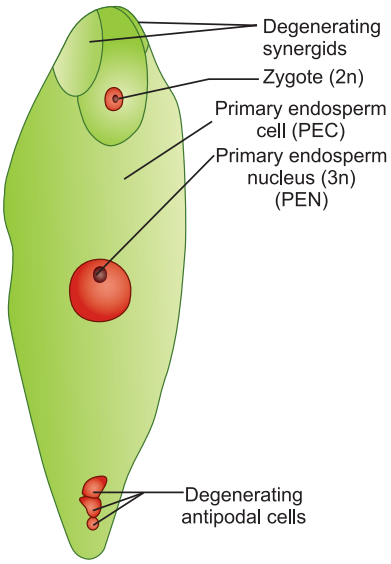
(*iii*) State the reason why pollen grains lose their viability when the tapetum in the anther is malfunctioning.

Ans. (*i*) A malfunctioning tapetum is not able to provide optimum nutrition for the production of viable male gametophytes.

(*ii*) 36 chromosomes

(*iii*) Due to malfunctioning of tapetum, the developing pollen grain do not get proper nourishment and thus lose its viability.

4. Observe the figure of fertilised embryo sac of an angiosperm and answer the questions that follow.



(*i*) In the embryos of a typical dicot and a grass, which are the true homologous structures?

(*ii*) Normally one embryo develops in one seed but when an orange seed is squeezed many embryos of different shapes and sizes are seen. Mention how it has happened.

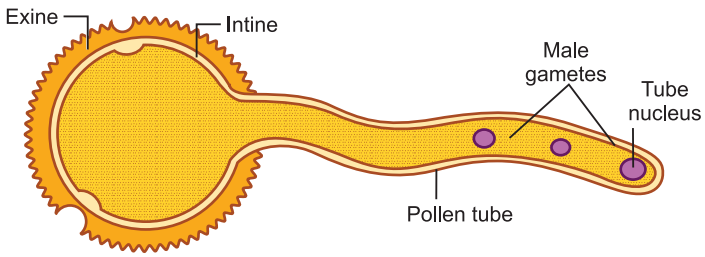
(*iii*) How many nuclei are present in a fully developed male gametophyte of flowering plants?

Ans. (*i*) Cotyledons and scutellum

(*ii*) An orange seed has many embryos because of polyembryony.

(*iii*) Three (one vegetative nucleus and two male nuclei)

5. Observe the diagram of pollen grain with germ tube and two male gametes given below. Answer the questions that follow:



(*i*) How many pollen grains and ovules are likely to be formed in the anther and the ovary of an angiosperm bearing 25 microspore mother cells and 25 megaspore mother cells respectively?

(*ii*) How do the pollen grains of *Vallisneria* protect themselves?

(*iii*) If the stamens are well exposed, usually which mode of pollination the plant is expected to follow?

Ans. (*i*) 100 pollen grains and 25 ovules

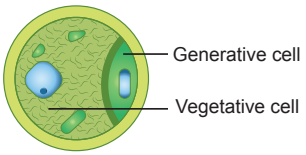
(*ii*) They have mucilaginous covering to prevent them from getting wet.

(*iii*) Wind-pollination

Very Short Answer Questions [1 mark]

Q. 1. Draw a diagram of a matured microspore of an angiosperm. Label its cellular components only. **[*CBSE (F) 2014*]**

Ans.



Q. 2. Give an example of a plant which came into India as a contaminant and is a cause of pollen allergy. **[*CBSE (AI) 2014*]**

Ans. *Parthenium* or Carrot grass.

Q. 3. The microscopic pollen grains of the past are obtained as fossils. Mention the characteristic of the pollen grains that makes it happen.

Ans. The exine of pollen grains have an outermost hard layer composed of a chemical, sporopollenin. It is highly resistant to high temperature, strong acids and alkali. So, pollen grains are obtained as fossils.

Q. 4. State the function of filiform apparatus found in mature embryo sac of an angiosperm. **[*CBSE (F) 2014*]**

Ans. The filiform apparatus guides the pollen tube into the synergid.

Q. 5. What is funiculus?

Ans. Funiculus is the stalk of ovule that attaches it to the placenta.

Q. 6. How many germ pores are there in the pollen grains of monocots and dicots?

Ans. There are three germ pores in dicots and one in monocots.

Q. 7. In maximum angiosperms pollen grains are shed at the two-celled stage. Name the 2 cells.

Ans. Vegetative cell and generative cell are the two-celled stage in which pollen grains are shed.

Q. 8. Name the component cells of the 'egg apparatus' in an embryo sac. **[*NCERT Exemplar*]**

Ans. Two synergids and an egg.

Q. 9. Why do pollen grains of some flowers trigger 'sneezing' in some people? **[*CBSE (F) 2012*]**

Ans. They result in an allergic reaction.

Q. 10. Name the tissue present in the fertilised ovules of angiospermic plants that supplies food and nourishment to the developing embryo.

Ans. Endosperm

Q. 11. How many cells are found in a typical embryo sac?

Ans. There are seven cells in a typical embryo sac. These are one egg cell, two synergids, three antipodal cells and a central cell.

Q. 12. What is an anatropous ovule?

Ans. It is an ovule that is completely inverted through 180° such that the micropyle comes close to the base of the funiculus and nucellus remains straight.

Q. 13. *Papaver* and *Michelia* both have multicarpellary ovaries. How do they differ from each other? **[*CBSE (F) 2012*]**

Ans. *Papaver* has syncarpous gynoecium whereas *Michelia* has apocarpous gynoecium.

Q. 14. An anther with malfunctioning tapetum often fails to produce viable male gametophytes. Give any one reason. [*CBSE Delhi 2013*]

Ans. A malfunctioning tapetum does not provide enough nourishment to the developing male gametophytes and thus fail to produce viable male gametophytes.

Q. 15. How is it possible in *Oxalis* and *Viola* plants to produce assured seed-sets even in the absence of pollinators? [*CBSE (F) 2012*]

Ans. By presence of cleistogamous flowers.

Q. 16. A bilobed, dithecous anther has 100 microspore mother cells per microsporangium. How many male gametophytes this anther can produce? [*CBSE Delhi 2010*]

Ans. The bilobed anther can produce 1600 male gametophytes.

Q. 17. The diploid number of chromosomes in an angiospermic plant is 16. What will be the number of chromosomes in its endosperm and antipodal cells? [*CBSE 2019 (57/5/1)*]

Ans. Endosperm—24 chromosomes, Antipodals—8 chromosomes.

Q. 18. How do flowers of *Vallisneria* get pollinated? [*CBSE (F) 2013*]

Ans. In *Vallisneria*, the female flower stalk is long to reach the water surface to receive the pollen grains carried by water currents and then it gets coiled after pollination.

Q. 19. How many microspore mother cells would be required to produce one hundred pollen grains in a pollen sac? And why? [*CBSE (F) 2013*]

Ans. 1 microspore mother cell undergoes meiosis to form 4 pollen grains. In order to produce 100 pollen grains, 25 microspore mother cells must undergo meiosis.

Q. 20. What is pollen–pistil interaction and how is it mediated? [*CBSE (F) 2014*]

Ans. The ability of the pistil to recognise the pollen followed by its acceptance or rejection is called pollen–pistil interaction. It is mediated by chemical components of pollen interacting with those of pistil.

Q. 21. How many microsporangia are present in a typical anther of an angiosperm? [*CBSE (F) 2013*]

Ans. Four

Q. 22. Pea flowers produce assured seed sets. Give a reason. [*CBSE (AI) 2010*]

Ans. Pea flowers are cleistogamous, *i.e.*, anther and stigma lie close to each other in closed flowers. So when anthers dehisce in the flower buds, pollen grains come in contact with the stigma to effect pollination. Thus, assured seeds are produced in pea.

Q. 23. Name the part of the flower which the tassels of the corn-cob represent. [*CBSE (AI) 2014*]

Ans. Style and stigma

Q. 24. Write the function of coleoptile. [*CBSE Delhi 2012*]

Ans. It protects the plumule of the monocot embryo.

Q. 25. Write the function of scutellum. [*CBSE Delhi 2012*]

Ans. It provides nourishment and protection to the developing embryo.

Q. 26. Name the part of gynoecium that determines the compatible nature of pollen grain. [*NCERT Exemplar*]

Ans. Stigma

Q. 27. Who discovered double fertilisation in angiosperms?

Ans. S. G. Nawaschin (1897) discovered double fertilisation in angiosperms.

Q. 28. Name a plant in which dichogamy is found.

Ans. *Magnolia*

Q. 29. What is nucellus?

Ans. The body of the ovule consists of a mass of parenchymatous cells rich in reserve food material which is called nucellus.

Q. 30. Name the common function that cotyledons and nucellus perform. [*NCERT Exemplar*]

Ans. Cotyledons and nucellus provide nourishment.

Q. 31. Which are the three cells found in a pollen grain when it is shed at the three-celled stage? [*NCERT Exemplar*]

Ans. One vegetative cell and two male gametes.

Q. 32. What features of flowers facilitate pollination by birds?

Ans. Presence of a large quantity of nectar, bright colours of petal, fragrance and large flowers attract birds from long distances.

Q. 33. Name the type of pollination in self-incompatible plants. [*NCERT Exemplar*]

Ans. Xenogamy.

Q. 34. Mention any two characteristics of pollen grains of plants such as maize and *Cannabis*.

Ans. (*i*) Pollen grains are small, dry and light in weight, non-sticky.

(*ii*) Pollen are produced in large numbers.

Q. 35. Define parthenocarpy.

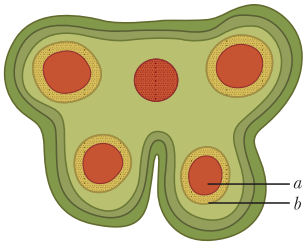
Ans. Parthenocarpy is an economically important process in which seedless fruit is formed without fertilisation, for example, banana.

Q. 36. In a case of polyembryony, if an embryo develops from the synergid and another from the nucellus, which is haploid and which is diploid? [*NCERT Exemplar*]

Ans. Synergid embryo is haploid and nucellar embryo is diploid.

Short Answer Questions [2 marks]

Q. 1. In the T.S. of a mature anther given below, identify "*a*" and "*b*" and mention their function.



Ans. ***a*—Sporogenous tissue:** It forms pollen grains.

***b*—Tapetum:** It provides nourishment to the developing pollen grains.

Q. 2. In a flowering plant a microspore mother cell produce four male gametophytes while a megaspore mother cell form only one female gametophyte. Explain. [*CBSE Delhi 2017*]

Ans. Male gametophytes are formed by meiosis of single microspore mother cell whereas female gametophytes are formed by meiosis of single megaspore mother cell to produce 4 megaspores, out of which 3 degenerate and only one survives. The surviving megaspore undergoes mitotic division to form the female gametophyte.

Q. 3. Name the organic materials the exine and intine of an angiosperm pollen grains are made up of. Explain the role of exine. [*CBSE Delhi 2014*]

Ans. Exine is made up of sporopollenin and intine is made up of cellulose and pectin. Exine is the most resistant organic material and can withstand high temperature, acidic and alkali environment.

Q. 4. Differentiate between the two cells enclosed in a mature male gametophyte of an angiosperm. [*CBSE (AI) 2013*]

Ans. **Table 2.7: Differences between vegetative and generative cell of pollen grain**

S.No.	Vegetative cell	Generative cell
(*i*)	It is bigger in size.	It is smaller and floats in the cytoplasm of vegetative cell.
(*ii*)	It has food reserves.	It gives rise to two male gametes.

Q. 5. "Pollen grains in wheat are shed at 3-celled stage while in peas they are shed at 2-celled stage." Explain. Where are germ pores present in a pollen grain? ***[CBSE (AI) 2017]***

Ans. At the time of shedding wheat pollen consists of one vegetative and two male gametes, which is the 3-celled stage. While pea pollen consists of one vegetative and one generative cell which is the 2-celled stage. Germ pores are present on the exine where sporpollenin is absent.

Q. 6. Gynoecium of a flower may be apocarpous or syncarpous. Explain with the help of an example each. ***[CBSE (AI) 2016]***

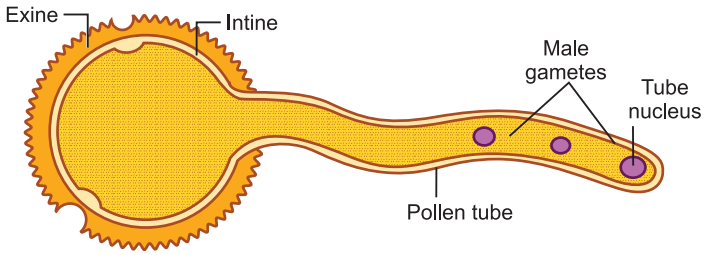
Ans. The gynoecium represents the female reproductive part of the flower. When there are more than one pistil, if the pistils are fused together, the flower is said to be syncarpous and if the pistils are free, it is said to be apocarpous. For example, pistil of *Papaver* is syncarpous and that of *Michelia* is apocarpous.

Q. 7. Name all the haploid cells present in an unfertilised mature embryo sac of a flowering plant. Write the total number of cells in it. ***[CBSE (AI) 2013]***

Ans. The haploid cells in an unfertilised mature embryo sac are: egg cell, synergids, antipodals and central cell. There are 7 cells in total.

Q. 8. Draw a diagram of pollen grain with germ tube and two male gametes.

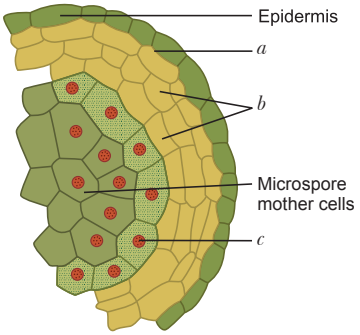
Ans.



Q. 9. Why does the zygote begin to divide only after the division of primary endosperm cell? ***[NCERT Exemplar]***

Ans. The zygote needs nourishment during its development. As the mature, fertilised embryo sac offers very little nourishment to the zygote, the primary endosperm cell (PEC) divides and generates the endosperm tissue which nourishes the zygote. Hence, the zygote always divides after division of PEC.

Q. 10. Given alongside is an enlarged view of one microsporangium of a mature anther.



(*i*) Name '*a*', '*b*' and '*c*' wall layers.

(*ii*) Mention the characteristics and function of the cells forming wall layer '*c*'.

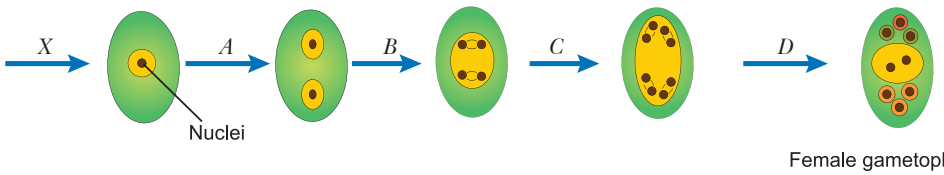
Ans. (*i*) *a* = Endothecium, *b* = Middle layers, *c* = Tapetum

(*ii*) Tapetum provides nourishment to the developing pollen grains. The tapetal cells also secrete Ubisch granules that provide sporopollenin and other materials for exine formation.

Q. 11. Which is the triploid tissue in a fertilised ovule? How is the triploid condition achieved? ***[NCERT Exemplar]***

Ans. The triploid tissue in the ovule is the endosperm. Its triploid condition is achieved by the fusion of two polar nuclei and one nucleus of male gamete, referred to as triple fusion.

Q. 12. Fill in the following labels with the type of cell function.



Ans. *X*—Meiosis (Reduction division); *A*—Mitosis; *B*—Mitosis; *C*—Mitosis; *D*—Cells reorganised as polar nuclei, antipodals and egg apparatus.

Q. 13. Mention the ploidy of the different types of cells present in the female gametophyte of an angiosperm. ***[CBSE Delhi 2017]***

Ans.

Table 2.8: Ploidy of cells in female gametophyte

Cells in female gametophyte	Their ploidy
1. Synergids	Haploid
2. Egg	Haploid
3. Polar nuclei	Haploid
4. Antipodals	Haploid
5. Central cell	2 haploid nuclei

Q. 14. Write briefly the role of pollination in the growth and development in an angiosperm.

Ans. Pollination is transfer of pollen grains from anthers to the stigma of a flower. Pollination is prerequisite for fertilisation, events after fertilisation like endosperm development, seed setting and fruit formation. Thus, pollination plays an important role in the growth and development of angiosperms.

Q. 15. Explain any two devices by which autogamy is prevented in flowering plants.

Ans. (*i*) Male and female flowers are present on different plants.

(*ii*) The stamens and stigma of a bisexual flower mature at different times.

(*a*) Anthers mature earlier than the stigma and release pollens.

(*b*) The stigma matures earlier than the anther.

(*iii*) Flowers are self-sterile or self-incompatible.

(*iv*) Chasmogamous flowers are present with exposed stamens and stigma which facilitate cross-pollination. (*Any two*)

Q. 16. What is cleistogamy? Write one advantage and one disadvantage of it, to the plant. ***[CBSE 2019 (57/4/1)]***

Ans. Pollination occurring in closed flowers is referred to as cleistogamy.

Advantage: It ensures self-pollination and assured seed set formation in absence of pollinators.

Disadvantage: It does not allow cross-pollination. This can cause inbreeding depression as there will be no genetic variation.

Q. 17. (*a*) List any two characteristic features of wheat flowers that make it a good example of wind pollination.

(*b*) It is observed that plant breeders carrying out wheat hybridisation often take pollen grains from the 'pollen banks'. Do you agree ? Give one reason in support of your answer. ***[CBSE 2019 (57/3/1)]***

Ans. (*a*) Light pollen grains/Pollen grains more in number/well exposed stamen/feathery and sticky stigma/Numerous flowers are packed into an inflorescence. (*Any two*)

(*b*) Yes.

Viability of wheat pollen grain is only 30 minutes and so it is stored in pollen bank for a long period of time for later use.

Q. 18. List the two steps that are essential for carrying out artificial hybridisation in crop plants and why. ***[CBSE (F) 2014]***

Ans. **(*a*) Selection of parents:** Only those plants should be selected which have desired traits.

Emasculation: Removal of anthers from flower before they are mature and dehisce.

(*b*) Crossing over: Pollen grains from selected male plant is collected and transferred to the female plant after which it is bagged.

Q. 19. Explain the steps that ensure cross pollination in an autogamous flower. ***[CBSE Delhi 2013]***

Ans. A bisexual flower is emasculated at unopened stage to prevent self-pollination in the flower and it is bagged after emasculation to prevent contact of unwanted pollen grain with the stigma of

the flower. Artificial pollination is then performed when the stigma is ready and the flower is rebagged.

Q. 20. Geitonogamous flowering plants are genetically autogamous but functionally cross-pollinated. Justify. Give similarity of geitonogamy with autogamy and xenogamy. ***[CBSE Delhi 2013]***

Ans. Geitonogamous flowers are genetically autogamous because both male and female flowers are borne on the same plant. They are functionally cross-pollinated because the pollen from one flower is transferred to the stigma of a different flower.

Q. 21. How does the Mediterranean orchid *Ophrys* ensures its pollination by bees? ***[CBSE Delhi 2010]***

Ans. The petals of the *Ophrys* resemble the female of a bee species in size, colour and odour. Male bee mistakes the *Ophrys* for female bee and tries to copulate. Few pollen grains adhered to the body of the male bee fall over stigma of the flower thereby leading to pollination showing sexual deceit.

Q. 22. Why should a bisexual flower be emasculated and bagged prior to artificial pollination? ***[CBSE (F) 2010]***

Ans. A bisexual flower is emasculated to prevent self-pollination in the flower and it is bagged after emasculation to prevent contact of unwanted pollen grain with the stigma of the flower.

Q. 23. Write the cellular contents carried by the pollen tube. How does the pollen tube gain its entry into the embryo sac? ***[CBSE (F) 2012]***

Ans. Pollen tube carries two male gametes.

Pollen tube, after reaching the ovary, enters the ovule through the micropyle and then enters one of the synergids through the filiform apparatus which guides the entry of pollen tube into egg cell.

Q. 24. A pollen grain in angiosperm at the time of dehiscence from an anther could be 2-celled or 3-celled. Explain. How are the cells placed within the pollen grain when shed at a 2-celled stage? ***[CBSE (AI) 2017]***

Ans. In 2-celled stage the mature pollen grain contains one generative and vegetative cells, whereas in 3-celled stage one vegetative cell and two male gamete cells are present.

The generative cell being small floats in the cytoplasm of the vegetative cell. The pollen grains are shed at this 2-celled stage.

Q. 25. State one advantage and one disadvantage of cleistogamy. ***[CBSE (AI) 2012]***

Ans. **Advantage:** Self-pollination is assured/Seed production is assured.

Disadvantage: Least variations observed/Leads to inbreeding depression.

Q. 26. Name the product of fertilisation that forms the kernel of coconut. How does the kernel differ from coconut water? ***[CBSE (F) 2012]***

Ans. Endosperm forms the kernel of coconut.

The coconut water is free-nuclear endosperm whereas kernel is cellular endosperm.

Q. 27. List the post-fertilisation events in angiosperms. ***[CBSE Delhi 2014]***

Ans. (*i*) Development of endosperm

(*ii*) Embryogeny/development of embryo

(*iii*) Seed formation

(*iv*) Fruit formation

Q. 28. Mention the function of each of the following:

(*a*) Tassels of corn cob.

(*b*) Tapetum in the microsporangium. ***[CBSE (F) 2012]***

Ans. (*a*) These are the stigma and style which wave in the wind to trap pollen grains.

(*b*) Provides nourishment to the developing pollen grains.

Q. 29. Describe the development of endosperm after double fertilization in an angiosperm. Why does endosperm development proceeds that of zygote? ***[CBSE Delhi 2015]***

Ans. Refer to Basic Concepts Point 9 (Endosperm Development).

Cells of the endosperm provide nutrition to the developimh embryo.

Q. 30. Draw a vertical section of a maize grain and label (*i*) pericarp, (*ii*) scutellum, (*iii*) coleoptile and (*iv*) radicle. ***[CBSE 2019 (57/5/1)]***

Ans. Refer to Fig. 2.15(*d*).

Q. 31. Explain the function of each of the following:

(*a*) Coleorhiza

(*b*) Germ pores ***[CBSE (AI) 2012]***

Ans. (*a*) Coleorhiza protects the radical of (monocot) embryo.

(*b*) Germ pores allow germination of pollen grain and formation of pollen tubes.

Q. 32. Differentiate between albuminous and non-albuminous seeds, giving one example of each. ***[CBSE Delhi 2011]***

Ans. Albuminous seeds have residual endosperm in them. For example, maize.

Non-albuminous seeds do not have any residual endosperm. For example, pea.

Q. 33. Mention the reasons for difference in ploidy of zygote and primary endosperm nucleus in an angiosperm. ***[CBSE Delhi 2010]***

OR

In angiosperms, zygote is diploid while primary endosperm cell is triploid. Explain. ***[CBSE (AI) 2013]***

Ans. A zygote is formed by the fusion of haploid male gamete with the haploid egg to form a diploid cell; whereas, primary endosperm nucleus (PEN) is formed by the fusion of haploid male gamete with two haploid polar nuclei, forming a triploid nucleus.

Q. 34. Some angiosperm seeds are said to be 'albuminous', whereas few others are said to have a perisperm. Explain each with the help of an example. ***[CBSE (F) 2014]***

Ans. Albuminous seeds are those which retain a part of endosperm as it is not completely used up during embryo development. For example, in wheat and maize. In some seeds remnants of nucellus are also persistent. This residual, persistent nucleus is the perisperm. For example, in black pepper and beet.

Q. 35. Double fertilisation is reported in plants of both, castor and groundnut. However, the mature seeds of groundnut are non-albuminous and castor are albuminous. Explain the post-fertilisation events that are responsible for it. ***[CBSE Delhi 2015]***

Ans. The development of endosperm (preceding the embryo) takes place from primary endosperm nucleus (PEN) in both, castor and groundnut.

The developing embryo derives nutrition from endosperm.

PEN undergoes repeated division to give free nuclei. Subsequently cell wall is formed and endosperm becomes cellular. At this stage endosperm is retained in castor or is not fully consumed but in groundnut endosperm is consumed by growing embryo.

Q. 36. (*a*) You are given castor and bean seeds. Which one of the two would you select to observe the endosperm?

(*b*) The development of endosperm precedes that of embryo in plants. Justify. ***[CBSE 2019 (57/2/1)]***

Ans. (*a*) Castor

(*b*) Endosperm stores reserve food materials. It provides nutrition to the developing embryo, therefore its development precedes that of embryo.

Q. 37. (*a*) Mature seeds of legumes are non-albuminous. Then, can it be assumed that double fertilisation does not occur in legumes? Explain your answer.

(*b*) List the differences between the embryos of dicot (pea) and monocot (grass family). ***[CBSE (AI) 2014]***

Ans. (*a*) No it cannot be assumed so because fertilisation does takes place but the endosperm is consumed during embryo development.

(*b*) **Table 2.9: Differences between dicot and monocot embryo**

S. No.	Dicot embryo	Monocot embryo
(*i*)	It has two cotyledons.	It has one cotyledon.
(*ii*)	Radicle and plumule are not covered with sheath.	Radicle is covered with coleorhiza and plumule is covered by coleoptile.

Q. 38. Draw a sectional view of an apple and label the different parts of an ovary in it. Fruits develop from an ovary. Then why is apple referred to as a false fruit? ***[CBSE (F) 2013, 2017]***

Ans. Refer to Fig. 2.16(*a*).

In apple, the thalamus also contributes to fruit formation. Therefore, it is called a false fruit.

Q. 39. What is pericarp? Mention its functions.

Ans. The wall of the ovary that develops into wall of the fruit is called pericarp.

Functions: (*i*) Protects the seed till its maturity.

(*ii*) Helps in seed dispersal.

Q. 40. A non-biology person is quite shocked to know that apple is a false fruit, mango is a true fruit and banana is a seedless fruit. As a biology student how would you satisfy this person? ***[CBSE Delhi 2015]***

Ans. In apple only the thalamus (along with ovary) portion contributes to fruit formation. Therefore, it is a false fruit. Mango develops only from the ovary, therefore it is a true fruit.

Banana develops from ovary but without fertilisation. The method is known as parthenocarpy. Since there is no fertilisation, no seeds are formed in banana.

Q. 41. Why are some seeds referred to as apomictic seeds? Mention one advantage and one disadvantage to a farmer who uses them. ***[CBSE (AI) 2015; (F) 2015]***

Ans. Seeds that are produced without fertilisation are referred to as apomictic.

Advantage: Desired characters are retained in offspring (progeny) as there is no segregation of characters in offspring (progeny). Seed production is assured even in absence of pollinators.

Apomictic seeds are economical as they can be used to grow crops year after year.

Disadvantage: Cannot control accumulation of deleterious genetic mutation. These are usually restricted to narrow ecological niches and lack ability to adapt to changing environment.

Q. 42. Explain any two ways by which apomictic seeds get developed. ***[CBSE (F) 2013]***

Ans. Ways by which apomictic seeds develop are:

(*i*) A diploid egg is formed without reduction division which develops into embryo without fertilisation.

(*ii*) Some cells of the nucellus, which are diploid in nature, start dividing and without fertilisation develop into embryo.

Q. 43. If you squeeze a seed of orange you might observe many embryos of different sizes? How is it possible? Explain. ***[CBSE (AI) 2010, Delhi 2011]***

Ans. In orange, the nucellar cells surrounding the embryo sac start dividing, protrude into the embryo sac and develop into a number of embryos of different sizes.

Q. 44. Banana is a parthenocarpic fruit whereas oranges show polyembryony. How are they different from each other with respect to seeds?

Ans. Banana develops from an ovary without fertilisation having non-viable seeds so it is called parthenocarpic fruit. An orange contain seeds with more than one embryo thus, it shows polyembryony.

Q. 45. (*a*) How are parthenocarpic fruits produced by some plants and apomictic seeds by some others? Explain.

(*b*) When do farmers prefer using apomictic seeds? ***[CBSE (AI) 2016]***

Ans. (*a*) Parthenocarpic fruits are formed when ovary develops into fruit without fertilisation.

Apomictic seeds are formed when formation of seeds take place without fertilisation.

(*b*) To maintain hybrid characters (year after year in a desired plant) and to avoid buying hybrid seeds every year (expensive seeds) farmers prefer using apomictic seeds.

Q. 46. What is agamospermy? How is agamospermy different from parthenogenesis and parthenocarpy?

Ans. The phenomenon of asexual reproduction that mimics sexual reproduction as it forms seed without fertilisation is called agamospermy.

Parthenogenesis refers to the development of unfertilised egg into an adult individual. On the other hand, parthenocarpy is the phenomenon of formation of fruits without fertilisation of an ovary.

Long Answer Questions–I [3 marks]

Q. 1. (*a*) Name the organic material exine of the pollen grain is made up of. How is this material advantageous to pollen grain?

(*b*) Still it is observed that it does not form a continuous layer around the pollen grain. Give reason.

(*c*) How are 'pollen banks' useful? ***[CBSE (AI) 2016]***

Ans. (*a*) Sporopollenin

It is most resistant material to high temperature, strong acids on alkali and no enzymes can degrade it.

(*b*) Germs pores are present to allow pollen tube to emerge out for pollen germination.

(*c*) Pollen banks help in storing pollen grains for years for crop breeding programmes.

Q. 2. Write the functions of:

(*a*) Coleoptile (*b*) Tapetum (*c*) Scutellum ***[CBSE Delhi 2012]***

Ans. **(*a*) Coleoptile:** It protects the plumule of the monocot embryo.

(*b*) Tapetum: It provides nourishment to developing pollen.

(*c*) Scutellum: It provides nourishment and protection to the developing embryo.

Q. 3. When and where do tapetum and synergids develop in flowering plants? Mention their functions. ***[CBSE 2019 (57/2/1)]***

Ans. Tapetum develop during microsporogenesis in the microsporangium (anther). It nourishes the developing pollen grains.

Synergids develop during megasporogenesis in the megasporangium (ovule). Synergids have filiform apparatus to guide the pollen tube into it.

Q. 4. Where are the following structures present in a male gametophyte of an angiosperm? Mention the function of each one of them.

(*a*) Germ pore (*b*) Sporopollenin (*c*) Generative cell ***[CBSE 2019 (57/2/1)]***

Ans. **(*a*) Germ pore:** Exine of pollen grain. It is the site from where pollen tube emerges.

(*b*) Sporopollenin: Exine of pollen grains. It protects the pollen grains from high temperature, strong acids and alkali, enzymes and adverse conditions.

(*c*) Generative Cells: These are present in pollen grains. These give rise to two male gametes.

Q. 5. Draw the diagram of microsporangium of an angiosperm and label any four parts. State the function of its innermost wall layer. ***[CBSE Sample Paper 2015, 2017, 2018]***

Ans. Refer to Fig. 2.3(*b*).

Tapetum nourishes the developing pollen grains

Q. 6. Make a list of any three outbreeding devices that flowering plants have developed and explain how they help to encourage cross-pollination. ***[CBSE (AI) 2014]***

Ans. (*i*) Time of pollen release and stigma receptivity are different (not synchronised). This prevents self-pollination.

(*ii*) Anther and stigma are placed at different positions, so the pollens cannot come in contact with the stigma of the same flower.

(*iii*) Self-incompatibility, which is a genetic mechanism to prevent the pollen germination on the stigma of the same flower.

Q. 7. Why are angiosperm anthers called dithecous? Describe the structure of its microsporangium. ***[CBSE (AI) 2014]***

Ans. The anthers of angiosperms are called dithecous because they are bilobed and each lobe of anther has two theca.

Microsporangium is surrounded by four wall layers named as epidermis, endothecium, middle layer and tapetum. In young anther, a group of compactly arranged homogenous cells called sporogenous tissue occupies the centre of each microsporangium which produce microspores or pollen grains.

Q. 8. The generative cell of a 2-celled pollen divides in the pollen tube but not in a 3-celled pollen. Give reasons. ***[NCERT Exemplar]*** ***[HOTS]***

Ans. In a 3-celled pollen, the generative cell has already divided and formed 2 male gametes. Hence, it will not divide again in the pollen tube. As the generative cell has not divided in a 2-celled pollen, it divides in the pollen tube.

Q. 9. During an excavation assignment, scientists collected pollen grains of a plant preserved in deeper layers of soil. Analyse the properties of pollen grains which help in the fossilization. ***[CBSE Sample Paper 2016]*** ***[HOTS]***

Ans. Pollen has an outer layer called exine which is made of sporopollenin.

It is the most resistant organic material known. It can withstand high temperature, strong acids and alkali as well. No enzyme that degrades sporopollenin is so far known.

Q. 10. Draw a longitudinal section of a post-pollinated pistil showing entry of pollen tube into a mature embryo sac. Label filiform apparatus, chalazal end, hilum, antipodals, male gametes and secondary nucleus. ***[CBSE Delhi 2010; 2019 (57/4/1)]***

Ans. Refer to Fig. 2.12(*a*) and (*b*).

Q. 11. (*a*) Draw a labelled sketch of a mature 7-celled, 8-nucleate embryo-sac.
(*b*) Which one of the cell in an embryo-sac produce endosperm after double fertilisation? ***[CBSE (F) 2016]***

Ans. (*a*) Refer to Fig. 2.8(*c*)
(*b*) Central cell

Q. 12. What will be the ploidy of the cells of the nucellus, microspore mother cell, the functional megaspore and female gametophyte? ***[HOTS]***

Ans.

Nucellus	:	Diploid
Microspore mother cell	:	Diploid
The functional megaspore	:	Haploid
Female gametophyte	:	Haploid

Q. 13. Given below are the events that are observed in artificial hybridisation programme. Arrange them in the correct sequential order in which they are followed in the hybridisation programme.

(*a*) re-bagging; **(*b*) selection of parents;**
(*c*) bagging; **(*d*) dusting the pollen on stigma;**
(*e*) emasculation; **(*f*) collection of pollen from male parent.**

[NCERT Exemplar] ***[HOTS]***

Ans. (*b*); (*e*); (*c*); (*f*); (*d*); (*a*).

Q. 14. Explain the process of artificial hybridisation to get improved crop variety in (*i*) plants bearing bisexual flowers (*ii*) female parent producing unisexual flowers. ***[CBSE (AI) 2010]***

Ans. (*i*) In plants bearing bisexual flowers, the anthers are removed from the flower before they dehisce. This is called emasculation. The emasculated flowers are covered with a bag of butter paper to prevent contamination of stigma with unwanted pollen. This process is called bagging. When this stigma attains receptivity, mature pollen grains are dusted on the stigma and the flowers are rebagged to allow the fruits to develop.

(*ii*) If the female parent produces unisexual flowers, emasculation is not done. The flower buds are bagged before the flowers open. When the stigma becomes receptive, pollen is dusted on stigma and the flower is rebagged.

Q. 15. Differentiate between geitonogamy and xenogamy in plants. Which one between the two will lead to inbreeding depression and why? ***[CBSE Delhi 2011]***

Ans.

Table 2.10: Differences between geitonogamy and xenogamy

S. No.	Geitonogamy	Xenogamy
(*i*)	It is transfer of pollen grains from the anther to the stigma of another flower of same plant.	It is transfer of pollen grains from the anther to the stigma of a different plant.
(*ii*)	The pollen grains are genetically similar to the plant.	The pollen grains are genetically different from the plant.

Geitonogamy will lead to inbreeding depression because the pollen grains are genetically similar, which results in inbreeding. Continued inbreeding will thus reduce fertility and productivity.

Q. 16. Write the differences between wind-pollinated and insect-pollinated flowers. Give an example of each type. ***[CBSE (F) 2014]***

Ans.

Table 2.11: Differences between wind-pollinated and insect-pollinated flowers

S. No.	Wind-pollinated flowers	Insect-pollinated flowers
(*i*)	These produce large numbers of pollen grains.	These produce less number of pollen grains.
(*ii*)	These are dull, nectarless and scentless.	These are bright, scented and have nectar.
(*iii*)	Stamens are long and protrude above petals.	Stamens lie within the corolla tube.
(*iv*)	The pollen grains are dry, light, small and smooth. For example, ragweed.	The pollen grains are larger, heavier with appendages like hooks and barbs. For example, rose, sweet pea.

Q. 17. (*i*) Write the characteristic features of anther, pollen and stigma of wind-pollinated flowers.
(*ii*) How do flowers reward their insect pollinators? Explain. ***[CBSE (AI) 2010, 2012]***

Ans. (*i*) The characteristics of wind-pollinated flowers are:

(*a*) Pollen grains are light in weight, non-sticky, dry and winged, so that they can be easily transported.

(*b*) Well-exposed stamens for easy dispersal of pollen grains in the wind.

(*c*) The stigma is sticky, large, feathery to trap pollen grains in air.

(*d*) Numerous flower are packed together to form inflorescence.

(*d*) The flowers are small and inconspicuous.

(*ii*) Insect pollinators are rewarded in following ways:

(*a*) The flowers offer floral reward like nectar and pollen grain.

(*b*) In some species floral reward provides safe place to lay eggs.

Q. 18. (*a*) Mention any four strategies adopted by flowering plants to prevent self-pollination.
(*b*) Why is geitonogamy also referred to as genetical autogamy? ***[CBSE (AI) 2010]***

Ans. (*a*) Refer to Basic Concepts Point 5 [Contrivances for self-pollination (Autogamy)].

(*b*) Geitonogamy is the transfer of pollen grains from the anther to the stigma of another flower of the same plant. Although geitonogamy is functionally cross-pollination involving a pollinating agent, genetically it is similar to autogamy, since the pollen grains come from the same plant.

Q. 19. State the significance of pollination. List any four differences between wind-pollinated and animal pollinated flowers.

Ans. Pollination is the phenomena of transfer of pollen grains from anthers to the stigma of a pistil. Pollination is prerequisite for the beginning of fertilisation.

Table 2.12: Differences between wind-pollinated and animal-pollinated flowers

S. No.	Wind-pollinated flowers	Animal-pollinated flowers
(*i*)	This kind of flower is pollinated by abiotic pollinating agent.	This kind of flower is pollinated by biotic pollinating agent.
(*ii*)	They are small and inconspicuous.	They are large, colourful, fragrant and rich in nectar.
(*iii*)	The pollen grains are dry, light and non-sticky so that they can be easily transported by wind.	The pollen gains are generally sticky in animal pollinated flowers.
(*iv*)	The flowers are often clustered so as to carry out pollination.	Flowers reward pollinators in terms of pollen, nectar or safe place to lay eggs.

Q. 20. (*a*) How does cleistogamy ensure autogamy?

(*b*) State one advantage and one disadvantage of cleistogamy to the plant.

[*CBSE (AI) 2012; Delhi 2013*]

Ans. (*a*) Cleistogamous flowers do not open. Therefore, the pollens have to land on the stigma of the same flower. This ensures autogamy.

(*b*) Advantage: Self-pollination is assured, thus ensuring seed formation.

Disadvantage: Least variations observed and it leads to inbreeding depression.

Q. 21. (*a*) Describe the endosperm development in coconut.

(*b*) Why is tender coconut considered a healthy source of nutrition?

(*c*) How are pea seeds different from castor seeds with respect to endosperm?

[*CBSE (AI) 2013*]

Ans. (*a*) The primary endosperm nucleus (PEN) undergoes successive nuclear divisions to give rise to free nuclei. Subsequently, cell wall is formed towards the periphery and endosperm becomes cellular, leaving free nuclear endosperm in the central part. This division is followed by cytokinesis and thus endosperm becomes cellular and is called cellular endosperm.

(*b*) It is rich in many nutrients like fats, proteins, carbohydrates, minerals, vitamins. Hence, tender coconut is considered a healthy source of nutrition.

(*c*) In peas, the endosperm is used up and there is no endosperm present in the mature seed. In castor, the endosperm remains intact in the mature seed.

Q. 22. Differentiate between perisperm and endosperm by giving one example of each.

[*CBSE (AI) 2012*]

Ans.

Table 2.13: Differences between perisperm and endosperm

S. No.	Perisperm	Endosperm
(*i*)	It is persistent nucellus.	It is the nutritive tissue for embryo.
(*ii*)	It is diploid.	It is triploid.
(*iii*)	Example: black pepper, beet.	Example: maize, rice, wheat, castor.

Q. 23. Explain any three advantages the seeds offer to angiosperms. **[*CBSE Delhi 2014*]**

Ans. (*i*) Since reproductive process such as pollination and fertilisation are independent of water, seed formation is more dependable.

(*ii*) Seeds have better adaptive strategies for dispersal to new habitats and help the species to colonise in other areas.

(*iii*) As they have sufficient food reserves young seedlings are nourished until they are capable of photosynthesis on their own.

(*iv*) The hard seed coat provides protection to the young embryo.

(*v*) Being products of sexual reproduction, they generate new genetic combinations or variations. (*Any three*)

Q. 24. State what is apomixis. Comment on its significance. How can it be commercially used?
[*CBSE (AI) 2015; 2019 (57/4/1)*]

Ans. Refer to NCERT Textbook Exercise, Q. No. 18.

Q. 25. Differentiate between parthenocarpy and parthenogenesis. Give one example of each.
[*CBSE 2018*]

Ans.

Table 2.14: Differences between parthenocarpy and parthenogenesis

S. No.	Parthenocarpy	Parthenogenesis
(*i*)	It is process of formation of fruit without fertilisation	It is the process of development of new organism without fertilisation.
(*ii*)	For example, banana, grapes, etc.	For example, drones, male honey bee, turkey, rotifers, etc.

Q. 26. (*a*) How are parthenocarpic fruits produced by some plants and apomictic seeds by some others? Explain.
(*b*) When do farmers prefer using apomictic seeds? **[*CBSE (AI) 2016*]**

Ans. (*a*) Parthenocarpic fruits are formed when ovary develops into fruit without fertilisation.
Apomictic seeds are formed when formation of seeds take place without fertilisation.
(*b*) To maintain hybrid characters (year after year in a desired plant) and to avoid buying hybrid seeds every year (expensive seeds) farmers prefer using apomictic seeds.

Q. 27. (*a*) How does a farmer use the dormancy of seeds to his advantage?
(*b*) What advantages a seed provides to a plant? **[*CBSE (AI) 2016*]**

Ans. (*a*) Dormancy of mature seeds are important for storage of seeds which can be used as food throughout the year and also to raise crop in the next season.
(*b*) Seeds offer several advantages to angiosperms. Firstly, since reproductive processes such as pollination and fertilisation are independent of water, seed formation is more dependable. Also seeds have better adaptive strategies for dispersal to new habitats and help the species to colonise in other areas. As they have sufficient food reserves, young seedlings are nourished until they are capable of photosynthesis on their own. The hard seed coat provides protection to the young embryo. Being products of sexual reproduction, they generate new genetic combinations leading to variations.

Q. 28. Draw a diagram of L.S. of an anatropous ovule of an angiosperm and label the following parts.
(*i*) Nucellus **(*ii*) Integument**
(*iii*) Antipodal cells **(*iv*) Secondary nucleus**

Ans. Refer to Fig. 2.7.

Q. 29. 'Fertilisation is not an obligatory event for fruit production in certain plants'. Explain the statement. **[*HOTS*]**

Ans. This can be observed in parthenocarpic fruits. The 'seedless fruits' that are available in the market, such as pomegranate, grapes, etc., are good examples. Flowers of these plants are sprayed by a growth hormone that induces fruit development even though fertilisation has not occurred. The ovules of such fruits, however, fail to develop into seeds.

Q. 30. Is pollination and fertilisation necessary in apomixis? Give reasons. [*NCERT Exemplar*] [*HOTS*]

Ans. No, they are not necessary. Apomixis is actually an alternative to sexual reproduction, although the female sexual apparatus is used in the process. In apomicts, embryos can develop directly from the nucellus or synergid or egg. Therefore, there is no need for either pollination or fertilisation.

Q. 31. Embryo sacs of some apomictic species appear normal but contain diploid cells. Suggest a suitable explanation for the condition. **[*NCERT Exemplar*] [*HOTS*]**

Ans. Many apomictic species have been seen to have normal looking embryo sacs. The only possibility of the embryo sac possessing diploid cells will be due to failure of meiotic division at the megaspore mother cell stage. Since the megaspore mother cell has a diploid nucleus, if it undergoes mitosis instead of meiosis, all the resulting nuclei and cells will be diploid in nature.

Long Answer Questions–II [5 marks]

Q. 1. Draw a labelled diagram of an anther lobe at microspore mother cell stage. Mention the role of different wall layers of anther.

Ans. Refer to Fig. 2.3.

Roles of different wall layers of anther:

(*i*) Epidermis, endothecium and middle layers perform the function of protection and help in dehiscence of anther to release the pollen.

(*ii*) Tapetum is the innermost wall layer and it provides nourishment to the developing pollen grains.

Q. 2. (*a*) Draw a diagram of an enlarged view of T.S. of one microsporangium of an angiosperm and label the following parts:

(*i*) Tapetum

(*ii*) Middle layer

(*iii*) Endothecium

(*iv*) Microspore mother cells

(*b*) Mention the characteristic features and function of tapetum.

(*c*) Explain the following giving reasons:

(*i*) Pollen grains are well preserved as fossils.

(*ii*) Pollen tablets are in use by people these days. ***[CBSE (F) 2011]***

Ans. (*a*) Refer to Fig. 2.3(*b*).

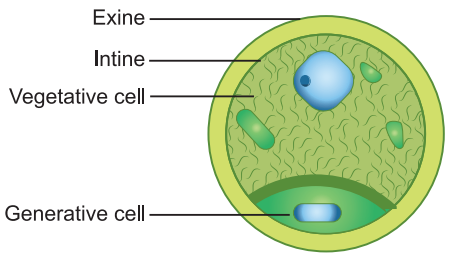
(*b*) Tapetum is the innermost wall layer of the microsporangium. It nourishes the developing pollen grains. Cells of the tapetum possess dense cytoplasm and generally have more than one nucleus.

(*c*) (*i*) Pollen grains have thick outer exine which is composed of sporopollenin. Sporopollenin can withstand high temperatures and strong acids and alkalis and are not degraded by any enzymes. Therefore, they are well preserved as fossils.

(*ii*) Pollen tablets are used by people because pollens are rich in nutrients so used to increase performance of athletes and race horses.

Q. 3. Draw a labelled diagram of the sectional view of a mature pollen grain in angiosperms. Explain the functions of its different parts.

Ans.



Functions:

(*i*) Pollen grains are generally spherical with a prominent two-layered wall. The hard outer layer is called exine made up of sporopollenin, which is a resistant organic material.

(*ii*) Exine can withstand high temperature, strong acids and alkali, thus provide protection.

(*iii*) It has prominent aperture called germ pore, through which pollen tube comes out.

(*iv*) Vegetative cell has abundant food reserve.

(*v*) Generative cell divides mitotically giving rise to two male gametes, before pollen grains are shed (3-celled stage).

Q. 4. (*a*) Where is microsporangium located in an angiosperm ? State the functions of tapetum and the other three layers of microsporangium?

(*b*) Describe the structure of the male gametophyte produced as a result of microsporogenesis.

(*c*) State the functions of each part of the male gametophyte. **[*CBSE 2019 (57/3/3)*]**

Ans. (*a*) Microsporangium is located in the anther lobe.

Tapetum nourishes the developing pollen grain.

The other three layers of microsporangium, *i.e.*, epidermis, endothecium and middle layers protect and dehisce the microsporangium.

(*b*) Structure of Pollen grain/male gemetophyte.

(*i*) Outer wall layer of the male gametophyte is called exine. It is a hard layer, made of sporopollenin. It protects the pollen grain.

(*ii*) Inner wall layer is called as intine. It is made up of cellulose and pectin.

(*iii*) Vegetative cell is rich in food reserve. It helps in formation of pollen tube.

(*iv*) Generative cell is smaller and has dense cytoplasm and a nucleus. It forms the two male gametes.

Q. 5. Describe in sequence the events that lead to the development of a 3-celled pollen grain from microspore mother cell in angiosperms. **[*CBSE (AI) 2010*]**

Ans. Refer to Basic Concept Point 3 (Microsporogenesis and Pollen grains).

Q. 6. (*a*) How does microspore mother cell develop into mature pollen grain in angiosperms?

(*b*) Describe the structure of a mature pollen grain and draw a labelled diagram of its two-celled stage. **[*CBSE (F) 2012*]**

Ans. (*a*) Refer to Basic Concepts Point 3 (Microsporogenesis).

(*b*) Refer to Basic Concepts Point 3 (Pollen grains). For diagram refer to Fig. 2.5 (*b*)

Q. 7. Draw a diagrammatic sectional view of a mature anatropous ovule and label the following parts in it:

(*a*) that develops into an endosperm in an albuminous seed.

(*b*) through which the pollen tube gains entry into the embryo sac.

(*c*) that attaches the ovule to the placenta.

Ans. Refer to Fig. 2.7.

Q. 8. (*a*) Draw a diagram of a mature embryo sac of an angiosperm and label the following parts in it:

(i) Filiform apparatus **(ii) Synergids**

(iii) Central cell **(iv) Egg cell**

(v) Polar nuclei **(vi) Antipodals**

(*b*) Write the fate of egg cell and polar nuclei after fertilisation. **[*CBSE Delhi 2013*]**

Ans. (*a*) Refer to Fig. 2.8 (*c*).

(*b*) After fertilisation egg cell fuses with male gamete to form zygote and polar nuclei fuse with other male gamete to form primary endosperm nucleus.

Q. 9. (*a*) Trace the development of megaspore mother cell up to the formation of a mature embryo sac in a flowering plant.

(*b*) Draw a labelled diagram of the structure of mature dicot embryo.

[*CBSE (AI) 2010; 2019 (57/4/1)*]

OR

How does the megaspore mother cell develop into 7-celled, 8 nucleate embryo sac in an angiosperm? Draw a labelled diagram of a mature embryo sac. **[*CBSE Delhi 2012*]**

Ans. (*a*) Refer to Basic Concept Point 4 (Megagametogenesis).

(*b*) For diagram refer to Fig. 2.14.

Q. 10. (*a*) Explain the post-pollination events leading to seed production in angiosperms.

(*b*) List the different types of pollination depending upon the source of pollen grain.

[*CBSE Delhi 2016*]

Ans. (*a*) Refer to Basic Concepts Points 6, 8 and 9.

(*b*) The different types of pollination are:

(*i*) Autogamy/self-pollination

(*ii*) Geitonogamy.

(*iii*) Xenogamy/cross-pollination.

Q. 11. (*a*) Describe any two devices in a flowering plant which prevent both autogamy and geitonogamy.

(*b*) Explain the events upto double fertilisation after the pollen tube enters one of the synergids in an ovule of an angiosperm. **[*CBSE 2018*]**

Ans. (*a*) **(*i*) Dioecy:** It refers to the production of unisexual flowers in different plants.

(*ii*) Self-incompatibility: It refers to the condition where pollens fail to pollinate the stigma of same flower.

(*b*) Refer to Basic Concepts Point 8.

Q. 12. (*a*) Explain the characteristic features of wind-pollinated flowers. How are insect-pollinated flowers different from them?

(*b*) Explain the mutually rewarding relationship between *Yucca* plant and a species of moth.

[*CBSE (F) 2011*]

Ans. (*a*) Wind-pollinated flowers have light-weight, non-sticky, dry and winged pollens. The well-exposed stamens help in easy dispersal of pollen grains. The stigma is sticky, large and feathery to trap pollen grains floating in the air. Numerous flowers are packed together to form inflorescence.

Insect-pollinated flowers are large, sticky and brightly coloured with honey and nectar glands to attract insects. They are highly fragrant and the stigma is sticky.

(*b*) Both *Yucca* plant and the moth cannot complete their life cycles without each other. The moth deposits its eggs in the locule of the ovary and the flower in turn, gets pollinated by the moth. The larvae of the moth come out of the eggs as the seeds start developing.

Q. 13. Make a list of any three outbreeding devices that flowering plants have developed and explain how they help to encourage cross-pollination. **[*CBSE (AI) 2014*]**

Ans. (*i*) Production of unisexual flowers/dioecious plants, cross pollination ensured.

(*ii*) Self incompatibility, genetic mechanism prevent the pollen germination on the stigma of the same flower.

(*iii*) Anther and stigma are placed at different positions, so the pollen can not come in contact with the stigma of the same flower.

Q. 14. (*a*) Plan an experiment and prepare a flow chart of the steps that you would follow to ensure that the seeds are formed only from the desired sets of pollen grains. Name the type of experiment that you carried out.

(*b*) Write the importance of such experiments. **[*CBSE (AI) 2015*]**

Ans. (*a*) Selection of flowers from desired plants → emasculation → bagging → dusting of the pollens on the stigma of the flowers that were bagged (pollination) → rebagging of flower → fruit formed

The name of the experiment is Artificial hybridisation.

(*b*) (*i*) Production of superior or improved varieties of plants. (*ii*) Improves crop yield.

Q. 15. (*a*) Draw a labelled long-sectional view of albuminous 'seed'.

(*b*) How are seeds advantageous to flowering plants? **[*CBSE (AI) 2010*]**

Ans. (*a*) Refer to Fig. 2.15(*c*) and (*d*).

(*b*) Refer to Basic Concepts Point 9 (Advantages of seeds).

Q. 16. (*a*) Explain the different ways apomictic seeds can develop. Give an example of each.
(*b*) Mention one advantage of apomictic seeds to farmers.
(*c*) Draw a labelled mature stage of a dicotyledonous embryo. ***[CBSE (AI) 2014]***

Ans. (*a*) (*i*) Diploid egg cell is formed without reduction division and develops into embryo without fertilisation, *e.g.*, Asteraceae/grasses.

(*ii*) In citrus/mango, some of the diploid nucellar cells surrounding the embryo sac start dividing, protrude into embryo sac and develop into a embryo.

(*b*) No segregation of character in hybrid seeds, economically beneficial and desired varieties are cultivated.

(*c*) Refer to Fig. 2.14.

Q. 17. Explain the events upto fertilisation that occur in a flower after the pollen grain has landed on its compatible stigma. ***[CBSE (F) 2016]***

Ans. When pollen grain lands over the stigma, it starts germinating and produces a pollen tube through a germ pore. Pollen tube passes through style and reaches the ovule. The generative cell divides and forms two male gametes. Finally the pollen tube enters the embryo sac through micropyle. Now the pollen tube enters the egg apparatus through one of the synergids with the help of filiform apparatus. The vegetative nucleus degenerates while pollen tube leaves two male gametes in embryo sac. Now one of the male gamete fuses with the egg cell to form diploid zygote known as syngamy. The other male gamete fuses with the two already fused polar nuclei (called secondary nucleus) and forms triploid primary endosperm nucleus (PEN) which later gives rise to endosperm. This is called triple fusion. Hence syngamy and triple fusion together are known as double fertilisation.

For diagram refer to Fig. 2.12.

Q. 18. (*a*) Explain the events after pollination leading to the formation of a seed in angiosperms.
(*b*) Mention the ploidy levels of the cells of different parts of an albuminous seed.
[CBSE (F) 2015]

Ans. (*a*) Refer to Basic Concepts Points 6 and 8.

(*b*) The embryo is diploid (2n) and the endosperm is triploid (3n).

Q. 19. (*a*) Explain the phenomenon of double fertilisation.
(*b*) Draw a labelled diagram of a typical anatropous ovule. ***[CBSE Delhi 2014]***

Ans. (*a*) Double fertilisation includes syngamy where one of the male gametes fuses with egg cell to form zygote and triple fusion which includes fusion of second male gamete with two polar nuclei.

(*b*) Refer to Fig. 2.7.

Q. 20. (*a*) Draw a L.S. of a pistil showing pollen tube entering the embryo sac in an angiosperm and label any six parts other than stigma, style and ovary.
(*b*) Write the changes a fertilised ovule undergoes within the ovary in an angiosperm plant.
[CBSE (AI) 2013]

Ans. (*a*) Refer to Fig. 2.12 (*a*).

(*b*) In a fertilised ovule, following changes occur:

(*i*) Zygote changes into embryo

(*ii*) Integument develops into the seed coat

(*iii*) Synergids and antipodals degenerate

(*iv*) Ovule changes to form the seed.

Q. 21. (*a*) Draw a schematic labelled diagram of a fertilised embryo sac of an angiosperm.

(*b*) Describe the stages in embryo development in a dicot plant.

Ans. (*a*) Refer to Fig. 2.13(*a*).

(*b*) For explanation refer to Basic Concepts Point 9 (Embryogeny in Dicots).

Q. 22. (*a*) As a senior biology student you have been asked to demonstrate to the students of secondary level in your school, the procedure(s) that shall ensure cross-pollination in a hermaphrodite flower. List the different steps that you would suggest and provide reasons for each one of them.

(*b*) Draw a diagram of a section of a megasporangium of an angiosperm and label funiculus, micropyle, embryo sac and nucellus. ***[CBSE (AI) 2016]***

Ans. (*a*) The following steps would be followed:

(*i*) Emasculation or removal of anthers from the flower bud, before the anther dehisce, to avoid self pollination.

(*ii*) Bagging, to prevent contamination of its stigma with unwanted pollen grains.

(*iii*) Rebagging, the stigma of the mature ovary are dusted with desired pollen grains and rebagged to allow the fruit to develop.

(*b*) For diagram refer to Fig. 2.7.

Q. 23. (*a*) Why is the process of fertilisation in angiosperms termed as double fertilisation? Explain.

(*b*) Draw a diagram of an angiospermic embryo sac where fertilisation is just completed. Label the following parts:

(i) Micropylar end of the embryo sac.

(ii) The part that develops into an embryo.

(iii) The part that develops into an endosperm.

(iv) The degenerating cells at the chalazal end.

(*c*) Draw a labelled diagram of globular embryonic stage of an angiosperm. ***[CBSE (F) 2011]***

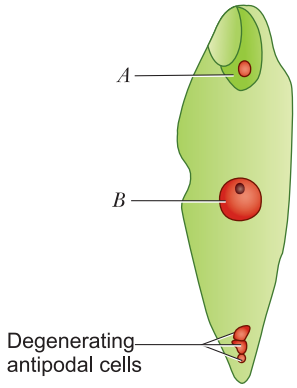
Ans. (*a*) In angiosperms, fusion of haploid egg cell with one haploid male gamete to form diploid zygote is called syngamy. Also, fusion of two (diploid) polar nuclei with the other haploid male gamete to form triploid primary endosperm nucleus is called triple fusion. Hence, the fertilisation is referred to as double fertilisation.

(*b*) Refer to Fig. 2.13(*a*).

(*c*) Refer to Fig. 2.13(*b*).

Q. 24. (*a*) Name the structures which the parts '*A*' and '*B*' shown in the diagram below respectively develop into.

(*b*) Explain the process of development which '*B*' undergoes in albuminous and exalbuminous seeds. Give one example of each of these seeds. ***[CBSE (F) 2011]***



Ans. (*a*) *A* develops into an embryo; *B* develops into endosperm.

(*b*) Refer to Basic Concepts Point 9 (Endosperm Development).

Q. 25. (*a*) Draw a labelled diagram of L.S. of a flower to show the growth of pollen tube reaching egg apparatus.

(*b*) Pistil of a flower does not accept pollen from any plant other than from its own kind. How does it happen? Explain.

Ans. (*a*) Refer to Fig. 2.12(*a*).

(*b*) The pistil has the ability to recognise pollen, whether it is of right type (compatible) or of the wrong type (incompatible). It is mediated by chemical components of the pollen interacting with those of the pistil.

Q. 26. Explain double fertilisation and trace the post-fertilisation events in sequential order leading to seed formation in a typical dicotyledonous plant. **[*CBSE (F) 2010*]**

Ans. **Double fertilisation:** Refer to Basic Concepts Point 8.

Following are the post-fertilisation events:

(*i*) Development of embryo: Embryo develops in fertilised ovule, from the zygote. The early stages of embryo development from a zygote is known as embryogeny. The formation of embryo starts only after certain amount of endosperm formation has taken place to assure the nutrition supply, for development and growth of embryo.

(*ii*) Development of seeds: Refer to Basic Concepts Point 9 (Embryogeny in Dicots).

As a result of double fertilisation number of changes takes place in an ovule due to which ovule is converted into seeds.

Q. 27. (*a*) Why does endosperm development precede embryo development in angiosperm seeds? State the role of endosperm in mature albuminous seeds.

(*b*) Describe with the help of three labelled diagrams the different embryonic stages that include mature embryo of dicot plants. **[*CBSE Delhi 2014*]**

Ans. (*a*) Endosperm development precedes embryo development because endosperm provides nutrition for the developing embryo. It is an adaptation to provide assured nutrition to the developing embryo.

The endosperm provides nutrition during seed germination.

(*b*) The zygote (in the embryo sac) divides to give rise to pro embryo and subsequently to the globular, heart shaped and mature embryo as shown in the diagram.

Refer to Fig. 2.13 (*b*).

Q. 28. Give reasons why:

(*i*) most zygotes in angiosperms divide only after certain amount of endosperm is formed.

(*ii*) groundnut seeds are exalbuminous and castor seeds are albuminous.

(*iii*) micropyle remains as a small pore in the seed coat of a seed.

(*iv*) integuments of an ovule harden and the water content is highly reduced, as the seed matures.

(*v*) apple and cashew are not called true fruits. **[*CBSE (AI) 2011*] [*HOTS*]**

Ans. (*i*) To obtain nutrition from the endosperm for the developing embryo, zygotes, divide after its formation.

(*ii*) The groundnut seeds are exalbuminous because the endosperm is completely consumed during embryo development. Whereas, castor seeds are albuminous because the endosperm persists and is used up during seed germination.

(*iii*) Micropyle remain as a small pore in the seed coat of a seed for the entry of water and oxygen required for germination.

(*iv*) To protect the embryo and keep the seed viable, until favourable conditions return for germination.

(*v*) In apple and cashew, apart from ovary, thalamus also contributes to fruit formation so they are not true fruits.

Q. 29. A flower of tomato plant following the process of sexual reproduction produce 240 viable seeds.

Answer the following questions giving reasons:

(*a*) What is the minimum number of pollen grains that must have been involved in the pollination of its pistil?

(*b*) What would have been the minimum number of ovules present in the ovary?

(*c*) How many megaspore mother cells were involved?

(*d*) What is the minimum number of microspore mother cells involved in the above case?

(*e*) How many male gametes were involved in this case? **[*CBSE Delhi 2015*] [*HOTS*]**

Ans. (*a*) 240 pollen grains. One pollen grain participates in fertilisation of one ovule.

(*b*) 240 ovules. One ovule after fertilisation forms one seed

(*c*) 240 MMC were involved. Each MMC forms four megaspores out of which only one remains functional.

(*d*) 60 MMCs (240/4 = 60). Each microspore mother cell meiotically divides to form four pollen grains.

(*e*) 480 male gametes (240 × 2 = 480). Each pollen grain carries two male gametes (which participate in double fertilisation)

Q. 30. A flower of brinjal plant following the process of sexual reproduction produces 360 viable seeds.

Answer the following questions giving reasons:

(*a*) How many ovules are minimally involved?

(*b*) How many megaspore mother cells are involved?

(*c*) What is the minimum number of pollen grains that must land on stigma for pollination?

(*d*) How many male gametes are involved in the above case?

(*e*) How many microspore mother cells must have undergone reduction division prior to dehiscence of another in the above case? **[*CBSE Delhi 2015*] [*HOTS*]**

Ans. (*a*) 360 ovules are involved. One ovule after fertilisation forms one seed.

(*b*) 360 MMC are involved. Each MMC forms four megaspores out of which only one remains functional.

(*c*) 360 pollen grains. One pollen grains participates in fertilisation of one ovule.

(*d*) 720 male gametes are involved. Each pollen grain carries two male gametes (which participate in double fertilisation) (360 × 2 = 720).

(*e*) 90 MMC undergo reduction division. Each microspore mother cell meiotically divides to form four pollen grains. (360/4 = 90).

Q. 31. (*a*) A capsicum flower has 240 ovules in its ovary. But, it produces a fruit with only 180 viable seeds.

Explain giving a reason that could be responsible for such a result.

(*b*) Describe the development of an endosperm in a viable seed. Why does endosperm development precede embryo development?

(*c*) Give an example of an angiosperm seed that has a perisperm. Name the part the perisperm develops from. **[*CBSE Delhi 2017*]**

Ans. (*a*) (*i*) 240 ovules giving rise to only 180 viable seeds, can be possible only if less number of pollen grains or male gametes were available.

(*ii*) All pollen grains did not germinate or did not form pollen tubes.

(*iii*) Many pollen were not compatible

(*b*) For the development of an Endosperm, Refer to Basic Concepts Point 9.

Cells of endosperm are filled with reserve food materials that are used for nutrition of developing embryo. Thus endosperm needs to develop before embryo.

(*c*) Black pepper and beet have a perisperm. The perisperm develop from the nucellus.

Q. 32. Rose plants produce large, attractive bisexual flowers but they seldom produce fruit. On the other hand, Lady's finger produces plenty of fruits. Analyse the reasons for failure of fruit formation in rose.

Ans. Failure of fruit formation in rose may be due to several reasons. Some of them are:

(*a*) Inability to produce viable pollens.

(*b*) Absence of functional egg.

(*c*) Presence of abortive ovules.

(*d*) Being hybrids, the meiotic process may be abnormal resulting in non-viable gametes.

(*e*) There may be self-incompatibility.

(*d*) There may be internal barriers for pollen tube growth and/or fertilisation.

Q. 33. (*a*) Seeds offer several advantages to angiosperms. Describe any three such advantages.

(*b*) Why is banana called a parthenocarpic fruit? Would you call banana a true fruit? Give reason in support of your answer.

Ans. (*a*) Reproductive processes such as pollination and fertilisation are independent of water. Following are their advantages:

(*i*) Better adaptive strategies for dispersal to new habitats.

(*ii*) Hard seed coat provides protection to young embryo .

(*iii*) Sexual reproduction—new genetic combinations.

(*iv*) Sufficient food reserves for the seedling.

(*v*) Basis of agriculture–storage of seeds can occur due to seed habit-dehydration and dormancy. (*Any three*)

(*b*) Banana fruit develops without fertilisation therefore, it is called parthenocarpic fruit.

Yes, it is a true fruit because it develops from ovary.

Self-Assessment Test

Time allowed: 1 Hour **Max. marks: 30**

1. Choose and write the correct option in the following questions. **(3×1 = 3)**

(i) Among the terms listed below, those that of are not technically correct names for a floral whorl are

A. androecium B. carpel

C. corolla D. sepal

(a) A and D (b) C and D

(c) B and D (d) A and B

(ii) Which of the following is true for typical bilobed anther?

(a) 2 theca, 2 sporangia (b) 4 theca, 4 sporangia

(c) 4 theca, 2 sporangia (d) 2 theca, 4 sporangia

(iii) The outermost and innermost wall layers of microsporangium in an anther are respectively [NCERT Exemplar]

(a) endothecium and tapetum (b) epidermis and endodermis

(c) epidermis and middle layer (d) epidermis and tapetum

2. In the following questions a statement of assertion followed by a statement of reason is given. Choose the correct answer out of the following choices. **(3×1 = 3)**

(a) Assertion and reason both are correct statements and reason is correct explanation for assertion.

(b) Assertion and reason both are correct statements but reason is not correct explanation for assertion.

(c) Assertion is correct statement but reason is wrong statement.

(d) Assertion is wrong statement but reason is correct statement.

(i) Assertion : Microspores are formed from microspore mother cells by mitosis.

Reason : Microspore form pollen grain when anthers mature.

(ii) Assertion : In angiosperms, the mature embryo sac is said to be 8-nucleate.

Reason : In mature embryo sac there are 3 nuclei at chalazal end, 3 nuclei at micropylar end and 2 nuclei in the central cell.

(iii) Assertion : Epicotyl develops into radicle on root tip.

Reason : A dicot embryo consist of two cotyledons.

3. What is self-incompatibility? **(1)**

4. Banana is a parthenocarpic fruit whereas oranges show polyembroyony. How are they different from each other with respect to seeds? **(1)**

5. Explain giving two reasons why pollen grains can be best preserved as fossils.[CBSE (F) 2010] **(2)**

6. "Pollen grains have some harmful effects". Discuss. **(2)**

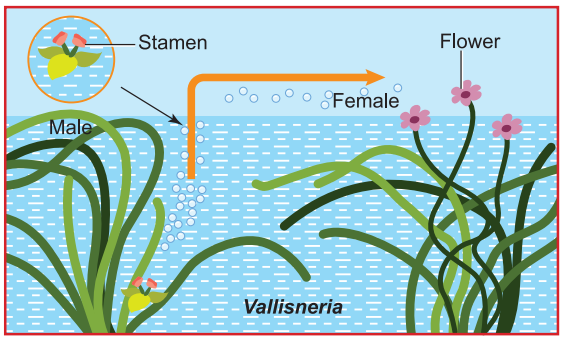
7. How many haploid cells are present in a mature female gametophyte of a flowering plant? Name them. **(2)**

8. Draw a labelled diagram of L.S. of an apple. **(2)**

9. List three strategies that a bisexual flower can evolve to prevent self-pollination. **(3)**

10. Trace the development of female gametophyte (embryo sac) from megaspore mother cell in a flower. Give a labelled diagram of the final stage of female gametophyte. **(3)**

11. Observe the diagram of pollination by water in *Vallisneria*.



Answer the following questions based on the diagram. **(3×1 = 3)**

(i) The following statements (a), (b) and (c) seem to describe the water-pollinated submerged plants. Which one of these statements is incorrect?

(a) The flowers do not produce nectar.

(b) The pollen grains have mucilaginous covering.

(c) The brightly coloured female flowers have long stalk to reach the surface.

(ii) Mention the pollinating agent of an inflorescence of small dull coloured flowers with well exposed stamens and large feathery stigma. Give any one characteristic of pollen grains produced by such flowers.

(iii) Name the type of pollination as a result of which genetically different types of pollen grains of the same species land on the stigma.

12. (i) State one difference and one similarity between geitonogamy and xenogamy.

(ii) Explain any three devices developed in flowering plants to discourage self-pollination and encourage cross-pollination. **(5)**

Answers

1. (*i*)—(*c*), (*ii*)—(*d*), (*v*)—(*d*) **2.** (*i*)—(*d*), (*ii*)—(*a*), (*iii*)—(*d*)

Chapter –3

Human Reproduction

basic concepts

1. The Human Male Reproductive System

- The male reproductive system consists of the following:
  - (*i*) **Primary sex organ (produce gametes):** testes.
  - (*ii*) **Secondary or accessory sex organs (essential for sexual reproduction):**
    - (*a*) **Accessory ducts:** rete testis, vasa efferentia, epididymis and vas deferens.
    - (*b*) **Accessory glands:** seminal vesicle, prostate and bulbourethral glands (Cowper's gland).
  - (*iii*) **External genitalia:** penis.

(i) Testes

- A pair of testes is situated outside the abdominal cavity in a sac of skin called the **scrotum**. Scrotum keeps the testes at a temperature 2–2.5°C lower than the internal body temperature, which is necessary for the synthesis of sperms.
- Each testis is oval in shape, measures about 4–5 cm in length and is 2–3 cm in width.
- The outermost covering of the testis is formed by a dense fibrous membrane called **tunica albuginea**.
- Each testis is divided into 250 compartments called **testicular lobules**.

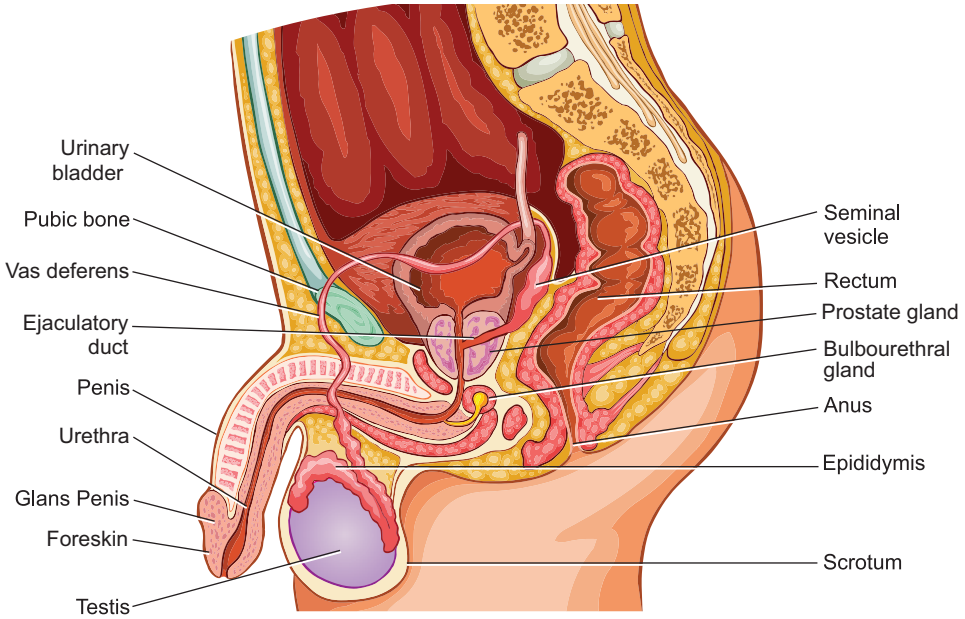


Fig. 3.1 Diagrammatic sectional view of male pelvis showing reproductive system

- Each lobule contains 1–3 highly coiled tubules known as **seminiferous tubules** in which sperms are produced.

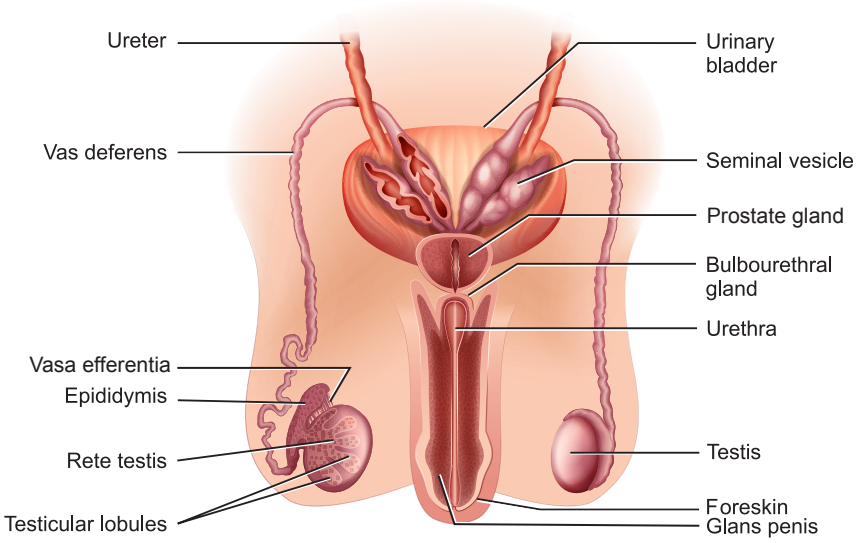


Fig. 3.2 Diagrammatic view of male reproductive system
(part of testis is open to show inner details)

- Each seminiferous tubule is lined on its inside, by two highly specialised cells called male germ cells (**spermatogonia**) and **Sertoli cells**.
- Spermatogonia undergo meiotic cell division to produce sperms.
- **Sertoli cells** or **nurse cells** provide nutrition to the germ cells.
- The regions outside the seminiferous tubules contain masses of cells called interstitial cells or **Leydig cells**. Leydig cells synthesise and secrete the male hormones called **androgens** (**testosterone**) which maintain male sex characteristics.

(ii) Accessory Duct System

- The seminiferous tubules open into the vasa efferentia through rete testis.
- Several vasa efferentia open into the epididymis and carry sperms outside the testes.
- **Epididymis** is a long, coiled tube present along the posterior surface of each testis. It continues as the vas deferens that ascends into the abdomen to loop over the urinary bladder. Epididymis temporarily stores non-motile and immature sperms.

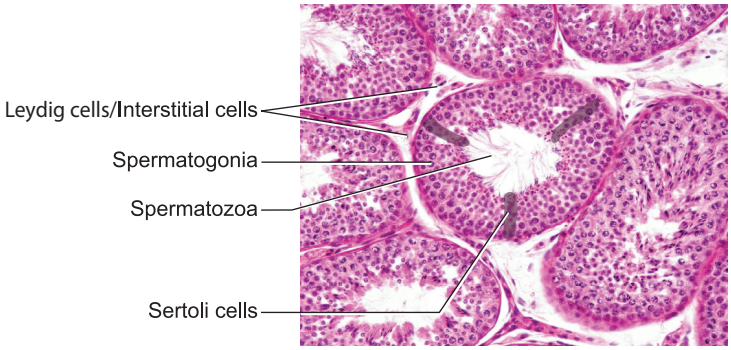


Fig. 3.3 Diagrammatic sectional view of seminiferous tubule

- The duct from seminal vesicle and **vas deferens** together form the **ejaculatory duct**. They pass through the prostate gland and join the urethra. They carry secretions of seminal vesicle and sperms from the testes to the outside through urethra.

- **Urethra** originates from the urinary bladder and extends through the penis to its external opening called urethral meatus. It carries urine from the bladder and sperms from the vas deferens through the penis.

(iii) Accessory Glands

- Secretions of these glands constitute **seminal plasma** which is rich in fructose, calcium and certain enzymes.
- The accessory or secondary glands include a prostate gland, two seminal vesicles and two bulbourethral glands.
- **Prostate gland:** It surrounds the urethra and produces a milky secretion which forms a considerable part of the semen. This secretion contains citric acid, lipids and enzymes. Secretion of the prostate gland nourishes and activates the spermatozoa to swim.
- **Seminal vesicles:** These secrete mucus and a watery alkaline fluid that contains fructose which provides energy to the sperms.
- **Bulbourethral glands** or Cowper's glands are attached to the urethra below the prostate gland. They secrete mucus fluid for the lubrication of the penis.

(iv) External Genitalia

- **Penis:** It is the male copulatory organ having erectile tissues and vascular spaces. When the male is sexually excited these spaces fill with blood, causing the penis to erect. The distal end of the penis is called **glans penis**. The glans penis is covered with a smooth skin called **foreskin** or **prepuce**.

2. The Female Reproductive System

- The female reproductive system consists of the following:
  - (*i*) **Primary sex organ (produce gametes):** ovary
  - (*ii*) **Secondary sex organs (essential for sexual reproduction):**
    - (*a*) **Accessory ducts:** pair of oviducts (fallopian tubes), uterus, cervix and vagina.
    - (*b*) **Accessory gland:** mammary gland.
  - (*iii*) **External genitalia:** vulva.

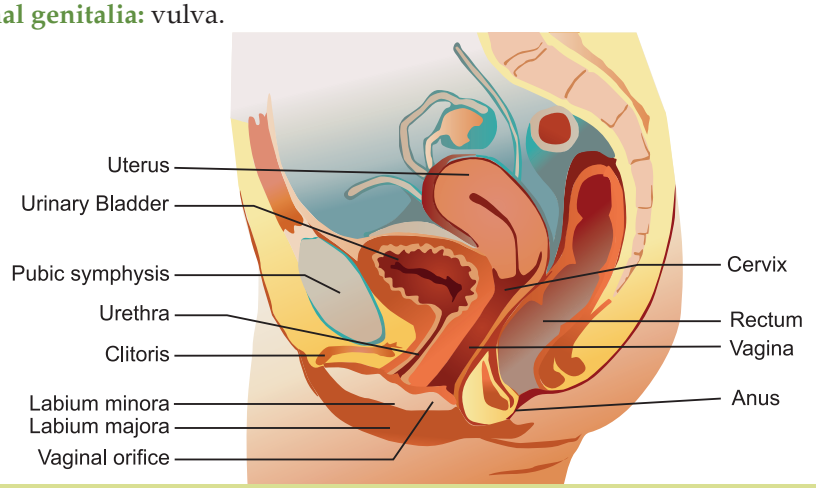


Fig. 3.4 Diagrammatic sectional view of female pelvis showing reproductive system

(i) Ovaries

- Ovaries are the primary female sex organs that produce the female gametes (ovum) and several steroid hormones (ovarian hormones).
- Ovaries are located one on each side of the lower abdomen and remain attached to the pelvic wall and uterus by ovarian ligaments.

- Each ovary is almond-like flattened body, measuring about 2–4 cm in length.
- The outer region of the ovary is composed of developing follicles and the middle region forms the stroma which contains connective tissue, blood vessels and mature follicles.
- The stroma is divided into two regions: a peripheral cortex and an inner medulla.

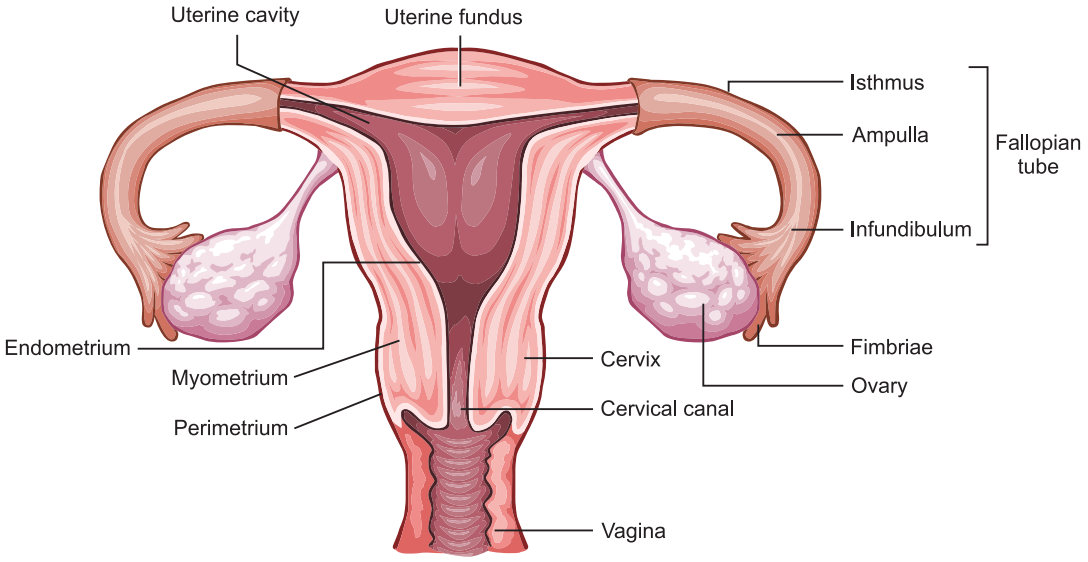


Fig. 3.5 Diagrammatic sectional view of the female reproductive system

(ii) Accessory ducts

(a) Oviducts (Fallopian tubes)

- These are two small tubes, about 10–12 cm in length, lying on either sides of uterus near the kidney.
- The opening of the fallopian tube is expanded into funnel-shaped **infundibulum**. The end of infundibulum has finger-like projections called **fimbriae**. They move closer to the ovaries at ovulation to collect the ovum after ovulation.
- The infundibulum leads to a wider part of the oviduct called **ampulla**.
- **Isthmus** is the last part of the oviduct having a narrow lumen which joins the uterus.

(b) Uterus (Womb)

- It is a single, hollow, muscular, pear-shaped structure supported by ligaments and attached to the pelvic wall.
- It is present between the urinary bladder and the rectum.
- The lower part of the uterus is very narrow and is called **cervix**. The cavity of the cervix is called cervical canal, which forms the **birth canal** along with vagina.
- The wall of the uterus has three layers of tissue:
  - **Perimetrium:** outer, thin membranous covering of the uterus wall.
  - **Myometrium:** middle, thick layer of smooth muscle fibres which contracts strongly during delivery of the baby.
  - **Endometrium:** inner layer, that contains glands and many blood vessels. It undergoes cyclical changes during the menstrual cycle.

(iii) Mammary Glands

- Human female has a pair of mammary glands (breasts) that contain glandular tissues and fatty tissues.
- Each glandular tissue is divided into 15–20 mammary lobes and each lobe consists of a group of cells called alveoli.

- The alveoli open into **mammary tubules**.
- The mammary tubules of each lobe open into small **mammary duct**.
- Several mammary ducts join to form a wider **mammary ampulla** that is connected to **lactiferous duct** just before the nipple through which milk is released.

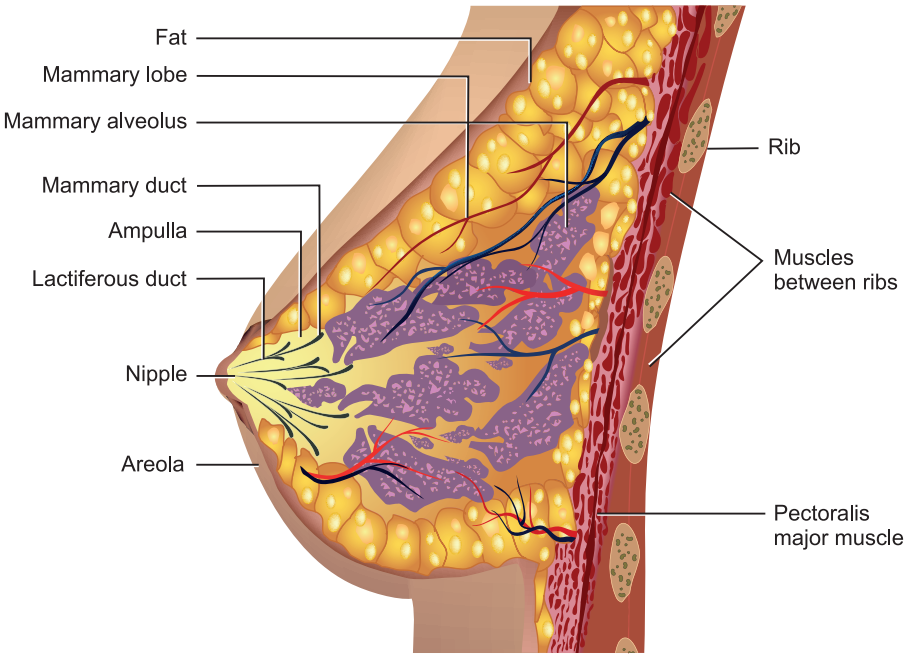


Fig. 3.6 A diagrammatic sectional view of mammary gland

(iv) External Genitalia (Vulva)

- The external genitalia of females are collectively called vulva and consists of the following parts:
  - (*a*) **Mons pubis:** A cushion of fatty tissue covered with skin and pubic hair.
  - (*b*) **Labia majora:** Two fleshy folds of fatty tissues which extend down from the mons pubis and surround the vaginal opening. Just inside the labia majora are the labia minora which enclose the vestibule containing the tiny opening of the urethra and the large mouth of the vagina.
  - (*c*) **Clitoris:** A tiny finger-like structure, which lies at the upper junction of the two labia minora, above the urethral opening.
  - (*d*) **Hymen:** A thin mucous membrane that covers the vaginal opening either partly or entirely. The hymen often breaks during the first intercourse or during sports like horse riding, cycling or sudden fall or jolt, etc. Hence, presence or absence of hymen is not a reliable indicator of virginity or sexual experience.

3. Gametogenesis

- It is the process of gamete formation in the gonads (testis and ovary) in sexually reproducing animals.
- The two processes of gametogenesis are:
  - (*i*) **Spermatogenesis:** Formation of haploid spermatozoa (sperms) from diploid spermatogonia in males.
  - (*ii*) **Oogenesis:** Formation of haploid ovum from the diploid germ cells in the ovary in females.

(i) Spermatogenesis

- The process of formation of spermatozoa (sperms) from diploid spermatogonia is called spermatogenesis. It occurs in the seminiferous tubules of the testes after attaining puberty.

- It includes the following phases:

(*a*) **Multiplication phase:** The male germ cells (spermatogonia) present on the inside wall of seminiferous tubules multiply by mitotic division and increase in numbers.

(*b*) **Growth phase:** Spermatogonia grow and increase in size and form primary spermatocytes. Each spermatogonium is diploid and contains 46 chromosomes.

(*c*) **Maturation phase or formation of spermatids:** Some of the spermatogonia called primary spermatocytes periodically undergomeiosis.Aprimaryspermatocyte completes the first meiotic division (reduction division) leading to formation of two equal haploid cells called secondary spermatocytes, which have only 23 chromosomes each. The secondary spermatocytes undergo the second meiotic division to produce four equal haploid spermatids.

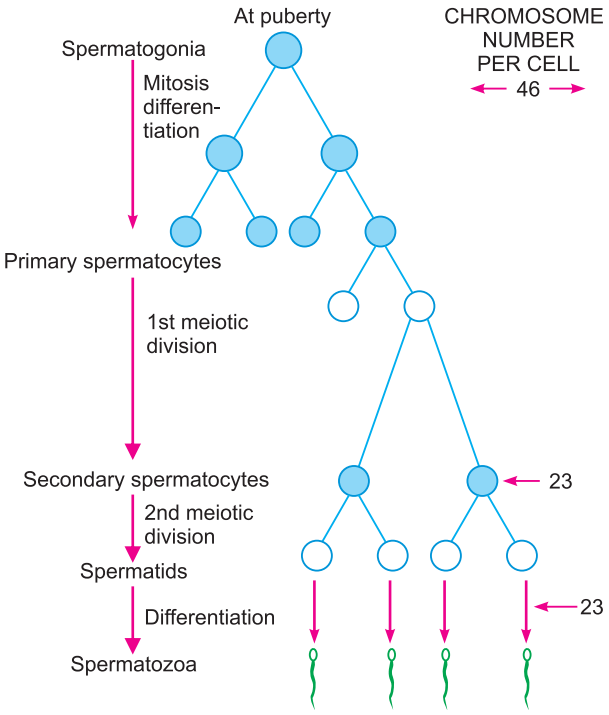


Fig. 3.7 Schematic representation of spermatogensis

(*d*) **Differentiation phase:** The spermatids are transformed into spermatozoa (sperms) by the process of **spermiogenesis**. After spermiogenesis, the sperm's head gets attached to Sertoli cells to draw nourishment and are finally released from the seminiferous tubules by the process called **spermiation**.

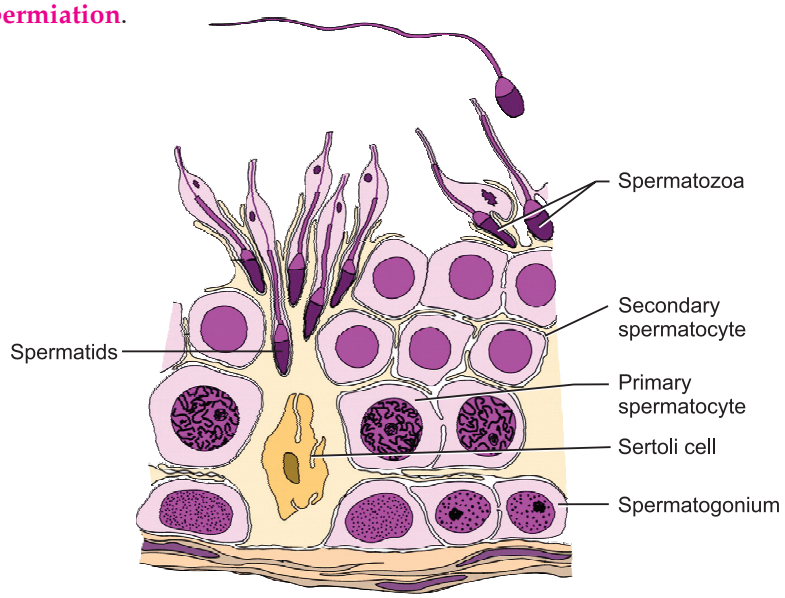


Fig. 3.8 Diagrammatic sectional view of a seminiferous tubule (enlarged)

Hormonal control of spermatogenesis

- Spermatogenesis is initiated at the age of puberty by the gonadotropin releasing hormone **(GnRH)** secreted by the hypothalamus.
- The increased levels of GnRH stimulate the anterior pituitary which then secretes the FSH (follicle stimulating hormone) and LH (luteinising hormone). **FSH** stimulates Sertoli cells to secrete some factors which help in spermiogenesis.

- **LH** acts on the Leydig cells and causes the secretion of androgens, *i.e.*, testosterone from the testes which in turn stimulate the process of spermatogenesis.

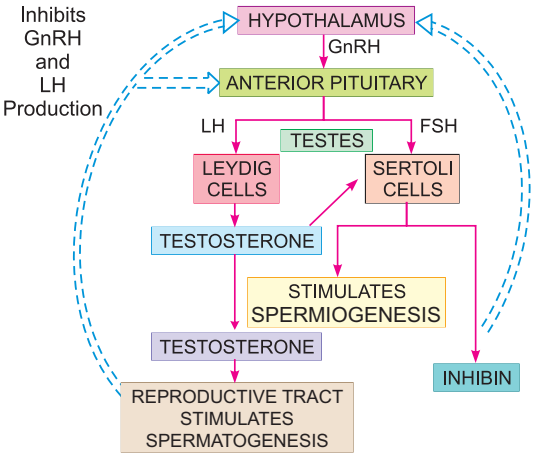


Fig. 3.9 Flow chart showing the hormonal control of the human male reproductive system

Structure of a sperm (Spermatozoa)

- It consists of four parts—head, neck, middle piece and tail—enveloped by a plasma membrane.
- **Head:** It is the enlarged end of a sperm, containing the large haploid nucleus, *i.e.*, condensed chromatin body and is capped by acrosome. The acrosome contains hydrolytic enzymes that help in dissolving membranes of the ovum for fertilisation.
- **Neck:** It contains proximal centriole which is necessary for the first cleavage division of zygote and the distal centriole that is connected to the tail filament.
- **Middle piece:** It contains a number of mitochondria that provide energy for the movement of the tail that facilitate sperm motility, essential for fertilisation.
- **Tail:** It consists of axial filaments surrounded by the plasma membrane. It helps the sperms to swim in a fluid medium.
- A human male ejaculates about 200–300 million sperms during a coitus. Seminal plasma along with the sperms constitute the **semen**.
- For normal fertility, at least 60% sperms must have normal shape and size and at least 40% of them must show vigorous motility.

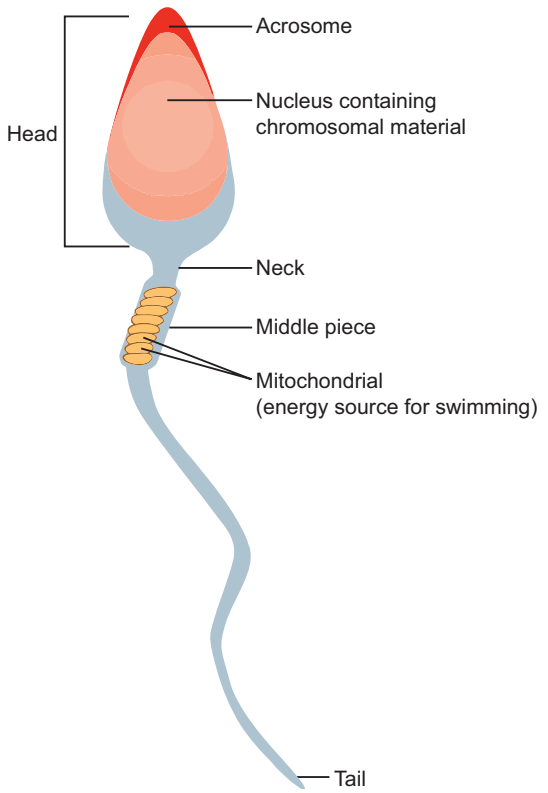


Fig. 3.10 Structure of a sperm

(ii) Oogenesis

- The process of formation of a mature female gamete is called oogenesis. It occurs in the ovaries. It consists of the following three phases:

(*a*) Multiplication phase: Oogenesis is initiated during the embryonic development stage when a couple of million gamete mother cells (oogonia) are formed within each foetal ovary. No

more oogonia are formed and added after birth. These cells start division and enter into prophase-I of the meiotic division. They get temporarily arrested at this stage and are called primary oocytes.

(b) Growth phase: Each primary oocyte then gets surrounded by a layer of granulosa cells. This structure is called the primary follicle. A large number of these follicles degenerate during the phase from birth to puberty. At puberty, only 60,000 to 80,000 primary follicles are left in each ovary. The primary follicles get surrounded by more layers of granulosa cells and a new theca to form secondary follicles.

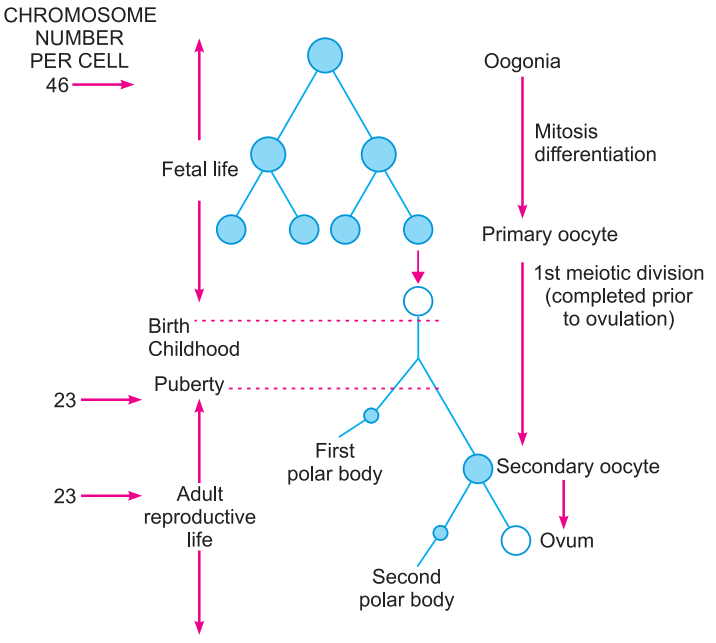


Fig. 3.11 Systematic representation of oogenesis

(c) Maturation phase: In the first maturation phase, the secondary follicle soon transforms into a tertiary follicle. The primary oocyte within the tertiary follicle grows in size and completes its first meiotic division to form a large, haploid, secondary oocyte and a tiny first polar body. The tertiary follicle changes into a mature follicle—the Graafian follicle—which ruptures to release the **secondary oocyte** (ovum) from the ovary by a process called **ovulation**. The second maturation phase occurs after fertilisation when the meiotic division of the secondary oocyte is complete. This second meiotic division results in the formation of a second polar body and a haploid ovum (ootid).

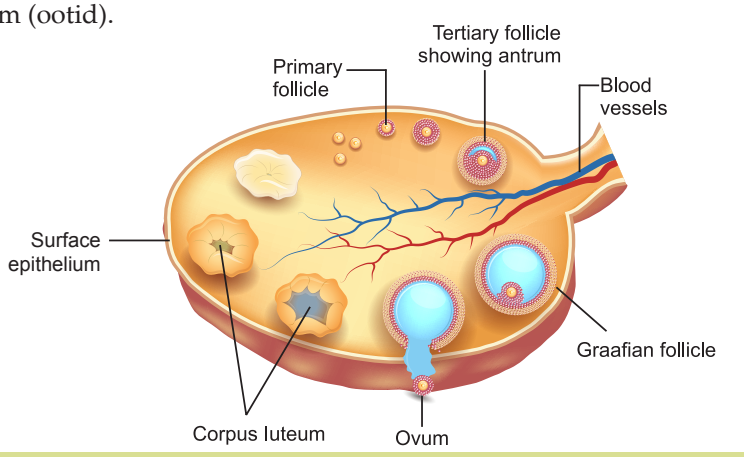


Fig. 3.12 Sectional view of ovary

4. Menstrual Cycle

- The rhythmic series of changes that occur in the reproductive organs of female primates (monkeys, apes and human beings) is called **menstrual cycle**.
- It is repeated at an average interval of about 28/29 days.
- The first appearance of menstruation at puberty is called **menarche**.
- The phase in woman's life when ovulation and menstruation stops is called **menopause**.
- The menstrual cycle has four phases. These are:

(i) Menstrual Phase

- The menstrual flow results due to breakdown of endometrial lining of uterus and its blood vessels, that are discharged through vagina.
- The unfertilised egg and soft tissues are discharged.
- It lasts for 3–5 days. It occurs only if released ovum is not fertilized.

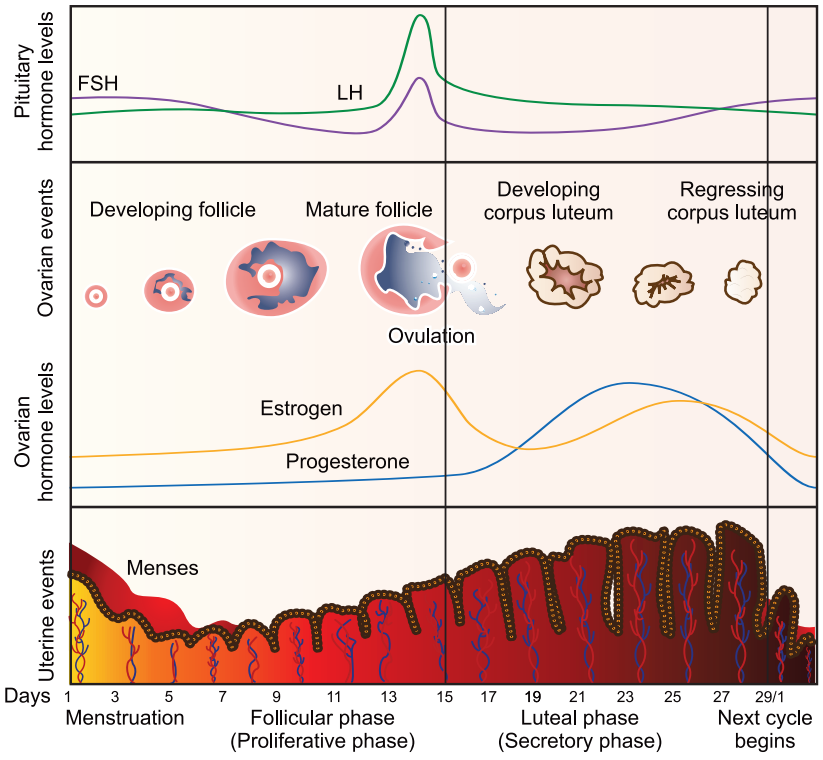


Fig. 3.13 Diagrammatic presentation of various events during a menstrual cycle

(ii) Follicular Phase/Proliferative Phase

- The primary follicles in the ovary grow and become a fully mature Graafian follicle.
- The endometrium of the uterus is regenerated due to the secretion of LH and FSH from anterior pituitary and ovarian hormone, estrogen.
- It lasts for about 10 to 14 days.

(iii) Ovulatory Phase

- Rapid secretion of LH leading to its maximum level during mid cycle called **LH surge**, induces rupture of Graafian follicle, thereby leading to **ovulation** (release of ovum).
- It lasts for only about 48 hours.

(iv) Luteal Phase/Secretory Phase

- In this phase the ruptured follicle changes into **corpus luteum** in the ovary and it begins to secrete the hormone progesterone which is essential for maintenance of endometrium.
- The endometrium thickens further and their glands secrete a fluid into the uterus.
- If ovum is not fertilised, the corpus luteum undergoes degeneration and this causes disintegration of the endometrium leading to menstruation.
- Estrogen and progesterone levels rise during this phase.
- It lasts for only 10–14 days.

- During pregnancy all events of the menstrual cycle stop and there is no menstruation. The menstrual cycle permanently stops in females at the age of around 50 years. This is called **menopause**.

5. Fertilisation

- The process of fusion of a sperm (male gamete) with an ovum (female gamete) is called **fertilisation**.
- During coitus, semen is released by the penis into the vagina **(insemination)**.
- The motile sperms swim rapidly through the cervix, enter into the uterus and reach the **ampullary–isthmic junction** of the oviduct.
- A sperm comes in contact with the zona pellucida layer of the ovum and induces changes in the membrane to block the entry of additional sperms.
- The enzymes of the acrosome of sperm help to dissolve zona pellucida and plasma membrane of the ovum and sperm head is allowed to enter into the cytoplasm of the ovum. This includes completion of meiosis II to form secondary oocyte and II polar body.

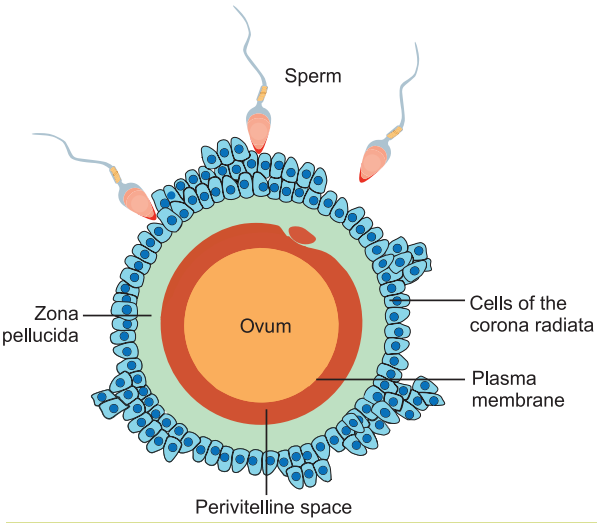


Fig. 3.14 Ovum surrounded by few sperms

- Ultimately diploid zygote is produced by the fusion of a sperm and an ovum.

6. Implantation

- Zygote divides rapidly by mitotic division as it moves through isthmus of oviduct towards uterus. This is called **cleavage.** As a result 2, 4, 8, 16 daughter cells are produced which are termed as **blastomeres**.
- Embryo with 8–16 blastomeres is called a **morula**.
- The morula continues to divide and transforms into a large mass of cells called **blastocyst,** which passes further into the uterus.
- Blastomeres in the blastocyst are arranged into an outer layer called **trophoblast** and an inner group of cells attached to trophoblast called **inner cell mass**.

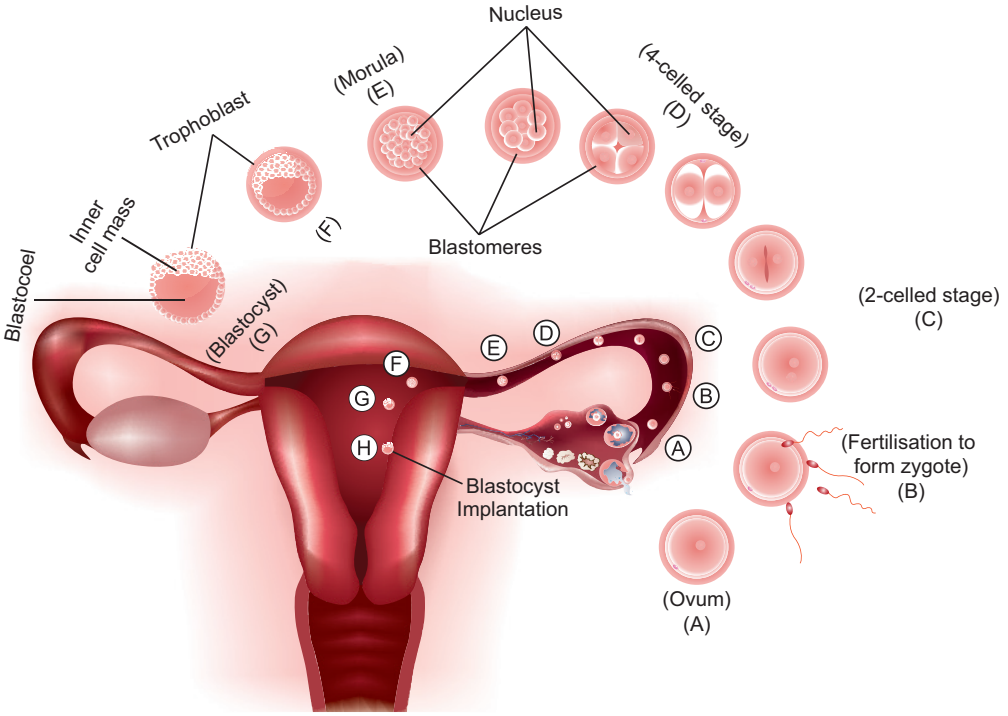


Fig. 3.15 Transport of ovum, fertilisation and passage of growing embryo through fallopian tube

- The trophoblast layer gets attached to the cells of the endometrium and the inner cell mass gives rise to the embryo.
- After attachment, the cells of endometrium divide rapidly and cover the blastocyst.
- So, the blastocyst gets embedded in the endometrium of the uterus. This is called **implantation**, which leads to pregnancy.

7. Pregnancy and Embryonic Development

- The cells of the trophoblast differentiate into an inner layer and an outer layer. The outer layer is called the **chorion** and forms the chorionic villi, which are finger-like projections that grow into the endometrium.
- An intimate connection is established between chorionic villi and uterine tissue, *i.e.*, chronic villi and uterine tissue become interdigitated with each other and forms a structural and functional unit between the developing embryo and the maternal body called **placenta**.

Functions of Placenta

(*i*) Provides nutrients and oxygen to the developing embryo.
(*ii*) Removes CO_2 and waste materials from the embryo.
(*iii*) Acts as an endocrine tissue and produces several hormones like **human chorionic gonadotropin (hCG), human placental lactogen (hPL), estrogens, progesterones** that are essential to maintain pregnancy.

- In later phase of pregnancy, hormone called **relaxin** is also secreted by ovary. During pregnancy, levels of other hormones like estrogen, progestogen, cortisol, prolactin, thyroxine, etc. are increased several fold and are essential for supporting foetal growth, metabolic changes in mother and maintenance of pregnancy.
- An umbilical cord connects placenta with the embryo that helps in the transport of substances to and from the embryo.
- The inner cell mass of blastocyst develops into three layers:
  (*i*) outer layer called **ectoderm**
  (*ii*) inner layer called **endoderm**
  (*iii*) middle layer called **mesoderm**

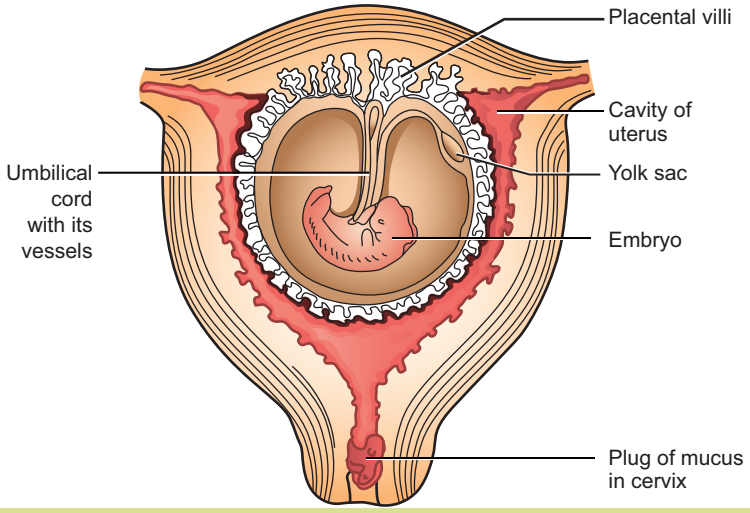


Fig. 3.16 The human foetus within the uterus

- Inner cell mass contains certain cells called stem cells which have the potency to give rise to all the tissues and organs.
- After **one month** of pregnancy, the embryo's heart is formed.

- By the end of **second month** of pregnancy, the foetus develops limbs and digits.
- By the end of **third month**, most of the organ systems are formed.
- Appearance of hair on the head and foetus movement is observed during **fifth month**.
- After **six months,** the body is covered with fine hair, eye-lids separate and eyelashes are also formed.
- By the end of **nine months** of pregnancy, the foetus is completely developed and is ready for its delivery.

8. Parturition

- The average duration of human pregnancy is about 9 months which is called the **gestation period.**
- The act of expelling the full term foetus from the mother's uterus at the end of gestation period by vigorous contraction of uterus is called **parturition**.
- It is induced by a complex neuroendocrine mechanism.
- Parturition signals originate from the fully developed foetus and the placenta which induce mild uterine contractions called **foetal ejection reflex**.
- This triggers the release of oxytocin from the maternal pituitary.
- Oxytocin induces stronger uterine muscle contractions which in turn stimulate further secretion of oxytocins. Stimulatory reflex between contraction and oxytocin secretion results in stronger and stronger contradiction which leads to expulsion of baby out of uterus through birth canal.

9. Lactation

- Mammary glands of female undergo differentiation and start producing milk at the end of pregnancy. This is called **lactation**.
- This helps the mother in feeding the newborn.
- The milk that comes out of the mammary glands during initial days of lactation is called **colostrum.** It contains several antibodies (I_gA) and nutrients (like calcium, fats, lactose) for the baby. It provides passive immunity to the baby.
- Thus, breast-feeding is recommended by doctors for bringing up a healthy baby.

NCERT Textbook Questions

Q. 1. Fill in the blanks.

(*a*) Humans reproduce _____. *(asexually/sexually)*

(*b*) Humans are _____. *(oviparous, viviparous, ovoviviparous)*

(*c*) Fertilisation is _____ in humans. *(external/internal)*

(*d*) Male and female gametes are _____. *(diploid/haploid)*

(*e*) Zygote is _____. *(diploid/haploid)*

(*f*) The process of release of ovum from a mature follicle is called _____.

(*g*) Ovulation is induced by a hormone called _____.

(*h*) The fusion of male and female gametes is called _____.

(*i*) Fertilisation takes place in _____.

(*j*) Zygote divides to form _____ which is implanted in the uterus.

(*k*) The structure which provides vascular connection between foetus and uterus is called _____.

Ans. (*a*) sexually, (*b*) viviparous, (*c*) internal, (*d*) haploid, (*e*) diploid, (*f*) ovulation, (*g*) luteinising hormone, (*h*) fertilisation, (*i*) oviduct (ampullary–isthmic junction), (*j*) blastocyst, (*k*) placenta.

Q. 2. Draw a labelled diagram of male reproductive system.

Ans. Refer to Fig. 3.2.

Q. 3. Draw a labelled diagram of the human female reproductive system. **[*CBSE (AI) 2011*]**

Ans. Refer to Fig. 3.5.

Q. 4. Write two major functions each of testis and ovary.

Ans. **Functions of testis:**

(*i*) Production of sperms by seminiferous tubules.

(*ii*) Production of male sex hormone, testosterone, by Leydig cells.

Functions of ovary:

(*i*) Production of ova (eggs).

(*ii*) Production of female sex hormones, estrogen and progesterone.

Q. 5. Describe the structure of a seminiferous tubule.

Ans. A seminiferous tubule is made up of layer of male germ cells and large Sertoli cells (nurse cells). The male germ cells undergo spermatogenesis to produce spermatocytes, spermatids and sperms. The regions outside the seminiferous tubules called interstitial spaces have connective tissue which includes blood vessels and Leydig cells (interstitial cells). Leydig cells synthesise and secrete the male sex hormones called androgens, of which testosterone is the principle one.

For diagram, refer to Fig. 3.8.

Q. 6. What is spermatogenesis? Briefly describe the process of spermatogenesis.

Ans. The process of formation of spermatozoa (sperms) from diploid spermatogonia is called spermatogenesis. The male germ cells of seminiferous tubules multiply mitotically to increase in numbers. Spermatogonia grow and increase in size to form primary spermatocyte (2n). The primary spermatocytes undergo the first meiotic division and produce two haploid secondary spermatocytes (n). Each secondary spermatocyte undergoes the second meiotic division and produces 4 equal haploid spermatids. The spermatids are finally transformed into spermatozoa by the process of spermiogenesis.

Q. 7. Name the hormones involved in regulation of spermatogenesis.

Ans. GnRH (Gonadotropin releasing hormone), LH (Luteinising hormone), FSH (Follicle stimulating hormone), androgen-binding protein (ABP), inhibin and androgens.

Q. 8. Define spermiogenesis and spermiation.

Ans. **Spermiogenesis:** The process involving transformation of spermatids into spermatozoa is called spermiogenesis.

Spermiation: After spermiogenesis, sperm heads become embedded in the Sertoli cells and are finally released from the seminiferous tubules by the process called spermiation.

Q. 9. Draw a labelled diagram of sperm. **[*CBSE (F) 2015*]**

Ans. Refer to Fig. 3.10.

Q. 10. What are the major components of seminal plasma?

Ans. Seminal plasma is the mixture of secretions of male accessory glands which include paired seminal vesicles, a prostate gland and a pair of bulbourethral glands.

Q. 11. What are the major functions of male accessory ducts and glands?

Ans. Male accessory ducts include rete testes, vasa efferentia, epididymis and vas deferens. These ducts store and transport the sperms from the testes to the outside through urethra. Male accessory glands include paired seminal vesicles, prostate gland and paired bulbourethral glands. Secretion of these glands constitute the seminal plasma which is rich in fructose, calcium and certain enzymes. The secretions of bulbourethral glands also help in the lubrication of the penis.

Q. 12. What is oogenesis? Give a brief account of oogenesis.

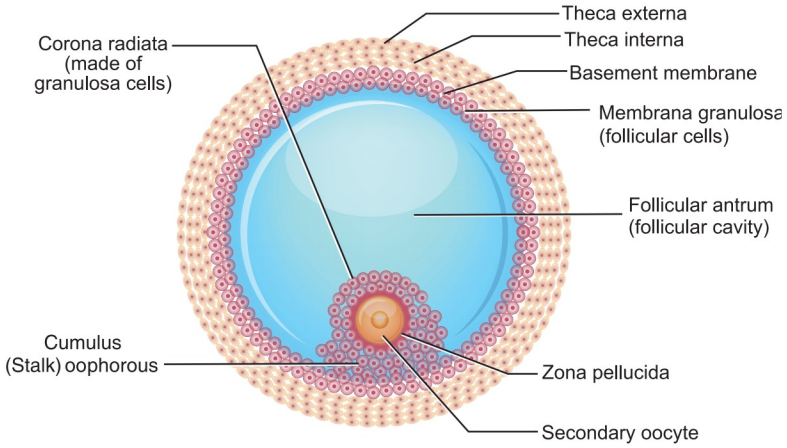
Ans. Refer to Basic Concepts Point 3(*ii*).

Q. 13. Draw a labelled diagram of a section through ovary.

Ans. Refer to Fig. 3.12.

Q. 14. Draw a labelled diagram of a Graafian follicle.

Ans.



Q. 15. Name the functions of the following:

(*a*) Corpus luteum **(*b*) Endometrium**

(*c*) Acrosome **(*d*) Sperm tail**

(*e*) Fimbriae

Ans. **(*a*) Corpus luteum:** It acts as an endocrine gland and secretes progesterone which is essential for maintenance of the endometrium.

(*b*) Endometrium: It is the innermost layer of uterus responsible for nutrition and development of the foetus. It undergoes cyclic changes during menstrual cycle. Implantation of blastocyst takes place on the endometrium.

(*c*) Acrosome: It contains hydrolytic enzymes that help in dissolving membranes of the ovum for fertilisation.

(*d*) Sperm tail: It helps in the sperm movement in the female genital tract for fertilisation.

(*e*) Fimbriae: It is present at the opening of oviduct which helps in the collection of the eggs after ovulation.

Q. 16. Identify True/False statements. Correct each false statement to make it true.

(*a*) Androgens are produced by Sertoli cells. **(*True/False*)**

(*b*) Spermatozoa get nutrition from Sertoli cells. **(*True/False*)**

(*c*) Leydig cells are found in ovary. **(*True/False*)**

(*d*) Leydig cells synthesise androgens. **(*True/False*)**

(*e*) Oogenesis takes place in corpus luteum. **(*True/False*)**

(*f*) Menstrual cycle ceases during pregnancy. **(*True/False*)**

(*g*) Presence or absence of hymen is not a reliable indicator of virginity or sexual experience. (True/False)

Ans. (*a*) False—Androgens are produced by Leydig cells or interstitial cells.

(*b*) True

(*c*) False—Leydig cells are found in testes.

(*d*) True

(*e*) False—Oogenesis takes place in Graafian follicles.

(*f*) True

(*g*) True

Q. 17. What is menstrual cycle? Which hormones regulate menstrual cycle?

Ans. The reproductive cycle in the female primates is called menstrual cycle. The uterus lining becomes thick and spongy to receive fertilised egg. If the egg is not fertilised this lining is not needed any

longer so, it slowly breaks and comes out through vagina as along with blood and mucous and is called menstruation.

Menstrual cycle is regulated by FSH (Follicle stimulating hormone), LH (Lutenising hormone), estrogen and progesterone.

Q. 18. What is parturition? Which hormones are involved in induction of parturition?

Ans. The process of delivery of the foetus (child birth) at the end of the pregnancy is called parturition. The signals for parturition originate from the fully developed foetus and the placenta, which trigger the release of oxytocin from the maternal pituitary. Oxytocin acts on the uterine muscles and induces stronger uterine contractions leading to expulsion of the baby. Relaxin hormone released by the ovary widens the vagina to facilitate birth.

Q. 19. In our society the women are often blamed for giving birth to daughters. Can you explain why this is not correct?

Ans. It is not correct to blame women for giving birth to daughters. The male sperm contains either X or Y chromosome whereas the female egg contains only X chromosomes. At the time of fertilisation when sperm carrying X chromosome combines with egg carrying X chromosome of female, XX-zygote is formed which would be a female and when sperm with Y chromosome combines with egg containing X chromosome, XY-zygote is formed which would be a male. Thus, scientifically sex of the baby is determined by the father and not by the mother as blamed in our society.

Q. 20. How many eggs are released by a human ovary in a month? How many eggs do you think would have been released if the mother gave birth to identical twins? Would your answer change if the twins born were fraternal?

Ans. Only one egg is released by a human (female) ovary in a month.

Only one egg is released if the mother gave birth to identical twins.

Yes. Two or more eggs are released in case fraternal twins are born.

Q. 21. How many eggs do you think were released by the ovary of a female dog which gave birth to 6 puppies?

Ans. Six eggs are released by the ovary of a female dog if it gave birth to six puppies.

Multiple Choice Questions [1mark]

Choose and write the correct option in the following questions.

1. Which hormone of pituitary gland regulates Sertoli cells?

(*a*) LH (*b*) FSH (*c*) GH (*d*) prolactin

2. The correct sequence of stages in spermatogenesis are:

(*a*) spermatogonia → spermatid → spermatocyte → sperm

(*b*) spermatocyte → spermatogonia → spermatid → sperm

(*c*) spermatogonia → spermatocyte → spermatid → sperm

(*d*) spermatid → spermatocyte → spermatogonia → sperm

3. Seminal plasma in humans is rich in

(*a*) fructose and calcium (*b*) glucose and calcium

(*c*) Progesterone and testosterone (*d*) potassium and calcium

4. The signals of parturition originate from

(*a*) placenta (*b*) fully developed foetus

(*c*) oxytocin released from pituitary (*d*) both placenta and fully developed foetus

5. The Leydig cells are a source of

(*a*) fructose (*b*) androgens (*c*) progesterone (*d*) mucus

6. The function of corpus luteum is to produce

(*a*) estrogen (*b*) progesterone (*c*) HCG (*d*) relaxin

7. Choose the incorrect statement from the following. [*NCERT Exemplar*]

(*a*) In birds and mammals internal fertilisation takes place.

(*b*) Colostrum contains antibodies and nutrients.

(*c*) Polyspermy in mammals is prevented by the chemical changes in the egg surface.

(*d*) In the human female implantation occurs almost seven days after fertilisation.

8. Identify the correct statement from the following. [*NCERT Exemplar*]

(*a*) High levels of estrogen triggers the ovulatory surge.

(*b*) Oogonial cells start to proliferate and give rise to functional ova in regular cycles from puberty onwards.

(*c*) Sperms released from seminiferous tubules are highly motile/non-motile.

(*d*) Progesterone level is high during the post ovulatory phase of menstrual cycle.

9. Spot the odd one out from the following structures with reference to the male reproductive system. [*NCERT Exemplar*]

(*a*) Rete testis (*b*) Epididymis

(*c*) Vasa efferentia (*d*) Isthmus

10. Seminal plasma, the fluid part of semen, is contributed by. [*NCERT Exemplar*]

(*i*) Seminal vesicle **(*ii*) Prostate gland**

(*iii*) Urethra **(*iv*) Bulbourethral gland**

(*a*) (*i*) and (*ii*) (*b*) (*i*), (*ii*) and (*iv*)

(*c*) (*ii*), (*iii*) and (*iv*) (*d*) (*i*) and (*iv*)

11. Which of the following statements is incorrect?

(*a*) GnRH stimulates secretion of FSH and LH

(*b*) LH stimulates the Leydig cells to secrete androgen

(*c*) FSH acts on the Sertoli cells and stimulates spermiogenesis

(*d*) None of these

12. Spermiation is the process of the release of sperms from. [*NCERT Exemplar*]

(*a*) Seminiferous tubules (*b*) Vas deferens

(*c*) Epididymis (*d*) Prostate gland

13. Mature Graafian follicle is generally present in the ovary of a healthy human female around. [*NCERT Exemplar*]

(*a*) 5 – 8 day of menstrual cycle (*b*) 11 – 17 day of menstrual cycle

(*c*) 18 – 23 day of menstrual cycle (*d*) 24 – 28 day of menstrual cycle

14. Acrosomal reaction of the sperm occurs due to [*NCERT Exemplar*]

(*a*) its contact with zona pellucida of the ova

(*b*) reactions within the uterine environment of the female

(*c*) reactions within the epididymal environment of the male

(*d*) androgens produced in the uterus

15. Which one of the following is not a male accessory gland? [*NCERT Exemplar*]

(*a*) Seminal vesicle (*b*) Ampulla

(*c*) Prostate (*d*) Bulbourethral gland

16. The immature male germs cell undergo division to produce sperms by the process of spermatogenesis. Choose the correct one with reference to above. [*NCERT Exemplar*]

(*a*) Spermatogonia have 46 chromosomes and always undergo meiotic cell division

(*b*) Primary spermatocytes divide by mitotic cell division

(*c*) Secondary spermatocytes have 23 chromosomes and undergo second meiotic division

(*d*) Spermatozoa are transformed into spermatids

17. Match between the following representing parts of the sperm and their functions and choose the correct option. [NCERT Exemplar]

Column I	Column II
(A) Head	(*i*) Enzymes
(B) Middle piece	(*ii*) Sperm motility
(C) Acrosome	(*iii*) Energy
(D) Tail	(*iv*) Genetic material

options:

(*a*) A-(*ii*), B-(*iv*), C-(*i*), D-(*iii*) (*b*) A-(*iv*), B-(*iii*), C-(*i*), D-(*ii*)
(*c*) A-(*iv*), B-(*i*), C-(*ii*), D-(*iii*) (*d*) A-(*ii*), B-(*i*), C-(*iii*), D-(*iv*)

18. Number of chromosomes in polar body of human is

(*a*) 23 (*b*) 46 (*c*) 21 (*d*) 1

19. Which among the following has 23 chromosomes? [NCERT Exemplar]

(*a*) Spermatogonia (*b*) Zygote
(*c*) Secondary oocyte (*d*) Oogonia

20. Match the following and choose the correct options [NCERT Exemplar]

Column I	Column II
(A) Trophoblast	(*i*) Embedding of blastocyst in the endome trium
(B) Cleavage	(*ii*) Group of cells that would differentiate as embryo
(C) Inner cell mass	(*iii*) Outer layer of blastocyst attached to the endometrium
(D) Implantation	(*iv*) Mitotic division of zygote

Options:

(*a*) A-(*ii*), B-(*i*), C-(*iii*), D-(*iv*) (*b*) A-(*iii*), B-(*iv*), C-(*ii*), D-(*i*)
(*c*) A-(*iii*), B-(*i*), C-(*ii*), D-(*iv*) (*d*) A-(*ii*), B-(*iv*), C-(*iii*), D-(*i*)

21. Which of the following hormones is not secreted by human placenta? [NCERT Exemplar]

(*a*) hCG (*b*) Estrogens
(*c*) Progesterone (*d*) LH

22. The vas deferens receives duct from the seminal vesicle and opens into urethra as [NCERT Exemplar]

(*a*) epididymis (*b*) ejaculatory duct
(*c*) efferent ductule (*d*) ureter

23. Urethral meatus refers to the [NCERT Exemplar]

(*a*) urinogenital duct (*b*) opening of vas deferens into urethra
(*c*) external opening of the urinogenital duct (*d*) muscles surrounding the urinogenial duct

24. Morula is a developmental stage [NCERT Exemplar]

(*a*) between the zygote and blastocyst (*b*) between the blastocyst and gastrula
(*c*) after the implantation (*d*) between implantation and parturition

25. The membranous cover of the ovum at ovulation is [NCERT Exemplar]

(*a*) corona radiata (*b*) zona radiata (*c*) zona pellucida (*d*) chorion

26. Identify the odd one from the following. [NCERT Exemplar]

(*a*) Labia minora (*b*) Fimbriae (*c*) Infundibulum (*d*) Isthmus

Answers

1. (*b*)	**2.** (*c*)	**3.** (*a*)	**4.** (*d*)	**5.** (*b*)	**6.** (*b*)	**7.** (*c*)	**8.** (*d*)	**9.** (*d*)	**10.** (*b*)
11. (*d*)	**12.** (*a*)	**13.** (*b*)	**14.** (*a*)	**15.** (*b*)	**16.** (*c*)	**17.** (*b*)	**18.** (*a*)	**19.** (*c*)	**20.** (*b*)
21. (*d*)	**22.** (*b*)	**23.** (*c*)	**24.** (*a*)	**25.** (*a*)	**26.** (*a*)				

Assertion-Reason Questions

In the following questions a statement of assertion followed by a statement of reason is given. Choose the correct answer out of the following choices.

(a) Assertion and reason both are correct statements and reason is correct explanation for assertion.

(b) Assertion and reason both are correct statements but reason is not correct explanation for assertion.

(c) Assertion is correct statement but reason is wrong statement.

(d) Assertion is wrong statement but reason is correct statement.

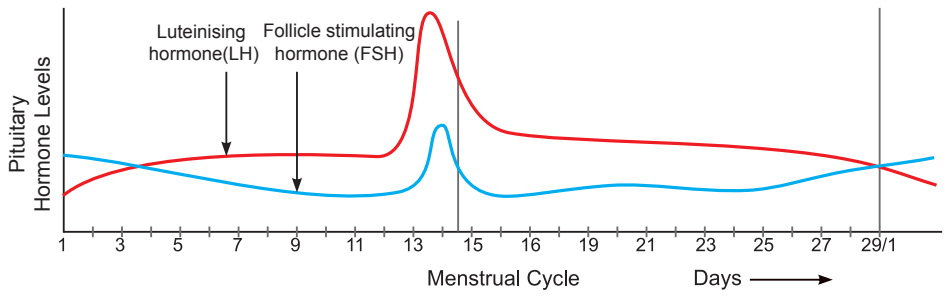
1. **Assertion :** A decrease in temperature has no effect on spermatogenesis.
   Reason : Spermatogonia cannot survive the high body temperature.
2. **Assertion :** The uterus is shaped like an inverted pear.
   Reason : The inner glandular layer lining the uterine cavity is called as myometrium.
3. **Assertion :** The middle piece of the sperm is called its powerhouse.
   Reason : Numerous mitochondria in the middle piece produce energy for the movement of the tail.
4. **Assertion :** All sperms released at a time do not fertilise the ovum.
   Reason : Fertilisation occur only when ovum and sperm fuse at the ampullary-isthmic junction.
5. **Assertion :** The embryo with 8 to 16 blastomeres is called a morula.
   Reason : The morula continuously divides to transform into trophoblast.
6. **Assertion :** After implantation, finger-like projections appear on the trophoblast called chorionic villi.
   Reason : Chorionic villi are surrounded by the uterine tissue and the maternal blood.
7. **Assertion :** The regions inside the seminiferous tubules contain Leydig cell.
   Reason : Leydig cells synthesise and secrete androgens.
8. **Assertion :** The endometrium undergoes cyclical changes during the menstrual cycle.
   Reason : Perimetrium contracts strongly during delivery of the baby.
9. **Assertion :** The signals for parturition, originating from the foetus, trigger release of oxytocin which stimulates uterine contraction.
   Reason : Vigorous contraction of the uterus at the end of pregnancy causes expulsion.
10. **Assertion :** In human beings, ovum is released from the ovary in the ootid stage.
    Reason : The secondary oocyte divides into unequal daughter cells, a large ootid and a small polar body.

Answers

1. (*b*) **2.** (*c*) **3.** (*a*) **4.** (*b*) **5.** (*c*) **6.** (*b*) **7.** (*d*) **8.** (*c*) **9.** (*a*) **10.** (*d*)

Case-based/Source-based Question

1. **Study the graph given below and answer the questions that follow:**



(*i*) What is the importance of LH surge?

(*ii*) Identify the ovarian phases during the menstrual cycle.

(a) 5th day to 12th day of the cycle.

(b) 14th day of the cycle.

(*iii*) Menstrual cycles are absent during pregnancy. Why?

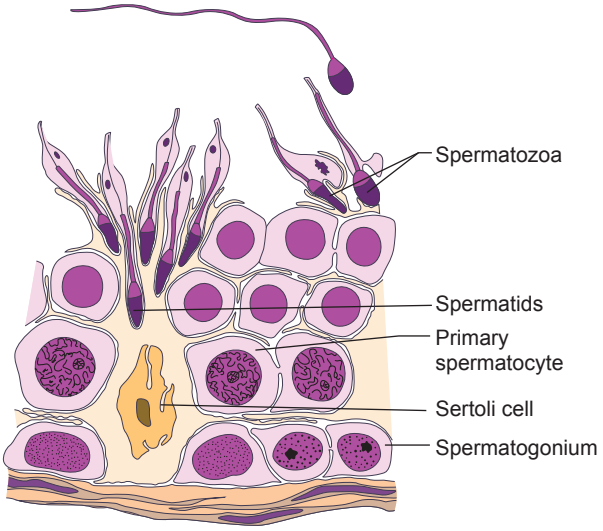
Ans. (*i*) LH surge is essential for the events leading to ovulation.

(*ii*) (*a*) 5th day to 12th day of the cycle: Follicular phase (Proliferative phase).

(*b*) 14th day of the cycle: Ovulatory phase (release of ovum) followed by luteal phase.

(*iii*) The high levels of progesterone and estrogens during pregnancy suppress the release of gonadotropins required for the development of new follicles. Therefore, new cycle cannot be initiated.

2. Study the figure given below:



(*i*) Pick out and name the cells that undergo spermiogenesis.

(*ii*) Differentiate between spermiogenesis and spermiation?

(*ii*) How many sperms will be produced from 50 primary spermatocytes?

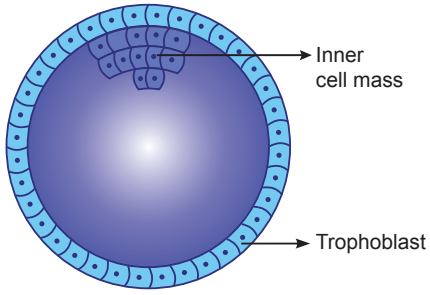
Ans. (*i*) Spermatids undergo spermiogenesis.

(*ii*) **Spermiogenesis:** It is the transformation of spermatids into spermatozoa or sperms.

Spermiation: It is the release of sperms from the sertoli cells in the seminiferous tubules.

(*iii*) One primary spermatocyte undergoes meiosis to form four sperms. So, primary spermatocyte will produce 200 sperms.

3. Study the figure given below and answer the questions that follow:



(*i*) Name the stage of human embryo the figure represents.

(*ii*) Mention the fate of the inner cell mass after implantation in the uterus.

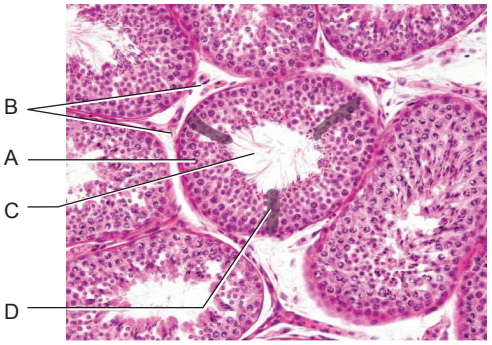
(*iii*) Where are the stem cells located in this embryo?

Ans. (*i*) Blastocyst

(*ii*) The inner cell mass differentiates into an outer layer of ectoderm and an inner layer of endoderm.

(*iii*) Inner cell mass.

4. Study the figures given below and answer the questions that follow.



(*i*) During reproduction, the chromosome number (2n) reduces to half (n) in the gametes and again resume the original number (2n) in the offspring, what are the processes through which these events take place?

(*ii*) Write the functions of A and D.

(*iii*) Mention the function of mitochondria in sperm.

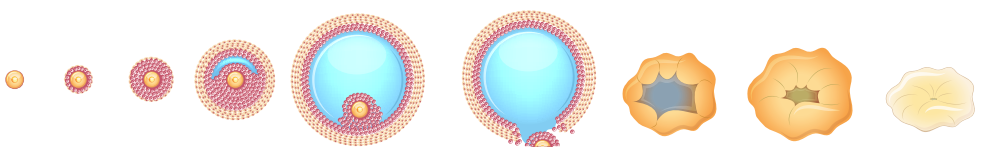
Ans. (*i*) Halving of chromosomal number takes place during gametogenesis by meosis and regaining the 2n number occur as a result of fertilisation by fusion of male and female gametes.

(*ii*) A : The spermatogonia or male germ cells undergo meiotic divisions leading to sperm formation.

D : Sertoli cells provide nutrition to the germ cells.

(*iii*) Provide energy for the movement of sperm tail.

5. The following is the illustration of the sequence of ovarian events (*a* – *i*) in a human female.



(*a*) (*b*) (*c*) (*d*) (*e*) (*f*) (*g*) (*h*) (*i*)

(*i*) Identify the figure that illustrates ovulation and mention the stage of oogenesis it represents.

(*ii*) Name the ovarian hormone and the pituitary hormone that have caused the above mentioned event.

(*iii*) Explain the changes that occur in the uterus simultaneously in anticipation.

Ans. (*i*) *f* ; secondary oocyte.

(*ii*) Estrogen and luteinising hormone (LH)

(*iii*) Endometrium proliferate (glands become cork-screw shaped) highly vascularised, high regeneration anticipating implantation of the fertilised ovum.

Very Short Answer Questions [1 mark]

Q. 1. Write the location and function of the Sertoli cells in humans. *[CBSE Delhi 2012, 2016; (AI) 2014]*

Ans. Sertoli cells are present in seminiferous tubules. They provide nutrition to the germ cells or sperms.

Q. 2. Mention the location and the function of Leydig cells in humans. **[CBSE (AI) 2014; (F) 2012]**

Ans. Leydig cells are present in the regions called interstitial spaces outside the seminiferous tubules. They synthesise and secrete androgens (testosterone).

Q. 3. Mention the function of mitochondria in sperm. *[CBSE (F) 2012]* *[HOTS]*

Ans. Provide energy for the movement of sperm tail.

Q. 4. When do the oogenesis and the spermatogenesis initiate in human females and males respectively? *[CBSE Delhi 2012]* *[HOTS]*

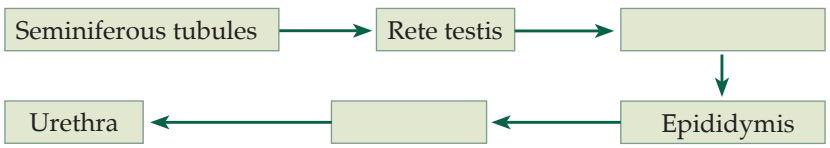
Ans. Oogenesis in human females initiate at the foetal/embryonic stage.

Spermatogenesis in human males starts at puberty.

Q. 5. Males in whom testes fail to descend to the scrotum are generally infertile. Why? *[HOTS]*

Ans. If the testes fail to descend to the scrotum, gametogenesis could be inhibited. The process of spermatogenesis requires a marginally lesser (2°C less) ambient temperature than that in the abdominal cavity.

Q. 6. The path of sperm transport is given below. Provide the missing steps in blank boxes. *[NCERT Exemplar]* *[HOTS]*



Ans. Vasa efferentia, Vas deferens.

Q. 7. What is the role of cervix of the human female system in reproduction? *[NCERT Exemplar]* *[HOTS]*

Ans. Cervix helps in regulating the passage of sperms into the uterus and forms the birth canal to facilitate parturition.

Q. 8. Name the important mammary gland secretions that help in resistance of the new born baby. *[HOTS]*

Ans. Colostrum

Q. 9. Name the hormones produced only during pregnancy in a human female. Mention their source organ. *[CBSE (F) 2011]*

Ans. During pregnancy, placenta produces hormones like human chorionic gonadotropin and human placental lactogen and ovary produces relaxin.

Q. 10. List the changes that the primary ooctye undergoes in the tertiary follicular stage in the human ovary. *[CBSE (F) 2011]*

Ans. The primary oocyte within the tertiary follicle grows in size and completes its first meiotic division to form secondary oocyte and first polar body.

Q. 11. Female reproductive organs and associated functions are given below in column A and B. Fill in the blank boxes. *[NCERT Exemplar]* *[HOTS]*

Column A	Column B
Ovaries	Ovulation
Oviduct	A
B	Pregnancy
Vagina	Birth

Ans. A—Fertilisation B—Uterus

Q. 12. Name the embryonic stage that gets implanted in the uterine wall of a human female. *[CBSE (AI) 2011]*

Ans. Blastocyst/blastula.

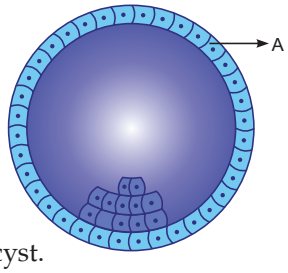
Q. 13. How is the entry of only one sperm and not many ensured into an ovum during fertilisation in humans? *[CBSE (AI) 2012]* *[HOTS]*

Ans. During fertilisation a sperm head comes in contact with zona pellucida layer of ovum and induces changes in the membrane that block the entry of additional sperms.

Q. 14. Mention the function of trophoblast in human embryo. *[CBSE Delhi 2011]* *[HOTS]*

Ans. Trophoblast is the outer layer of blastocyst which helps in the attachment of blastocyst to the endometrium of the uterus.

Q. 15. Identify the figure given below and the part labelled "*A*". *[CBSE (AI) 2012]* *[HOTS]*



Ans. The figure is of blastula/blastocyst.

A—Trophoblast.

Q. 16. Explain the function of umbilical cord. *[CBSE (AI) 2012]* *[HOTS]*

Ans. Umbilical cord transports nutrients and respiratory gases and metabolic wastes to and from mother and foetus.

Q. 17. What name is given to the cells of inner cell mass, that have the potential to give rise to all tissues and organs in a human being? *[HOTS]*

Ans. Stem cells

Q. 18. What is corona radiata?

Ans. The follicle cells that envelope the egg outside zona pellucida are called corona radiata.

Q. 19. Which part of the blastula is destined to form the germ layers of the developing embryo in humans? *[HOTS]*

Ans. Inner cell mass

Q. 20. Given below are the stages in human reproduction. Write them in correct sequential order.

Insemination, Gametogenesis, Fertilisation, Parturition, Gestation, Implantation

[NCERT Exemplar] *[HOTS]*

Ans. Gametogenesis, Insemination, Fertilisation, Implantation, Gestation, Parturition.

Short Answer Questions [2 marks]

Q. 1. Why are the human testes located outside the abdominal cavity? Name the pouch in which they are present. *[CBSE (AI) 2012, 2014]* *[HOTS]*

Ans. The human testes need lower temperature, 2 – 2.5°C less than the body temperature, for the formation of sperms which is provided outside the body.

Testes are present in scrotal sac or scrotum.

Q. 2. What is the number of chromosomes in the following cells of a human male? *[HOTS]*

(*i*) Spermatogonial cells **(*ii*) Spermatids**

(*iii*) Primary spermatocytes **(*iv*) Sertoli cells**

Ans. (*i*) 46 (*ii*) 23

(*iii*) 46 (*iv*) 46.

Q. 3. (*i*) How many spermatozoa are formed from one secondary spermatocyte?

(*ii*) Where does the first cleavage division of zygote take place? [*NCERT Exemplar*] [*HOTS*]

Ans. (*i*) Two

(*ii*) During the passage of zygote from fallopian tube to the uterus.

Q. 4. Draw a diagram of a human sperm. Label only those parts along with their functions, that assist the sperm to reach and gain entry into the female gamete. [*CBSE (F) 2014*]

Ans. Refer to Fig. 3.10.

Q. 5. Where is acrosome present in humans? Write its function. [*CBSE (AI) 2012*] [*HOTS*]

Ans. Acrosome is present on the sperm head. It has enzymes to help the sperm enter into the cytoplasm of ovum through zona pellucida and plasma membrane to facilitate entry of sperm nucleus for fertilisation.

Q. 6. Write the function of each of the following:

(*a*) Middle piece in human sperm.

(*b*) Luteinising hormone in human males. [*CBSE Delhi 2012*]

Ans. (*a*) Provides energy for movement as it contains mitochondria.

(*b*) Stimulates synthesis and secretion of androgens or male hormones for spermatogenesis.

Q. 7. Write the function of each of the following:

(*a*) Seminal vesicle

(*b*) Acrosome of human sperm. [*CBSE Delhi 2012*]

Ans. (*a*) It is responsible for storage and transport of sperms. It provides secretions for motility and nourishment of sperms.

(*b*) It helps the sperm to enter into the cytoplasm of the ovum through the zona pellucida and provides enzymes for fertilisation.

Q. 8. Spermatogenesis in human males is a hormone regulated process. Justify. [*CBSE (F) 2010*]

Ans. Refer to Basic Concepts Point 3(*i*) (Hormonal control of spermatogenesis).

Q. 9. Write the location and functions of myometrium and endometrium. [*CBSE Delhi 2014; (F) 2016*]

Ans. Endometrium is the inner layer of uterus. It assists in cyclic changes during menstruation and implantation of embryo.

Myometrium is the middle layer of uterus. It consist of smooth muscles and thus assists in contractions of the uterus during parturition.

Q. 10. Where are fimbriae present in a human female reproductive system? Give their function.

Ans. The fimbriae are the finger-like projections present on the edges of infundibulum (fallopian tubes). They help in collection of ovum after ovulation.

Q. 11. Differentiate between major structural changes in the human ovary during the follicular and luteal phase of the menstrual cycle. [*CBSE (AI) 2010*]

Ans. **Table 3.1: Differences between follicular and luteal phases of mentrual cycle**

S. No.	Follicular phase	Luteal phase
(*i*)	During this, primary follicles grow to become fully mature Graafian follicle.	During this, remaining part of Graafian follicle transforms into corpus luteum.
(*ii*)	Endometrium regenerates through proliferation.	Endometrium further thickens secreting progesterone for implantation after fertilisation. If fertilisation does not occur, corpus luteum degenerates.

Q. 12. What is the number of chromosomes in the following cells of a human female? [*HOTS*]

(*i*) Primary oocyte **(ii) Ootid**

(iii) Secondary oocyte **(*iv*) Follicle cells**

Ans. (*i*) 46 (*ii*) 23

(*iii*) 23 (*iv*) 46

Q. 13. Corpus luteum in pregnancy has a long life. However, if fertilisation does not take place it remains active only for 10–12 days. Why? ***[NCERT Exemplar] [HOTS]***

Ans. This is because of a neural signal given by the maternal endometrium to its hypothalamus in presence of a zygote to sustain the gonadotropin (LH) secretion, so as to maintain the corpus luteum as long as the embryo remains there. In the absence of a zygote, therefore, the corpus luteum degenerates.

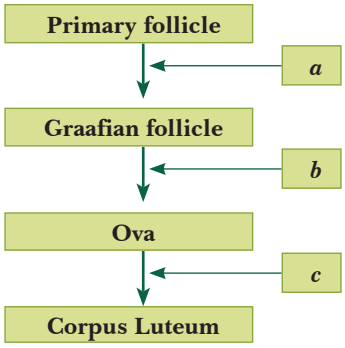
Q. 14. Why does corpus luteum secrete large amount of progesterone during luteal/secretory phase of the menstrual cycle? ***[HOTS]***

Ans. The hormone progesterone is essential for the maintenance of endometrium of the uterus. It maintains the endometrial lining of uterus so that the foetus may get implanted in the uterus. So, corpus luteum secretes large amounts of progesterone during the luteal phase of menstrual cycle.

Q. 15. Mention the fate of corpus luteum and its effect on the uterus in absence of fertilisation of the ovum in a human female. ***[CBSE (F) 2010]***

Ans. In the absence of fertilisation, corpus luteum degenerates and this causes disintegration of the endometrium of ovary, leading to menstruation.

Q. 16. Given below is a flow chart showing ovarian changes during menstrual cycle. Fill in the spaces with the hormonal factor(s) responsible for the events shown. ***[NCERT Exemplar]***



Ans. *a*: FSH and estrogen

b: LH

c: Progesterone

Q. 17. Explain the events that follow up to fertilisation when the sperms come in contact with the ovum in the fallopian tube of a human female. ***[CBSE (F) 2016]***

Ans. The secretion of the acrosome help the sperm enter into the cytoplasm of ovum through zona pellucida and the plasma membrane. This induce the completion of second meiotic division of the secondary oocyte, forming second polar body and a haploid ovum. Soon the haploid nucleus of the sperm and that of the ovum fuse together to form a diploid zygote.

Q. 18. Differentiate between menarche and menopause. ***[CBSE (AI) 2010]***

Ans. Menarche is the beginning of menstrual cycle at puberty. It starts at the age of 13–15 years. Menopause is the cessation of menstrual cycle. It happens around 50 years of age.

Q. 19. Mention the target cells of luteinising hormone in human males and females. Explain the effect and the changes which the hormone induces in each case.

Ans. The target cells of luteinising hormone (LH) in males are the Leydig cells and in females are the mature growing follicles.

LH in males stimulates the Leydig cells (interstitial cells) of testes to synthesise and secrete androgens which in turn stimulate the process of spermatogenesis. LH in females stimulate the ovulation (release of ovum) and transformation of Graafian follicle into corpus luteum to secrete progesterone which prepares the endometrium to receive and implant blastocyst.

Q. 20. Write the effect of the high concentration of LH on a mature Graafian follicle. [*CBSE (AI) 2014*]

Ans. In high conventration of LH, the mature Graafian follicle ruptures to release the secondary oocyte or ovum from the ovary by the process of ovulation.

Q. 21. After implantation interdigitation of maternal and foetal tissues takes place. Identify the tissues involved and justify their role. [*CBSE Sample Paper 2016*]

Ans. After implantation interdigitation of maternal and foetal tissues results in formation of structural and functional unit between embryo and maternal body called placenta.

It facilitates supply of oxygen and nutrients to the embryo, removal of carbon dioxide and excretory material and also acts as an endocrine tissue and produces hormones like HCG, hPL, estrogen, progesterone and relaxin.

Q. 22. What are the events taking place in the ovary and uterus during follicular phase of the menstrual cycle? [*NCERT Exemplar*]

Ans. (*i*) The primary follicles grow and become fully mature Graafian follicles.

(*ii*) Secretion of estrogen hormone.

(*iii*) Endometrium of uterus regenerates through proliferation.

Q. 23. Name two hormones that can be found only in the blood of a pregnant woman. Mention the source organ/tissue that secretes each of them. [*HOTS*]

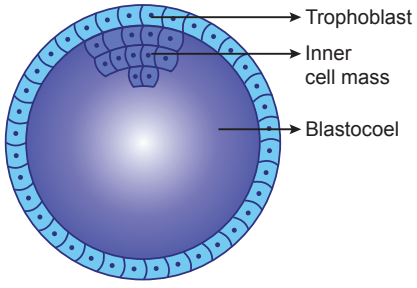
Ans. Human chorionic gonadotropin (hCG)—Placenta.

Human placental lactogen (hPL)—Placenta.

Relaxin (towards the end of pregnancy)—Ovary.

Q. 24. Draw a labelled diagram of a human blastocyst. How does it get implanted in the uterus? [*CBSE (F) 2013*]

Ans. Human blastocyst



The trophoblast layer of the blastocyst gets attached to the cells of the endometrium and the inner cell mass gives rise to the embryo. The cells of endometrium divide rapidly and cover the blastocyst. So, the blastocyst gets embedded in the endometrium of the uterus.

Q. 25. Differentiate with the help of diagrams only between morula and blastocyst of a human. [*CBSE (F) 2013*]

Ans. Refer to Fig. 3.15.

Q. 26. Write the function of each one of the following:

(*i*) (Oviducal) Fimbriae (*ii*) Oxytocin [*CBSE Delhi 2012*]

Ans. (*i*) Collection of ovum released by ovary.

(*ii*) Cause uterine contraction for parturition; promotes milk ejection.

Q. 27. State the fate of trophoblast of a human blastocyst at the time of implantation and that of the inner cell mass immediately after implantation. [*CBSE 2019 (57/5/2)*]

Ans. The trophoblast layer gets attached to the endometrium, and the inner cell mass gets differentiated as the embryo.

Q. 28. Placenta acts as an endocrine tissue. Justify. [*CBSE (AI) 2010*]

Ans. Placenta produces several hormones like human chorionic gonadotropin (hCG), human placental lactogen (hPL), estrogens, progesterones that are essential to maintain pregnancy. This way placenta acts as an endocrine tissue.

Q. 29. **(*i*) Where do the signals for parturition originate from in humans?** **[CBSE 2019 (57/4/1)]**

(*ii*) Why is it important to feed the newborn babies on colostrum? ***[CBSE (AI) 2012]***

Ans. (*i*) Signals for parturition originate from the fully developed foetus the placenta which induce uterine contractions. This is called as foetal ejection reflex. (*Any one*)

(*ii*) Colostrum contains antibodies (IgA), to (passively) immunise the baby.

Q. 30. **State the role of oxytocin in parturition. What triggers its release from the pituitary?** ***[CBSE (F) 2016]***

Ans. Oxytocin acts on uterine muscle and cause stronger uterine contraction. This leads to expulsion of the foetus or baby out of uterus.

Q. 31. **When and where do chorionic villi appear in humans? State their functions.** ***[CBSE Delhi 2013]***

Ans. Chorionic villi appear after implantation on the trophoblast. It becomes interdigitated with uterine tissue to form the placenta and increases the surface area for exchange of materials between the mother and the embryo.

Q. 32. **Why is breast-feeding recommended during the initial period of an infant's growth? Give reasons.** ***[CBSE Delhi 2016]***

OR

Medically it is advised to all young mothers that breast feeding is the best for their newborn babies. Do you agree? Give reasons in support of your answer.

Ans. The milk produced during the initial few days of lactation is called colostrum. It contains several antibodies (IgA) absolutely essential, to develop passive immunity in the new-born babies. It also contains nutrients such as calcium, fats, lactose. Breast feeding also develops a bond between mother and child.

Q. 33. **What stimulates pituitary to release the hormone responsible for parturition? Name the hormone.** ***[CBSE (AI) 2011]*** **[*HOTS*]**

Ans. The signal from the fully developed foetus and placenta or the foetal ejection reflex induces mild uterine contraction. The hormone released is oxytocin.

Q. 34. **Women experience two major events in their life time, one at menarche and the second at menopause. Mention the characteristics of both the events.** ***[NCERT Exemplar]***

Ans. Menarche represents the beginning of menstrual cycle which is an indication of attainment of sexual maturity. Menopause, on the other hand, refers to the cessation of menstruation which in turn means stoppage of gamete production, *i.e.*, it marks the end of reproductive or fertile life of the female.

Long Answer Questions–I [3 marks]

Q. 1. **(*i*) Draw a sectional view of seminiferous tubule of a human. Label the following cells in the seminiferous tubule:**

(*a*) Cells that divide by mitosis to increase their number.

(*b*) Cells that undergo Meiosis I.

(*c*) Cells that undergo Meiosis II.

(*d*) Cells that help in the process of spermiogenesis.

(*ii*) Mention the role of Leydig cells.

OR

Draw a labelled sectional view of seminiferous tubule of a human male.

[CBSE Delhi 2010, 2014, 2017; (F) 2015; 2019 (57/2/1), (57/5/1)]

Ans. (*i*) Refer to Fig. 3.8.

(*a*) Cells that divide by mitosis to increase their number—Spermatogonia

(*b*) Cells that undergo Meiosis I—Primary spermatocytes

(*c*) Cells that undergo Meiosis II—Secondary spermatocytes

(*d*) Cells that help in the process of spermiogenesis—Sertoli cells

(*ii*) Role of Leydig cells: They synthesise and secrete testicular hormones called androgens.

Q. 2. Draw a diagram of the microscopic structure of human sperm. Label the following parts in it and write their functions.

(*i*) Acrosome (*ii*) Nucleus (*iii*) Middle piece [*CBSE Delhi 2013; (AI) 2013*]

OR

Draw a diagram of a human sperm. Label only those parts along with their functions, that assist the sperm to reach and gain entry into the female gamete. [*CBSE (F) 2014*]

OR

Draw a diagram of a mature human sperm. Label any three parts and write their functions. [*CBSE 2018*]

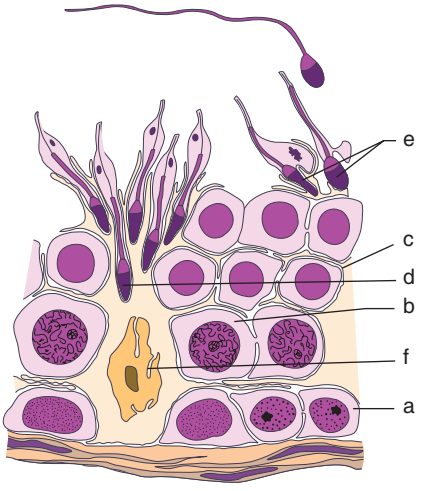
Ans. For diagram refer to Fig. 3.10.

(*i*) Acrosome: Contains hydrolytic enzymes that help in dissolving membranes of the ovum for fertilisation.

(*ii*) Nucleus: Carries genetic material of male.

(*iii*) Middle piece: Contains a number of mitochondria that provide energy for the movement of the tail that facilitate sperm motility.

Q. 3. Study the figure given below:



(*i*) What is being depicted in the diagram?

(*ii*) Name '*a*' and '*b*' cells. What is the difference between them with reference to the number of chromosomes?

(*iii*) Pick out and name the motile cells.

(*iv*) What is '*f*' cell? Mention its function.

(*v*) Name the structure of which the given diagram is a part.

Ans. (*i*) The seminiferous tubule is being depicted in the diagram.

(*ii*) *a*—Spermatogonium, *b*—Primary spermatocyte

They both are diploid and have 46 chromosomes each.

(*iii*) *e*—Spermatozoa

(*iv*) *f*—Sertoli cell. It provides nutrition to the germ cells.

(*v*) Seminiferous tubule.

Q. 4. Explain the hormonal control of spermatogenesis in humans. [*CBSE (F) 2014*]

Ans. Refer to Basic concept 3 (*i*) Hormonal control of spermatogenesis.

Q. 5. (*i*) Draw a sectional view of human ovary and label [*CBSE (F) 2013; CBSE 2019 (57/4/1)*]

(*a*) Primary follicle (*b*) Graafian follicle (*c*) Corpus luteum

(*ii*) Mention the effect of pituitary hormones on the parts labelled.

Ans. (*i*) Refer to Fig. 3.12.

(*ii*) The pituitary hormones FSH and LH effect the growth and development of primary follicle, Graafian follicle and corpus luteum.

Q. 6. Construct a flow chart exhibiting sequential events of oogenesis. **[*CBSE 2019 (57/2/1)*]**

Ans. Refer to Fig. 3.11.

Q. 7. Name the hormones influencing (i) ovulation, (ii) development of corpus luteum. **[CBSE (F) 2015]**

Ans. **(*i*) Ovulation:** Gonadotropins like luteinising hormone and follicular stimulating hormone, and estrogen.

(*ii*) Development of corpus luteum: Luteinising hormone and progesterone.

Q. 8. Explain the steps in the formation of an ovum from an oogonium in humans. **[*CBSE (AI) 2013*]**

Ans. Refer to Basic Concepts Point 3 (*ii*).

Q. 9. (*i*) Draw a diagram of the structure of a human ovum surrounded by corona radiata. Label the following parts:

(*a*) Ovum (*b*) Plasma membrane (*c*) Zona pellucida

(*ii*) State the function of zona pellucida. **[*CBSE Delhi 2013*]**

Ans. (*i*) Refer to Fig. 3.14.

(*ii*) Zona pellucida allows the entry of one sperm into the cytoplasm of the ovum and then undergoes changes to prevent entry of additional sperms.

Q. 10. Draw the following diagrams related to human reproduction and label them.

(*i*) The zygote after the first cleavage division

(*ii*) Morula stage

(*iii*) Blastocyst stage (sectional view) **[*CBSE Delhi 2013*]**

Ans. Refer to Fig. 3.15.

Q. 11. Name the stage of human embryo at which it gets implanted. Explain the process of implantation. **[*CBSE Delhi 2015*]**

OR

Draw a labelled diagram of a human blastocyst. How does it get implanted in the uterus? **[*CBSE (F) 2013*]**

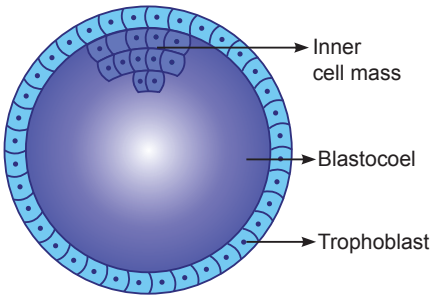
Ans. Refer to Fig. 3.15(*g*).

The human embryo gets implanted at blastocyst stage.

The trophoblast layer of the blastocyst get attached to the endometrium and the inner cell mass gets differentiated as the embryo. After attachment the uterine cell divides rapidly and covers the blastocyst. As a result the blastocyst becomes embedded in the endometrium of the uterus.

Q. 12. Draw a labelled diagram of the embryonic stage that gets implanted in the human uterus. State the functions of the two parts labelled. **[*CBSE (F) 2016*]**

Ans.



- Trophoblast helps in implantation or attachment to endometrium.
- Inner cell mass gets differentiated into an embryo.

Q. 13. (*i*) Draw a labelled diagrammatic view of human male reproductive system.
(*ii*) Differentiate between:
(*a*) Vas deferens and vasa efferentia
(*b*) Spermatogenesis and spermiogenesis ***[CBSE Delhi 2014]***

Ans. (*i*) Refer to Fig. 3.2.

(*ii*) (*a*) **Table 3.2: Differences between vas deferens and vasa efferentia**

S.No.	Vas deferens	Vasa efferentia
(*i*)	Carries sperm from epididymis to urethra.	Carries sperm from testis to epididymis.
(*ii*)	One in number from each testis.	Many in number.

(*b*) **Table 3.3: Difference between spermatogenesis and spermiogenesis**

Spermatogenesis	Spermiogenesis
Process of production of sperms (by meiosis).	Process by which spermatids are transformed to spermatozoa.

Q. 14. Name the source of gonadotropins in human females. Explain the changes brought about in the ovary by these hormones during menstrual cycle.

OR

Describe how the changing levels of FSH, LH and progesterone during menstrual cycle induce changes in the ovary and the uterus in human female. ***[CBSE (F) 2011]***

Ans. Gonadotropins (LH and FSH) are secreted by the anterior lobe of pituitary gland.

- Gonadotropins (LH and FSH) increase gradually during the follicular phase (proliferative phase) of menstrual cycle and stimulate follicular development as well as secretion of estrogen by the growing follicles.
- LH and FSH attain a peak level in the middle of the cycle (about 14th day) and rapid secretion of LH induces rupture of Graafian follicle followed by ovulation (release of ovum).
- LH stimulates transformation of Graafian follicle into corpus luteum.

Q. 15. When and where do chorionic villi appear in humans? State their function. ***[CBSE Delhi 2013]***

Ans. Chorionic villi appear after implantation on the trophoblast.

It becomes interdigitated with uterine tissue to form the placenta and increases the surface area for exchange of materials between the mother and the embryo.

Q. 16. (*i*) How is placenta formed in the human female?
(*ii*) Name any two hormones which are secreted by it and are also present in a non-pregnant woman. ***[CBSE (F) 2014]***

Ans. (*i*) The chorionic villi and uterine tissue become interdigitated with each other and jointly form a structural and functional unit called placenta.

(*ii*) Estrogen and progestogens.

Q. 17. It is commonly observed that parents feel embarrassed to discuss freely with their adolescent children about sexuality and reproduction. The result of this parental inhibition is that the children go astray sometimes.
(*i*) Explain the reasons that you feel are behind such embarrassment amongst some parents to freely discuss such issues with their growing children.
(*ii*) By taking one example of a local plant and animal, how would you help these parents to overcome such inhibitions about reproduction and sexuality? ***[CBSE (AI) 2017]***

Ans. (*i*) The reasons behind this embarrassment are illiteracy, their conservative attitude, misconceptions, social myths and generation gap.

(*ii*) It can be seen in animals such as honey bee and plants such as orchid *ophrys* flower that sexual attraction is a natural phenomenon. The male honey bee assumes the petal of orchid as its female partner and pseudocopulates with it. So, sexuality is a natural phenomenon and parents should speak to their children about it.

Q. 18. Distinguish between:

(*a*) Corona radiata and Zona pellucida

(*b*) Blastula and Gastrula

Ans. (*a*)

Table 3.4: Differences between corona radiata and zona pellucida

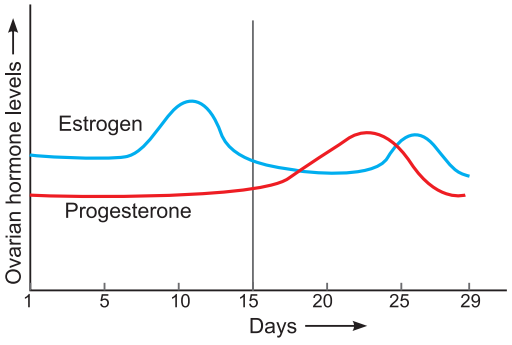
S. No.	Corona radiata	Zona pellucida
(*i*)	It consists of follicle cells.	It is a single membrane.
(*ii*)	It envelops the egg outside the zona pellucida.	It is above the vitelline membrane making the membrane thick.
(*iii*)	The cells provide nourishment to the egg at the time of release from the ovary.	It protects the egg and shows changes that block entry of additional sperms.

(*b*)

Table 3.5: Differences between blastula and gastrula

S. No.	Blastula	Gastrula
(*i*)	It is a hollow ball of cells with trophoblast and inner cell mass.	It is a three-layered embryo—3 germ layers being ectoderm, mesoderm and endoderm.
(*ii*)	The cavity of the blastula is known as the blastocoel.	The cavity of the gastrula is known as archenteron.
(*iii*)	It results after the cleavage.	It is formed from blastula due to the movement of cells into 3 germ layers.

Q. 19.



Read the graph given above showing the levels of ovarian hormones during menstruation and correlate the uterine events that take place according to the hormonal levels on:

(*i*) 6–15 days

(*ii*) 16–25 days

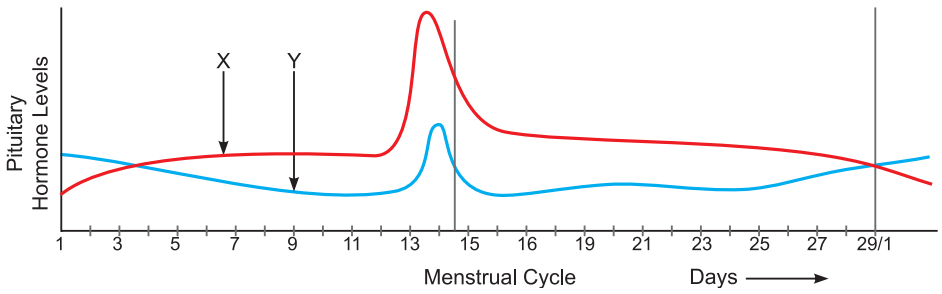
(*iii*) 26–28 days (if the ovum is not fertilised) ***[CBSE Sample Paper 2014]***

Ans. (*i*) Regeneration of endometrium.

(*ii*) Uterus gets highly vascularised, ready for embryo implantation.

(*iii*) Disintegration of the endometrium leading to menstruation.

Q. 20. Study the graph given below and answer the questions that follow: [*HOTS*]



(*a*) Name the hormones '*X*' and '*Y*'.

(*b*) Explain the ovarian events (*i*), (*ii*) and (*iii*) under the influence of hormones '*X*' and '*Y*'.

Ans. (*a*) **Hormone '*X*':** Luteinising hormone.

Hormone '*Y*': Follicle stimulating hormone.

(*b*) (*i*) FSH is secreted by the anterior pituitary which stimulates the ovarian follicle to secrete estrogen, which in turn stimulates the proliferation of the endometrium of the uterine wall.

(*ii*) Both LH and FSH attain a peak level in the middle of cycle (about 14th day). Rapid secretion of LH leading to its maximum level during the mid-cycle called LH surge induces rupture of Graafian follicle and thereby the release of ovum (ovulation).

(*iii*) The remaining cells of ovarian follicles are stimulated by the LH to transform into corpus luteum. The corpus luteum secretes large amount of progesterone which is essential for maintenance of the endometrium.

Long Answer Questions–II [5 marks]

Q. 1. (*i*) Draw a diagrammatic labelled sectional view of a seminiferous tubule of a human.

(*ii*) Describe in sequence the process of spermatogenesis in humans. [*CBSE (AI) 2010*]

Ans. (*i*) Refer to Fig. 3.8.

(*ii*) Refer to Basic Concepts Point 3(*i*).

Q. 2. (*a*) Draw a diagrammatic sectional view of a human seminiferous tubule, and label Sertoli cells, primary spermatocyte, spermatogonium and spermatozoa in it.

(*b*) Explain the hormonal regulation of the process of spermatogenesis in humans. [*CBSE Delhi 2013; (AI) 2013*]

Ans. (*a*) Refer to Fig. 3.8.

(*b*) Refer to Fig. 3.9.

Q. 3. (*a*) Write the specific location and the functions of the following cells in human males:

(*i*) Leydig cells (*ii*) Sertoli cells

(*iii*) Primary spermatocyte. [*CBSE (AI) 2014*]

(*ii*) Explain the role of any two accessory glands in human male reproductive system. [*CBSE Delhi 2011*]

Ans. (*a*)

	Cells	Location	Function
(*i*)	Leydig cells	Outside seminiferous tubules in interstitial space	Synthesis and secretion of testicular hormones called androgens.
(*ii*)	Sertoli cells	Inside the seminiferous tubules	Provide nutrition to the germ cells.
(*iii*)	Primary spermatocyte	Inner wall of seminiferous tubules	Undergo meiotic divisions to form secondary spermatocyte and then haploid sperms.

(*b*) The two accessory glands are:

(*i*) Prostate gland: It surrounds the urethra and produces a milky secretion which forms a considerable part of semen. This secretion contains citric acid, lipids and enzymes. The secretion nourishes and activates the spermatozoa to swim.

(*ii*) Seminal vesicles: These secrete mucous and a watery alkaline fluid that contains fructose which provides energy to the sperms.

Q. 4. (*a*) Where does spermatogenesis occur in human testes? Describe the process of spermatogenesis upto the formation of spermatozoa.

(*b*) Trace the path of spermatozoa from the testes upto the ejaculatory duct only.

[*CBSE (F) 2016*]

OR

Schematically represent and explain the events of spermatogenesis in humans.

[*CBSE (AI) 2014*]

Ans. (*a*) Spermatogenesis occur in seminiferous tubules.

For process, refer to Fig. 3.7.

(*b*) The path of spermatozoa is as follows:

Seminiferous tubules ⟶ Rete testis ⟶ Vasa efferentia ⟶ Epididymis ⟶ Vas deferens ⟶ Ejaculatory duct

OR

Refer to Fig. 3.7.

Q. 5. (*a*) When and where does spermatogenesis occur in a human male?

(*b*) Draw a diagram of a mature human male gamete. Label the following parts: Acrosome, nucleus, middle piece and tail. **[*CBSE (AI) 2010; Delhi 2011*]**

(*c*) Mention the functions of acrosome and middle piece.

Ans. (*a*) Spermatogenesis occurs at puberty in testes.

(*b*) Refer to Fig. 3.10.

(*c*) **Acrosome:** Acrosome contains hydrolytic enzymes that help in dissolving membranes of the ovum for sperm entry, ensuring fertilisation.

Middle piece: It contains a number of mitochondria that provide energy for the movement of the tail and thus provides motility to sperm.

Q. 6. (*a*) Draw a schematic diagram of a human sperm and label the cellular components. Give the functions of any three parts.

(*b*) Where are the sperm heads found embedded to survive after spermatogenesis?

Ans. (*a*) Refer to Basic Concepts Point 3(*i*) (Structure of sperm) and Fig. 3.10.

(*b*) The sperm head becomes embedded in the Sertoli cells.

Q. 7. (*i*) Draw a diagrammatic sectional view of the female reproductive system of human and label the parts

(*a*) where the secondary oocytes develop

(*b*) which helps in collection of ovum after ovulation

(*c*) where fertilisation occurs

(*d*) where implantation of embryo occurs.

(*ii*) Explain the role of pituitary and the ovarian hormones in menstrual cycle in human females. **[*CBSE Delhi 2013*]**

Ans. (*i*) Refer to Fig. 3.5.

(*ii*) Pituitary hormone:

(*a*) FSH stimulates maturation of follicle.

(*b*) Rapid secretion of LH (LH surge) induces rupture of Graafian follicle, thereby leading to ovulation (release of ovum).

Ovarian hormone:

(*a*) Estrogen stimulates follicular development.

(*b*) Progesterone produced by corpus luteum helps to maintain endometrium.

In the absence of fertilisation corpus luteum degenerates and the endometrium disintegrates leading to menstruation.

Q. 8. Explain the different stages of oogenesis in humans starting from foetal life till its completion. When and where in the body is oogenesis completed?

Ans. Refer to Basic Concepts Point 3(*ii*).

For diagram, refer to Fig. 3.11.

Q. 9. When and where are primary oocytes formed in a human female? Trace the development of these oocytes till ovulation (in menstrual cycle). How do gonadotropins influence this developmental process? [CBSE Delhi 2010]

Ans. Refer to Basic Concepts Point 3(*ii*).

For diagram, refer to Fig. 3.11.

Q. 10. (*a*) At which stage of life does gametogenesis begin in human male and female respectively?

(*b*) Name the organs where gametogenesis gets completed in human male and female, respectively.

Ans. (*a*) Gametogenesis, *i.e.*, spermatogenesis in males starts at puberty and oogenesis in females, start during embryonic development at foetal stage.

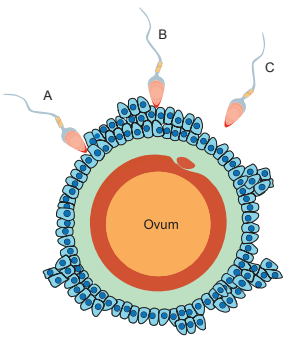
(*b*) In human males, the process is completed in the testes (seminiferous tubules) whereas in females, it is completed in the fallopian tube (oviduct).

Q. 11. Meiotic division during oogenesis is different from that in spermatogenesis. Explain how and why? [*NCERT Exemplar*]

Ans. Unequal cytoplasmic division of the oocyte is to ensure the retention of bulk of cytoplasm in one cell called secondary oocyte instead of sharing it with two. It has to provide nourishment for the developing embryo during early stages, so it is essential to retain as much cytoplasmic materials it could in a single daughter cell.

For diagrams, refer to Fig. 3.7 and Fig. 3.11.

Q. 12. Given alongside is the diagram of a human ovum surrounded by a few sperms. Observe the diagram and answer the following questions:



(*a*) Compare the fate of sperms shown in the diagram.

(*b*) What is the role of zona pellucida in this process?

(*c*) Analyze the changes occurring in the ovum during the process.

(*d*) Mention what helps in the entry of sperm into the ovum.

(*e*) Specify the region of female reproductive system where the event represented in the diagram takes place. [*CBSE Sample Paper 2015, 2017, 2018*] [*HOTS*]

Ans. (*a*) A is able to penetrate/fertilize the ovum, whereas B and C are unable to penetrate/fertilise B and C will degenerate.

(*b*) Zona pellucida ensures the entry of only one sperm into the ovum

(*c*) Induces completion of meiotic division of the secondary oocyte, formation of second polar body and a haploid ovum

(*d*) Enzymes of acrosome

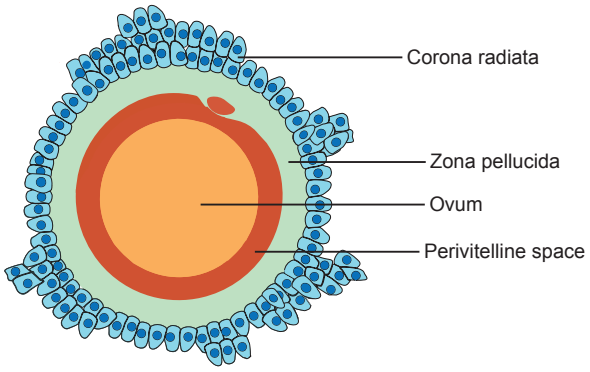
(*e*) Ampullary-isthmic junction of the fallopian tube

Q. 13. (*a*) Describe the stages of oogenesis in human females.

(*b*) Draw a labelled diagram of a human ovum released after ovulation. [*CBSE Delhi 2011*]

Ans. (*a*) Refer to Basic Concepts Point 3(*ii*).

(*b*)



Q. 14. (*a*) How is 'oogenesis' markedly different from 'spermatogenesis' with respect to the growth till puberty in the humans?

(*b*) Draw a sectional view of human ovary and label the different follicular stages, ovum and corpus luteum. ***[CBSE Delhi 2014]***

Ans. (*a*) Oogenesis is initiated at the embryonic stage whereas spermatogenesis begins only at puberty.

(*b*) Refer to Fig. 3.12.

Q. 15. Describe the change that occur in ovaries and uterus in human female during the reproductive cycle. ***[CBSE Delhi 2015]***

Ans. Refer to Figure 3.13 or Basic Concepts Point 4.

Q. 16. Enumerate the events in the ovary of a human female during:

(*i*) Follicular phase

(*ii*) Luteal phase of menstrual cycle. ***[CBSE Delhi 2011]***

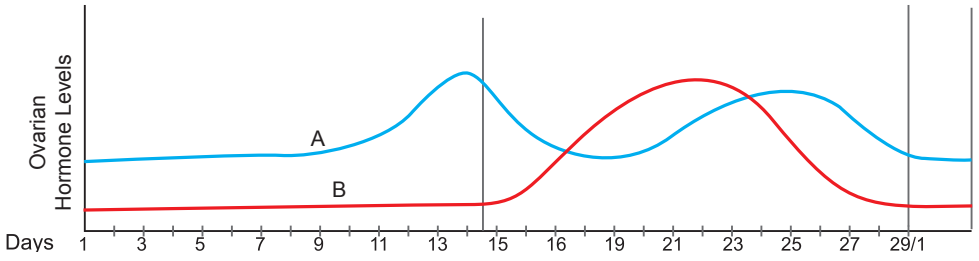
Ans. (*i*) In the follicular phase, following events occur:

1. The primary follicles in the ovary grow to form a fully mature Graafian follicle.
2. The endometrium of uterus regenerates through proliferation.
3. The secretion of gonadotropins (LH and FSH) gradually increases.

(*ii*) In the luteal phase, following events occur:

1. The parts of Graafian follicle remaining after the rupture, transform into the corpus luteum.
2. The corpus luteum secretes large amounts of progesterone.

Q. 17. The graph given below shows the variation in the levels of ovarian hormones during various phases of menstrual cycle:



(*a*) Identify 'A' and 'B'.

(*b*) Specify the source of the hormone marked in the diagram.

(*c*) Reason out why A peaks before B.

(*d*) Compare the role of A and B. ***[CBSE Sample Paper 2015, 2017, 2018]*** **[*HOTS*]**

(*e*) Under which condition will the level of B continue to remain high on the 28th day?

Ans. (*a*) A – Estrogen

B – Progesterone

(*b*) A – Maturing ovarian follicle/Graafian follicle

B – Corpus luteum

(*c*) Formation of Graaffian follicle (releases estrogen) is followed by the formation of corpus luteum (releases progesterone)

(*d*) **Role of A (Estrogen):** leads to changes in the ovary and uterus / regeneration of endometrium through proliferation

Role of B (Progesterone): Maintenance of endometrium for implantation of the fertilized ovum/maintenance of other events of pregnancy

(*e*) In case of pregnancy.

Q. 18. Explain the ovarian and uterine events that occur during a menstrual cycle in a human female, under the influence of pituitary and ovarian hormones respectively. ***[CBSE Delhi 2014]***

Ans. Release of gonadotropins (FSH and LH) from pituitary, during follicular phase or 5-14 days of menstrual cycle leads to growth of primary follicle to Graafian follicle (GF.) in the ovary. Estrogen from growing follicle helps in proliferation of uterine endometrium or its repair. High level of LH at middle, *i.e.*, 14th day of the menstrual cycle, leads to rupture of GF causing release of ovum. This is called ovulation. The remaining cells of GF transform into corpus luteum (CL) under the influence of LH. CL secretes progesterone that maintains endometrium in preparation for pregnancy. Level of FSH and LH fall due to rise of progesterone and estrogen (25th day of the cycle), leading to degeneration of CL. Level of progesteron falls, leading to disintegration of uterine endometrium and menstruation starts (0-5 day of the cycle).

Q. 19. Write the duration and the events that occur in the ovary and the uterus during follicular and luteal phases of the menstrual cycle in humans.

How do pituitary and ovarian hormones influence these two phases ? ***[CBSE 2019 (57/5/1)]***

Ans. Refer to Basic Concepts Point 4(*ii*) and (*iv*).

Refer to question above.

Q. 20. Explain the development of a secondary oocyte (ovum) in human female from the embryonic stage upto its ovulation. Name the hormones involved in this process. ***[CBSE Delhi 2015]***

Ans. Refer to Fig. 3.11.

Hormones involved are:

- LH (Luteinising hormone)
- FSH (Follicle stimulating hormone)
- Estrogen

Q. 21. Explain the process of fertilisation in human female, and trace the post-fertilisation events in a sequential order up to implantation of the embryo. ***[CBSE (F) 2010]***

OR

Explain the process of fertilisation and implantation in humans. ***[CBSE (F) 2015]***

Ans. Refer to Basic Concepts Points 5 and 6.

Q. 22. (*i*) Explain the events taking place at the time of fertilisation of an ovum in a human female.

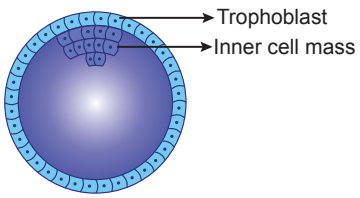
(*ii*) Trace the development of the zygote up to its implantation in the uterus.

(*iii*) Name and draw a labelled sectional view of the embryonic stage that gets implanted. ***[CBSE Delhi 2010]***

Ans. **(*i*) Fertilisation:** Refer to Basic Concepts Point 5.

(*ii*) Implantation: Refer to Basic Concepts Point 6.

(*iii*)



(Blastocyst)

Q. 23. (*a*) Draw a diagrammatic sectional view of human ovary showing different stages of oogenesis along with corpus luteum.

(*b*) Where is morula formed in humans? Explain the process of its development from zygote. **[*CBSE Sample Paper 2014*]**

Ans. (*a*) Refer to Fig. 3.12.

(*b*) Morula is formed in the upper portion of oviduct, *i.e.*, isthmus. The haploid nucleus of the sperms and that of the ovum fuse together to form a diploid zygote. Zygote divides rapidly as it moves through the isthmus of the oviduct by mitotic division called cleavage and as a result 2, 4, 8, 16 daughter cells are produced, which are termed as blastomeres. The embryo with 8–16 blastomeres is called a morula.

Q. 24. Describe the post-zygotic events leading to implantation and placenta formation in humans. Mention any two functions of placenta. **[*CBSE (AI) 2010; (57/3/1) 2019*]**

OR

(*a*) Briefly explain the events of fertilisation and implantation in an adult human female.

(*b*) Comment on the role of placenta as an endocrine gland. **[*CBSE Delhi 2016*]**

Ans. Refer to Basic Concepts Points 5, 6 and 7.

For diagram, refer to Fig. 3.14 and Fig. 3.15.

Functions of placenta:

(*i*) Transports substances like nutrients, O_2 and CO_2 to and from the embryo.

(*ii*) Acts as an endocrine tissue and produces hormones like human chorionic gonadotropin (hCG), human placental lactogen (hPL), estrogens and progesterones to maintain pregnancy.

Q. 25. Study the following flow chart. Name the hormones involved at each stage. Explain their functions.

Hypothalamus ⟶ Pituitary ⟶ Testes ⟶ Sperms

Ans. Hypothalamus $\xrightarrow{\text{GnRH}}$ Pituitary $\xrightarrow{\text{LH and FSH}}$ Testes $\xrightarrow[\text{(Testosterone)}]{\text{Androgen}}$ Sperms

- Hypothalamus secretes gonadotropin releasing hormone (GnRH) which stimulates the anterior lobe of pituitary gland to secrete LH (Luteinising hormone) and FSH (Follicle stimulating hormone).
- LH stimulates Leydig cells for the secretion of testosterone from the testes.
- FSH stimulates Sertoli cells of the testes to secrete an androgen-binding protein (ABP) that concentrates testosterone in seminiferous tubules. It also causes the secretion of some factors which help in spermiogenesis.

Q. 26. Describe the roles of pituitary and ovarian hormones during the menstrual cycle in a human female. **[*CBSE (AI) 2015*]**

Ans. **Pituitary hormones**

FSH: Secreted by the anterior lobe of pituitary gland, it stimulates follicular development as well as secretion of estrogens by the growing follicles.

LH: (*a*) It induces rupture of Graafian follicle and thereby release of ovum (ovulation).

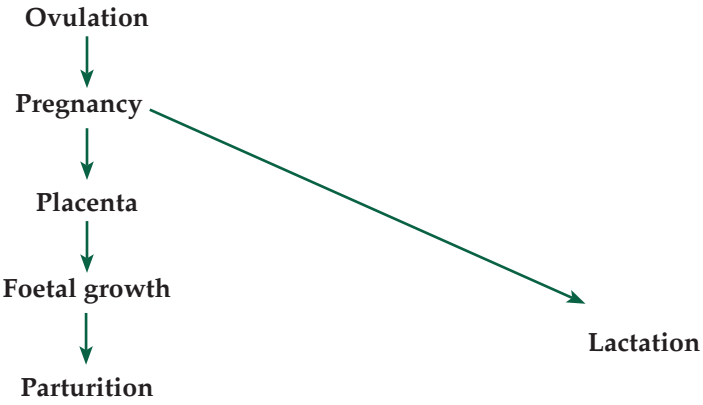
(*b*) Its secretion also stimulates follicular development along with FSH.

Ovarian hormones

Estrogen: It stimulates the proliferation of the endometrium of the uterine wall.

Progesterone: It is essential for maintenance of the endometrium for implantation of fertilised ovum and other events of pregnancy. It is secreted by corpus luteum.

Q. 27. Study the flow chart given below. Name the hormones involved at each stage and explain their role. ***[CBSE (F) 2010]***



Ans.
- Rapid release of luteinising hormone ruptures Graafian follicle and release ovum (ovulation).
- Corpus luteum secretes large amount of progesterone hormone that is essential for maintenance of the endometrium required for implantation of blastocyst leading to pregnancy.
- Placenta produces several hormones like human chorionic gonadotropin (hCG), human placental lactogen (hPL). Relaxin is also produced during later phase of pregnancy. Level of other hormones like estrogens, progestogens, cortisol, prolactin and thyroxine also increases which is essential for supporting foetal growth, metabolic changes in mother and maintenance of pregnancy.
- Parturition signals originate from the fully developed foetus and the placenta induce mild uterine contractions which triggers release of oxytocin from pituitary. Oxytocin acts on the uterine muscle causing stronger uterine contractions.
- Mammary glands undergo differentiation during pregnancy and produce milk by lactation. Secretion and storage of milk occurs under influence of hormone. Prolactin secreted by anterior lobe of pituitary. Ejection of milk is stimulated by oxytocin from posterior lobe of pituitary.

Q. 28. During the reproductive cycle of a human female, when, where and how does a placenta develop? What is the function of placenta during pregnancy and embryo development? ***[CBSE Delhi 2015]***

Ans. After implantation, uterus, chorionic villi and uterine tissue become interdigitated (physically fused) to form a structural and functional unit between the developing embryo and the maternal body called placenta.

Functions:

(*a*) Placenta facilitates supply of oxygen and nutrients to the embryo.

(*b*) Removes carbon dioxide, waste material and excretory material produced by the embryo.

(*c*) Produces hCG/hPL, estrogens and progestrogens.

Q. 29. (*a*) Explain the menstrual phase in a human female. State the levels of ovarian and pituitary hormones during this phase.

(*b*) Why is follicular phase in the menstrual cycle also referred as proliferative phase? Explain.

(*c*) Explain the events that occur in a graafian follicle at the time of ovulation and thereafter.

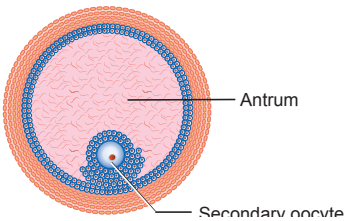
(*d*) Draw a Graafian follicle and label antrum and secondary oocyte. ***[CBSE (AI) 2016]***

Ans. (*a*) Refer to Basic Concepts Point 4(*i*) or Fig. 3.13.

(*b*) Primary follicle grows into Graafian follicle under the influence of LH and FSH leading to regeneration of endometrium (under the influence of estrogen).

(*c*) Graafian follicle ruptures to release the ovum (secondary oocyte) and remaining parts of the Graafian follicle gets transformed into corpus luteum.

(*d*)



Q. 30. (*a*) Explain menstrual cycle in human females.

(*b*) How can the scientific understanding of the menstrual cycle of human females help as a contraceptive measure? [*CBSE Delhi 2018*]

Ans. (*a*) Refer to Basic Concepts Points 4.

(*b*) By understanding the menstrual cycle a couple can abstain from coitus from day 10–17 of the menstrual cycle, when ovulation is expected to occur and can thus prevent pregnancy.

Q. 31. (*a*) Describe the events of spermatogenesis with the help of a schematic representation.

(*b*) Write two differences between spermatogenesis and oogenesis. [*CBSE Delhi 2013*]

Ans. (*a*) Refer to Fig. 3.7.

(*b*) **Table 3.5: Differences between spermatogenesis and oogenesis**

S.No.	Spermatogenesis	Oogenesis
(*i*)	It is the process of formation of haploid spermatozoa from diploid male germ cells of the testes.	It is the process of formation of haploid ova from the gamete mother cells (oogonia) in the ovary.
(*ii*)	It occurs in testes.	It occurs in ovaries.
(*iii*)	Spermatogonia changes to primary spermatocyte.	Oogonia changes to primary oocyte.
(*iv*)	A primary spermatocyte divides to form two secondary spermatocytes by meiosis I.	A primary oocyte divides by meiosis I to form one secondary oocyte and a polar body.
(*v*)	A secondary spermatocyte divides to form two spermatids by meiosis II.	A secondary oocyte divides by meiosis II to form ovum and a polar body.
(*vi*)	No polar body is formed.	Polar bodies are formed.
(*vii*)	Four spermatozoa are produced from one primary spermatocyte.	One ovum/egg is produced from 1 primary oocyte.

[*Any two*]

Q. 32. (*a*) Name the hormones secreted and write their functions:

(*i*) by corpus luteum and placenta (any two).

(*ii*) during follicular phase and parturition.

(*b*) Name the stages in a human female where:

(*i*) Corpus luteum and placenta co-exist.

(*ii*) Corpus luteum temporarily ceases to exist. [*CBSE Delhi 2017*]

Ans. (*a*)

		Hormones Secreted	Their functions
(*i*)	By corpus luteum	1. Progesterone 2. Estradiol	Essential for maintaining endometrium for implantation of fertilised ovum. It also inhibits release of FSH.
	By placenta	1. Human Placental Lactogen	Stimulates the growth of the mammary glands during pregnancy.
		2. hCG (Human chorionic gonadotropin)	Maintains corpus luteum in pregnancy and stimulates release of progesterone.

(*ii*)	During follicular phase	1. LH 2. FSH	Stimulates follicular development as well as secretion of estrogen by growing follicles.
	During parturition	Oxytocin	Leads to contraction of smooth muscles of myometrium of the uterus during child birth.

(*b*) (*i*) During pregnancy

(*ii*) During menstruation.

Q. 33. (*a*) When and how does placenta develop in human female?

(*b*) How is the placenta connected to the embryo?

(*c*) Placenta acts as an endocrine gland. Explain.

Ans. (*a*) Placenta develops after implantation of embryo in human female in the uterus. After implantation, finger-like projections called chorionic villi are surrounded by the uterine tissue and maternal blood. The chorionic villi and uterine tissue become interdigitated with each other and together form a structural and functional unit between developing embryo and maternal body called placenta.

(*b*) An umbilical cord connects placenta with the embryo.

(*c*) The placenta also acts as an endocrine gland as it secretes the following hormones:

(*i*) Human chorionic gonadotropin (hCG)

(*ii*) Human placental lactogen (hPL)

(*iii*) Progestogens

(*iv*) Estrogens

The increased production of these hormones during pregnancy is essential for supporting the foetal growth and metabolic changes in the mother.

Q. 34. (*a*) Arrange the following hormones in sequence of their secretion in a pregnant woman.

(*b*) Mention their source and the function they perform:

hCG, LH, FSH, Relaxin **[*CBSE Delhi 2017*]**

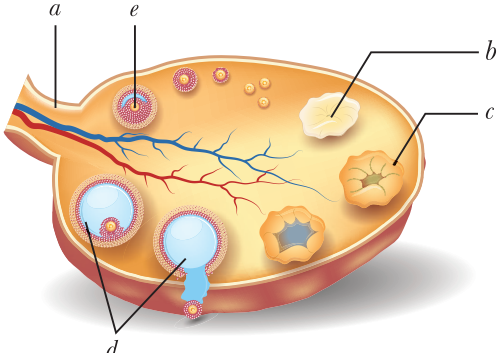
Ans. (*a*) The sequence of secretion of hormones is:

(*i*) FSH (*ii*) LH (*iii*) hCG (*iv*) Relaxin

(*b*)

Hormone	Source	Function
(*i*) FSH	Anterior pituitary lobe.	Stimulates growth of ovarian follicles and maturation of primary oocytes.
(*ii*) LH	Anterior pituitary lobe.	Induces ovulation and maintains corpus luteum.
(*iii*) hCG	Chorionic cells of placenta	Maintains the corpus luteum and stimulates it to secrete progesterone.
(*iv*) Relaxin	Ovary	Helps during child birth by relaxing the pelvic muscles as well as muscles of the cervix.

Q. 35. (*a*) Given below is the T.S. of human ovary. Identify the following in the diagram:



(*i*) Corpus luteum **(*ii*) Secondary oocyte**
(*iii*) Antrum **(*iv*) Primary follicle**
(*v*) Blood vessels

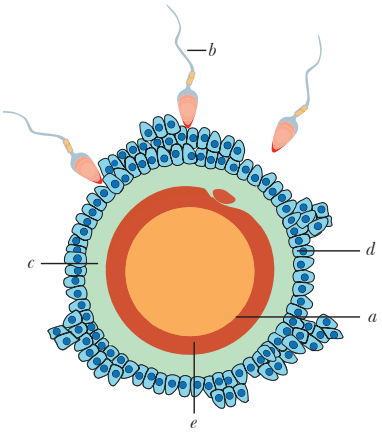
(*b*) Explain the changes the primary oocyte undergoes while in different follicular stages before ovulation.

Ans. (*a*) (*i*) Corpus luteum—*d* (*ii*) Graafian follicle —*c*
(*iii*) Tertiary follicle showing antrum—*b* (*iv*) Primary follicle—*e*
(*v*) Blood vessels—*a*

(*b*) Changes in the primary oocyte:

- Each primary oocyte gets surrounded by a single layer of granulosa cells and is known as primary follicle.
- Primary follicle get surrounded by more layers of granulosa cells and a new theca and thus form secondary follicle.
- A secondary follicle gets transformed into tertiary follicle, characterised by a fluid-filled space, the antrum.
- Primary oocyte undergoes first meiotic division and produces two unequal haploid cells—a large haploid secondary oocyte and a tiny first polar body.
- The tertiary follicle further changes into the mature Graafian follicle.
- The secondary oocyte forms a new membrane called zona pellucida around it.

Q. 36. Study the illustration given and answer the questions that follow:



(*i*) Identify '*a*' and '*e*'.
(*ii*) Name and state the function of '*c*'.
(*iii*) Identify '*d*'.
(*iv*) Explain the role of hormones in the formation and release of '*a*'.
(*v*) Draw a diagram of '*b*' separately and label the parts:
— that help its entry into 'a';
— that carry genetic material;
— that help in its movement. **[*CBSE (F) 2012*] [*HOTS*]**

Ans. (*i*) *a*—ovum and *e*—perivitelline space
(*ii*) *c*—zona pellucida. It protects ovum and regulates interaction between ovum and sperms during fertilisation.
(*iii*) *d*—cells of corona radiata.
(*iv*) Follicular stimulating hormone (FSH) stimulate follicular development. Luteinising hormone (LH) ruptures Graafian follicle and thereby release ovum.
(*v*) Refer to Fig. 3.10.

Q. 37. Human female is not fertile after menopause whereas males can produce gametes at any age after puberty. Analyse the statement and schematically represent a comparison between gametogenesis in males and females. **[*CBSE Sample Paper 2016*]**

Ans. Refer to Fig. 3.7 and Fig. 3.11.

Q. 38. What role does pituitary gonadotropins play during follicular and ovulatory phases of menstrual cycle and also explain the shift in steroidal secretions. **[*NCERT Exemplar*]**

Ans. Menstrual cycle is regulated by hypothalamus through the pituitary gland. At the end of menstrual phase, the pituitary FSH gradually increases resulting in follicular development within the ovaries. As the follicles mature, estrogen secretion increases resulting in a surge in FSH and LH. The surge of LH is responsible for ovulation and formation of corpus luteum that secretes progesterone which helps in maintaining the endometrium for implantation.

Q. 39. Give the term/reason: *[HOTS]*

(*a*) Mechanism responsible for parturition.

(*b*) Role of oxytocin during expulsion of the baby out of uterus

(*c*) Why does zona pellucida layer block the entry of additional sperms?

(*d*) Sperm cannot reach ovum without seminal plasma.

(e) All copulations do not lead to fertilisation and pregnancy.

Ans. (*a*) The complete neuro-endocrine mechanism.

(*b*) Oxytocin acts on uterine muscle for stronger contraction.

(*c*) To ensure the fusion of only one sperm with the ovum nucleus.

(*d*) Seminal plasma is a liquid medium which helps the sperm to move and nourishes it.

(*e*) All copulations do not lead to fertilization and pregnancy because fertilisation can only occur of the ovum and sperms are transported simultaneously to the ampullary-isthmic junction.

Self-Assessment Test

Time allowed: 1 Hour **Max. marks: 30**

1. Choose and write the correct option in the following questions. **(3×1 = 3)**

(i) Correct sequence of hormone secretion from beginning of menstruation is

(a) FSH, progesterone, estrogen (b) FSH, estrogen, progesterone

(c) Estrogen, FSH, progesterone (d) Estrogen, progesterone, FSH

(ii) _____ part of the fallopian tube is closest to the ovary.

(a) isthmus (b) infundibulum

(c) ampulla (d) cervix

(iii) Withdrawal of which hormone causes menstruation?

(a) Estrogen (b) Progesterone

(c) FSH (d) LH

2. In the following questions a statement of assertion followed by a statement of reason is given. Choose the correct answer out of the following choices. **(3×1 = 3)**

(a) Assertion and reason both are correct statements and reason is correct explanation for assertion.

(b) Assertion and reason both are correct statements but reason is not correct explanation for assertion.

(c) Assertion is correct statement but reason is wrong statement.

(d) Assertion is wrong statement but reason is correct statement.

(i) Assertion : The female gamete is produced at the time of puberty.

Reason : Gonadotropin releasing hormone controls the process of oogenesis.

(ii) Assertion : The fertilised egg, i.e., the zygote contains 23 pairs of chromosomes.

Reason : Zygote is formed by the fusion of egg and sperm.

(iii) Assertion : Colostrum produced in first 2-3 days of parturition is rich in nutrients.

Reason : Placenta induces the signals for expulsion of the fully developed foetus.

3. Why does failure of testes to descend into the scrotum cause sterility? **(1)**

4. What is acrosome? **(1)**

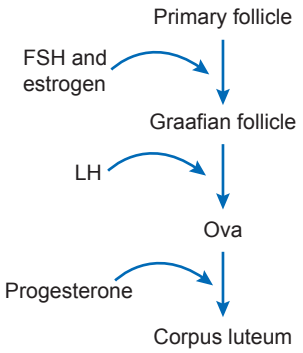
5. Why do meiosis and mitosis occur in germ cells? **(2)**

6. How is milk production regulated by hormones in human female? Explain. **(2)**

7. Name and explain the role of inner and middle walls of the human uterus. **(2)**

8. Describe the process of parturition in humans. *[CBSE DELHI 2015]* **(2)**

9. Given below is a flowchart showing ovarian changes during menstrual cycle. **(3×1 = 3)**



Answer the following questions based on the information given.

(i) Menstrual cycles are absent during pregnancy. Why?

(ii) Given below are the stages in human reproduction. Write them in correct sequential order.

Insemination, Gametogenesis, Fertilisation, Parturition, Gestation, Implantation

(iii) Name two hormones that can be found only in the blood of a pregnant woman. Mention the source organ/tissue that secretes each of them.

10. Write a brief account of the structure and functions of placenta. **(3)**

11. Explain the role of ovarian hormones in inducing changes in the uterus during menstrual cycle. What triggers release of oxytocin at the time of parturition? **(3)**

12. (i) Systematically represent the process of Oogenesis.

(ii) Enumerate the events in the ovary of a human female during:

(a) Follicular phase

(b) Luteal phase of menstrual cycle. **(5)**

Answers

1. (*i*)—(*b*), (*ii*)—(*b*), (*iii*)—(*b*) **2.** (*i*)—(*d*), (*ii*)—(*a*), (*iii*)—(*b*)

Chapter –4

Reproductive Health

basic concepts

1. Reproductive Health—Problems and Strategies

- Reproductive health means a total well-being in all aspects of reproduction, *i.e.*, physical, emotional, behavioural and social.

Problems

(*i*) There is little knowledge of personal hygiene and hygiene of reproductive organs. This causes sexually transmitted diseases (STDs).

(*ii*) Early marriages lead to high maternal and infant mortality rates.

(*iii*) Due to lack of awareness, there has been a rapid increase in population size.

(*iv*) People encourage beliefs in myths and misconceptions about sex-related issues.

Strategies

- 'Family planning' programmes were initiated by the Government of India as early as 1951.
- 'Reproductive and Child Health Care' (RCH) programmes were launched in 1997 for:
  - (*i*) creating awareness among people about various reproduction related aspects.
  - (*ii*) providing facilities and support for building up a reproductively healthy society.
- With the help of audio–visual aids and print-media, both government and non-government agencies are engaged in creating awareness among people about reproduction-related aspects.
- Encouraging sex education in schools, to give the right information to young minds and save them from myths and misconceptions about sex-related aspects.
- Proper information about reproductive organs, adolescence and related changes, safe and hygienic sexual practices and sexually transmitted diseases (STDs) should be given.
- Educating people about available birth control options, care for pregnant mothers, post-natal care of the mother and child, importance of breast feeding, equal opportunities for the male and female child.
- Awareness of problems due to uncontrolled population growth and social evils like sex-abuse and sex-related crimes, etc.
- Statutory ban on **amniocentesis** (a foetal sex-determination test based on the chromosome pattern in the cells found in amniotic fluid surrounding the developing embryo) for sex-determination to legally check increasing female foeticides.

2. Population Explosion

- The tremendous increase in size and growth rate of population is called **population explosion**.
- The world population was about 2 billion in 1900 and it was 6 billion in 2000.
- Population of India at the time of Independence was about 350 million and it crossed 1 billion in May 2000.

Reasons for High Population Growth

(*i*) Rapid decline in death rate due to control of diseases and better public health care.
(*ii*) Decline in maternal mortality rate (MMR).
(*iii*) Decline in infant mortality rate (IMR).
(*iv*) Increase in number of people in reproductive age with advancement in agriculture and better means of transport and technology.

- According to 2001 census report, the population growth rate was about 1.7 per cent, *i.e.*, 17/1000/year in India—a rate at which our population could double in 33 years.

Steps to Curb Population Growth

(*i*) Raising marriageable age of girls to 18 years and of boys to 21 years.
(*ii*) Incentives should be given to couples with small family.
(*iii*) Motivate couples to use contraceptive methods for small families.
(*iv*) Advertisements and posters with slogans like "*Hum Do Humare Do*', '*One Child Norm*' should be displayed to educate people.

3. Birth Control

- The most important step to control population growth is to motivate smaller families by using various contraceptive methods.
- An ideal contraceptive should be:
  (*i*) user-friendly (*ii*) easily available
  (*iii*) effective and reversible with no or least side-effects
  (*iv*) non-interfering with the sexual drive/desire and/or the sexual act of the user.

Methods of Birth Control

- The contraceptive methods are divided into following categories:
  (*i*) Natural/traditional methods (*ii*) Barrier methods
  (*iii*) Intra uterine devices (IUDs) (*iv*) Oral contraceptives
  (*v*) Injections and implants (*vi*) Surgical methods.

(i) Natural methods

- These are natural methods that work on the principle of avoiding the meeting of ovum and sperm.
  (*a*) Periodic abstinence is a method in which a couple avoids or abstains from coitus from day 10–17 of the menstrual cycle, when ovulation is expected to occur.
  (*b*) Coitus interruptus or withdrawal is a method in which male partner withdraws his penis from the vagina just before ejaculation, so as to avoid insemination.
  (*c*) Lactational amenorrhea is based on the principle that during the period of lactation after parturition, ovulation does not occur.

(ii) Barrier methods

- These methods prevent the contact of sperm and ovum with the help of barriers. Such methods are available for both males and females.
  (*a*) Condoms are barriers made of thin rubber/latex sheath used to cover the penis in the male or vagina and cervix in females. It prevents the deposition of ejaculated semen into the vagina of the female.
  (*b*) Diaphragms, cervical caps and vaults are the barriers made of rubber that are inserted into the female reproductive tract to cover the cervix during coitus. They prevent the entry of sperms through cervix. They are reusable.
  (*c*) Spermicidal creams, jellies and foams are used along with these barriers to increase their contraceptive efficiency.

(iii) Intra uterine devices (IUDs)

- These devices are inserted by doctors in the uterus through vagina.
- There are three types of IUDs available:
  - **(*a*) Non-medicated IUDs:** These increase phagocytosis of sperms within the uterus, *e.g.*, Lippes loop.
  - **(*b*) Copper releasing IUDs:** Along with phagocytosis of sperms, the copper ions released suppress sperm motility and fertilising capacity of sperms, *e.g.*, CuT, Cu 7, Multiload 375.
  - **(*c*) Hormone releasing IUDs:** These make the uterus unsuitable for implantation and the cervix hostile to sperms, *e.g.*, Progestasert, LNG-20.

(iv) Oral contraceptive

- This involves uptake of hormonal preparations of either progestogens or progestogen–estrogen combinations in the form of **pills** by females.
- They inhibit ovulation and implantation as well as alter the quality of cervical mucus to prevent entry of sperms.
- Pills are to be taken for period of 21 days starting within first five days of menstrual cycle. After gap of 7 days, to be repeated in same pattern.
- '*Saheli*', an oral contraceptive for females containing a non-steroidal preparation was developed by scientists at Central Drug Research Institute (CDRI) in Lucknow. It is a *once a week pill*'.
- Pills have high contraceptive value and few side effects.

(v) Injections and implants

- Progestogens or progestogen–estrogen combination can also be used by females as injections or implants under the skin.
- Their mode of action is similar to that of pills but their effective periods are longer.

(vi) Surgical methods (Sterilisation)

- These are terminal and permanent methods which block the transport of gametes, thereby preventing conception effectively.
- In males, a small part of the vas deferens is removed and tied up through a small incision on the scrotum. This is called **vasectomy**.
- In females, a small part of the fallopian tube is removed and tied up through a small incision in the abdomen or vagina. This is called **tubectomy**.

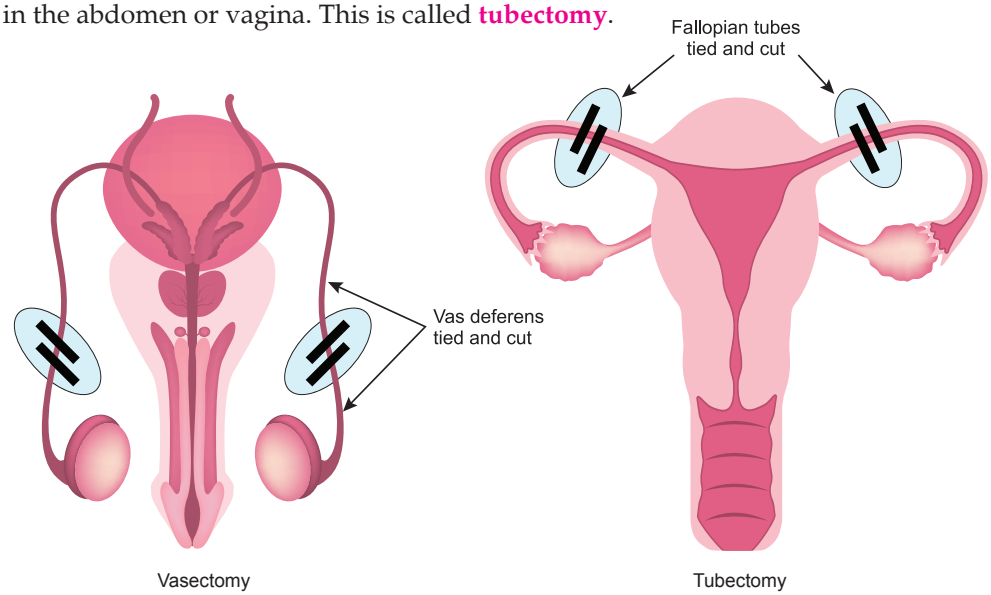


Fig. 4.1 Sterilisation methods

4. Medical Termination of Pregnancy (MTP)

- It is defined as intentional or voluntary termination of pregnancy before full term.
- MTP was legalised by Government of India in 1971 under strict conditions to avoid misuse.
- MTP is done in the following situations:
  - (*i*) Failure of contraceptive used during coitus
  - (*ii*) When continued pregnancy is harmful or fatal to either mother or foetus or both.
  - (*iii*) rape cases.
- It is safe during first trimester, *i.e.*, up to 12 weeks of pregnancy.

5. Sexually Transmitted Diseases (STDs)

- Infections or diseases that are transmitted through sexual intercourse are collectively called **sexually transmitted diseases (STDs) or venereal diseases (VD) or reproductive tract infections (RTI).**
- STDs are caused by bacteria (syphilis, gonorrhoea), virus (AIDS, hepatitis B, genital herpes, genital warts), protozoans, nematodes, ectoparasites (trichomoniasis, chlamydiasis) and fungi.
- **Early symptoms:** Itching, fluid discharge, slight pain and swellings in the genital region.
- **Complications due to chronic STDs:** Pelvic inflammatory diseases **(PID)**, abortions, still births, ectopic pregnancies, infertility, or even cancer of the reproductive tract.
- **Transmission of hepatitis-B and HIV** also occurs by the following ways:
  - (*i*) Sharing of injection needles or surgical instruments with infected persons;
  - (*ii*) transfusion of infected blood;
  - (*iii*) transfer from infected mother to the foetus through placenta.
- **By following simple principles, STDs can be prevented.**
  - (*i*) Avoid sex with unknown partners/multiple partners.
  - (*ii*) Always use condoms during coitus.
  - (*iii*) Contact a qualified doctor for any doubt, in early stage of infection.

6. Infertility

- It is the inability to produce children in spite of unprotected sexual cohabitation.
- The reasons of infertility could be physical, congenital diseases, drugs, immunological, or even psychological.
- Specialised health-care units called infertility clinics could help in diagnosis and corrective treatment of some of these disorders.
- The infertile couples could be assisted to have children through certain special techniques called **Assisted Reproductive Technologies (ART)**, which are given below.

(i) Test Tube Baby Programmes

- In this method, ova from the wife/donor (female) and the sperms from the husband/donor (male) are collected and induced to form zygote under simulated conditions in the laboratory. This process is called *in vitro* fertilisation **(IVF)**.
- The zygote or early embryo with up to 8 blastomeres is transferred into the fallopian tube (process is called zygote intra fallopian transfer or **ZIFT**) and if embryo with more than 8 blastomeres is transferred into the uterus (process is called intra uterine transfer or **IUT**).
- In females who cannot conceive, embryos formed by fusion of gametes in another female (called *in vivo* fertilisation) are transferred.

(ii) Gamete Intra Fallopian Transfer (GIFT)

- It is the transfer of an ovum collected from a donor into the fallopian tube of another female who cannot produce one, but can provide suitable environment for fertilisation and further development of the embryo.

(iii) Intra Cytoplasmic Sperm Injection (ICSI)

- It is a procedure to form an embryo in the laboratory by directly injecting the sperm into an ovum. The embryo is later transferred by ZIFT or IUT.

(iv) Artificial Insemination (AI)

- In this method, the semen collected either from the husband or a healthy donor is artificially introduced into the vagina or into the uterus (**intra uterine insemination** or **IUI**).
- This technique is used in cases where the male is unable to inseminate sperms in the female reproductive tract or due to very low sperm counts in the ejaculation.

NCERT Textbook Questions

Q. 1. What do you think is the significance of reproductive health in a society?

Ans. In a society, if people are aware of birth control methods to avoid sexually transmitted diseases and the importance of breast feeding and post-natal care of the mother and baby, then the society can have healthy children who are the future citizens of a nation.

Q. 2. Suggest the aspects of reproductive health which need to be given special attention in the present scenario.

Ans. (*i*) Introduction of sex education in school that helps in eradicating myths and misconceptions regarding sex-related aspects.

(*ii*) Proper information about reproductive organs, safe and hygienic sexual practices and sexually transmitted diseases (STDs).

(*iii*) Awareness of problems due to uncontrolled population growth, social evils like sex-abuse and sex-related crimes, etc.

(*iv*) Strong infra-structural facilities, professional expertise and material support to provide medical assistance and care to people in reproduction-related problems.

(*v*) Educating people about available birth control options, care of pregnant mothers, post-natal care of mother and child, importance of breast-feeding, equal opportunities for the male and female child.

Q. 3. Is sex education necessary in schools? Why?

Ans. Yes, sex education is necessary in schools because

(*i*) it will provide proper information about reproductive organs, adolescence, safe and hygienic sexual practices and sexually transmitted diseases (STDs).

(*ii*) it will provide right information to avoid myths and misconceptions about sex-related queries.

Q. 4. Do you think that reproductive health in our country has improved in the past 50 years? If yes, mention some such areas of improvement.

Ans. Yes, reproductive health in our country has improved in the last 50 years.

Some areas of improvement are:

(*i*) Better awareness about sex-related matters.

(*ii*) Increased number of medically assisted deliveries and better post-natal care of child and mother leading to decreased maternal and infant mortality rates.

(*iii*) Increased number of couples with small families.

(*iv*) Better detection and cure of STDs and overall increased medical facilities for all sex-related problems.

Q. 5. What are the suggested reasons for population explosion?

Ans. The suggested reasons of population explosion are

(*i*) rapid decline in death rate.

(*ii*) decline in maternal mortality rate (MMR)

(*iii*) decline in infant mortality rate (IMR) and

(*iv*) increase in number of people in reproducible age.

Q. 6. Is the use of contraceptives justified? Give reasons.

Ans. Yes, use of contraceptive is justified because it helps to control the rapid growth of human population. It will also help in preventing unwanted pregnancies and STDs. Contraceptives also help in controlling the population growth rate.

Q. 7. Removal of gonads cannot be considered as a contraceptive option. Why?

Ans. Removal of gonads not only stops the production of gametes but will also stop the secretions of various important hormones which are important for bodily functions. This method is irreversible and thus, cannot be considered as a contraceptive method.

Q. 8. Amniocentesis for sex determination is banned in our country. Is this ban necessary? Comment.

Ans. Yes, the ban is necessary because amniocentesis is misused for determining the sex of the foetus and then aborting the child if it is a female.

Q. 9. Suggest some methods to assist infertile couples to have children.

Ans. The reasons of infertility could be physical, congenital diseases, drugs, immunological and even psychological. Specialised health-care units called infertility clinics could help in diagnosis and corrective treatment of some of these disorders. Through special techniques called assisted reproductive technologies (ART), infertile couple could be assisted to have children. ART includes: (*i*) *In vitro* fertilisation, (*ii*) Gamete intra fallopian transfer (GIFT), (*iii*) Intra cytoplasmic sperm injection (ICSI), and (*iv*) Artificial insemination (AI).

Q. 10. What are the measures one has to take to prevent from contracting STDs?

Ans. STDs can be prevented by the following methods:

(*i*) Avoid sex with unknown partners/multiple partners.

(*ii*) Always use condoms during coitus.

(*iii*) Always contact a qualified doctor for any doubt in early stage of infection and get complete treatment if diagnosed with disease.

Q. 11. State True/False with explanation.

(*a*) Abortions could happen spontaneously too. (*True/False*)

(*b*) Infertility is defined as the inability to produce a viable offspring and is always due to abnormalities/defects in the female partner. (*True/False*)

(*c*) Complete lactation could help as a natural method of contraception. (*True/False*)

(*d*) Creating awareness about sex related aspects is an effective method to improve reproductive health of the people. (*True/False*)

Ans. **(*a*) True:** Due to internal factors like incompatibility, abortion could happen spontaneously.

(*b*) False: Infertility may also be caused due to male partner when sperm count is low or their mobility is less.

(*c*) True: Lactational amenorrhea is a method of contraception as ovulation does not occur during the period of intense lactation following parturition.

(*d*) True: Creating awareness about sex-related aspects removes the myths and misconceptions about these problems.

Q. 12. Correct the following statements:

(*a*) Surgical methods of contraception prevent gamete formation.

(*b*) All sexually transmitted diseases are completely curable.

(*c*) Oral pills are very popular contraceptives among the rural women.

(*d*) In E.T. techniques, embryos are always transferred into the uterus.

Ans. (*a*) Surgical methods of contraception prevent gamete transport.
(*b*) All sexually transmitted diseases are not completely curable.
(*c*) Oral pills are very popular contraceptives among the urban women.
(*d*) In E.T. techniques, embryos with up to 8 blastomeres are transferred into the fallopian tube and embryos with more than 8 blastomeres are transferred into the uterus.

Multiple Choice Questions [1mark]

Choose and write the correct option in the following questions.

1. *In-vitro* fertilization involves transfer of _____ into the fallopian tube.
(*a*) embryo upto eight cell stage
(*b*) embryo of thirty two cell stage
(*c*) zygote
(*d*) either zygote or embryo up to eight cell stage

2. Tubectomy is a method of sterilization in which
(*a*) nucleus is removed
(*b*) ovaries are removed
(*c*) small part of fallopian tube is removed
(*d*) small part of vast deferens is removed

3. IUDs release copper ion to
(*a*) prevent ovulation
(*b*) suppress mortility
(*c*) increase phagocytosis of sperm
(*d*) make uterus unsuitable for implantation.

4. The method of directly injecting a sperm into ovum in Assisted Reproductive Technology is called ***[NCERT Exemplar]***
(*a*) GIFT (*b*) ZIFT (*c*) ICSI (*d*) ET

5. Increased IMR and decreased MMR in a population will ***[NCERT Exemplar]***
(*a*) cause rapid increase in growth rate
(*b*) result in decline in growth rate
(*c*) not cause significant change in growth rate
(*d*) result in an explosive population

6. Intensely lactating mothers do not generally conceive due to the ***[NCERT Exemplar]***
(*a*) suppression of gonadotropins
(*b*) hyper secretion of gonadotropins
(*c*) suppression of gametic transport
(*d*) suppression of fertilisation

7. Sterilisation techniques are generally fool proof methods of contraception with least side effects. Yet, this is the last option for the couples because
(*i*) it is almost irreversible
(*ii*) of the misconception that it will reduce sexual urge
(*iii*) it is a surgical procedure
(*iv*) of lack of sufficient facilities in many parts of the country ***[NCERT Exemplar]***
Choose the correct option.
(*a*) (*i*) and (*iii*)
(*b*) (*ii*) and (*iii*)
(*c*) (*ii*) and (*iv*)
(*d*) (*i*), (*ii*), (*iii*) and (*iv*)

8. Which of the following STDs are caused by bacteria?
(*a*) AIDS and Genital Herpes
(*b*) Syphilis and gonorrhoea
(*c*) Trichomoniasis and scabies
(*d*) All of these

9. Which of the followings is example of hormone releasing IUDs ?
(*a*) CuT and Multilobed 375
(*b*) LNG-20 and Progestasert
(*c*) Lippes loop
(*d*) Both (*b*) and (*c*)

10. A national level approach to build up a reproductively healthy society was taken up in our country in ***[NCERT Exemplar]***
(*a*) 1950s (*b*) 1960s (*c*) 1980s (*d*) 1990s

11. Emergency contraceptives are effective if used within [NCERT Exemplar]

(*a*) 72 hrs of coitus (*b*) 72 hrs of ovulation

(*c*) 72 hrs of menstruation (*d*) 72 hrs of implantation

12. Choose the right one among the statements given below. [NCERT Exemplar]

(*a*) IUDs are generally inserted by the user herself

(*b*) IUDs increase phagocytosis reaction in the uterus

(*c*) IUDs suppress gametogenesis

(*d*) IUDs once inserted need not be replaced

13. Following statements are given regarding MTP. [NCERT Exemplar]

(*i*) MTPs are generally advised during first trimester

(*ii*) MTPs are used as a contraceptive method

(*iii*) MTPs are always surgical

(*iv*) MTPs require the assistance of qualified medical personnel

Choose the correct option.

(*a*) (*ii*) and (*iii*) (*b*) (*i*) and (*iii*) (*c*) (*i*) and (*iv*) (*d*) (*i*) and (*ii*)

14. From the sexually transmitted diseases mentioned below, identify the one which does not specifically affect the sex organs. [NCERT Exemplar]

(*a*) Syphilis (*b*) AIDS (*c*) Gonorrhea (*d*) Genital warts

15. Condoms are one of the most popular contraceptives because of the following reasons. [NCERT Exemplar]

(*a*) These are effective barriers for insemination (*b*) They do not interfere with coital act

(*c*) These help in reducing the risk of STDs (*d*) All of the above

16. Which of the followings is/are barrier method of contraception?

(*a*) Rhythm method/Periodic abstinence (*b*) Lactational amenorrhea

(*c*) Withdrawal method (*d*) None of these

17. Which of the followings is not a cause of population explosion in India?

(*a*) Better health care (*b*) Increased IMR

(*c*) Decline MMR (*d*) Increased population of reproductive age

18. Choose the correct statement regarding the ZIFT procedure. [NCERT Exemplar]

(*a*) Ova collected from a female donor are transferred to the fallopian tube to facilitate zygote formation.

(*b*) Zygote is collected from a female donor and transferred to the fallopian tube

(*c*) Zygote is collected from a female donor and transferred to the uterus

(*d*) Ova collected from a female donor and transferred to the uterus

19. The correct surgical procedure as a contraceptive method is [NCERT Exemplar]

(*a*) ovariectomy (*b*) hysterectomy (*c*) vasectomy (*d*) castration

20. Diaphragms are contraceptive devices used by the females. Choose the correct option from the statements given below: [NCERT Exemplar]

(*i*) They are introduced into the uterus

(*ii*) They are placed to cover the cervical region

(*iii*) They act as physical barriers for sperm entry

(*iv*) They act as spermicidal agents

Choose the correct option:

(*a*) (*i*) and (*ii*) (*b*) (*i*) and (*iii*) (*c*) (*ii*) and (*iii*) (*d*) (*iii*) and (*iv*)

21. Lactational amenorrhoea means

(*a*) absence of menstruation during pregnancy (*b*) absence of menstruation during lactation

(*c*) excessive bleeding during menstruation (*d*) no production and secretion of milk

22. Match the items of column I with suitable items of column II.

Column I	Column II
A. Barrier method	(*i*) Condoms
B. IUD	(*ii*) Multiload 375
C. Surgical technique	(*iii*) Tubectomy
D. Hormone administration	(*iv*) Implants

Choose the correct option.

(*a*) A-(*i*), B-(*ii*), C-(*iv*), D-(*iii*) (*b*) A-(*i*), B-(*ii*), C-(*iii*), D-(*iv*)
(*c*) A-(*i*), B-(*iv*), C-(*ii*), D-(*iii*) (*d*) None of these

23. Amniocentesis is a process to

(*a*) grow of cells on the culture medium (*b*) determine any hereditary disease of the embryo
(*c*) know about the diseases of the brain (*d*) determine any disease of heart

24. Which of the following methods of contraception is most widely used?

(*a*) IUDs (*b*) tubectomy
(*c*) cervical caps (*d*) diaphragms

25. Medical Termination of Pregnancy is safe up to

(*a*) 8 weeks of pregnancy (*b*) 12 weeks of pregnancy
(*c*) 18 weeks of pregnancy (*d*) 24 weeks of pregnancy

26. Assisted Reproductive Technology involves transfer of

(*a*) ovum into the fallopian tube (*b*) zygote into the fallopian tube
(*c*) embryo into the fallopian tube (*d*) zygote into the uterus

Answers

1. (*d*)	**2.** (*d*)	**3.** (*b*)	**4.** (*c*)	**5.** (*c*)	**6.** (*a*)	**7.** (*d*)	**8.** (*b*)	**9.** (*b*)	**10.** (*a*)
11. (*a*)	**12.** (*b*)	**13.** (*c*)	**14.** (*b*)	**15.** (*d*)	**16.** (*d*)	**17.** (*d*)	**18.** (*b*)	**19.** (*c*)	**20.** (*c*)
21. (*b*)	**22.** (*d*)	**23.** (*b*)	**24.** (*d*)	**25.** (*c*)	**26.** (*c*)				

Assertion-Reason Questions

In the following questions a statement of assertion followed by a statement of reason is given. Choose the correct answer out of the following choices.

(a) Assertion and reason both are correct statements and reason is correct explanation for assertion.
(b) Assertion and reason both are correct statements but reason is not correct explanation for assertion.
(c) Assertion is correct statement but reason is wrong statement.
(d) Assertion is wrong statement but reason is correct statement.

1. Assertion : IUT is the transfer of embryo with more than 8 blastomeres into the uterus.
Reason : IUT is a very popular method of forming embryos *in vivo*.

2. Assertion : In IVF fertilisation is done inside the body of the woman.
Reason : Zygote up to 8 blastomeres can be transferred into the fallopian tube.

3. Assertion : *Saheli* is an oral contraceptive pill for females containing nonsteroidal preparation.
Reason : It is 'once in a day' pill with very few effects.

4. Assertion : Diaphragms and cervical caps are barriers made of rubber.
Reason : They block the entry of sperms through the cervix.

5. Assertion : In barrier methods of contraception ovum and sperms are prevented from physical meeting.
Reason : Barrier methods are used during coitus to prevent entry of sperms into the female reproductive tract.

6. **Assertion :** In tubectomy, a small part of the fallopian tubes is cut and tied up.
   Reason : In vasectomy, a small part of the vas deferens is cut and tied up.
7. **Assertion :** Syphilis, gonorrhea and AIDS are some common STDs.
   Reason : STDs are transmitted through sexual intercourse.
8. **Assertion :** ICSI is an assisted reproductive technique.
   Reason : In ICSI sperm is directly injected into the ovum to form an embryo *in vitro*.
9. **Assertion :** Oral contraceptive pills are effective method of contraception with few side effects.
   Reason : Oral pills like *Saheli* inhibit ovulation and implantation.
10. **Assertion :** Lactational amenorrhea is a natural method of contraception.
    Reason : Ovulation does not take place during the period of intense lactation following child birth.

Answers

1. (*c*) **2.** (*d*) **3.** (*c*) **4.** (*b*) **5.** (*a*) **6.** (*b*) **7.** (*a*) **8.** (*a*) **9.** (*b*) **10.** (*a*)

Case-based/Source-based Question

1. Given below is the diagram of CuT, a commonly used contraceptive method. Based on the information answer the following questions:

(*i*) A mother of one year old daughter wanted to space her second child. Her doctor suggested CuT. Explain its contraceptive actions.

(*ii*) Bring out one main difference between CuT and LNG-20.

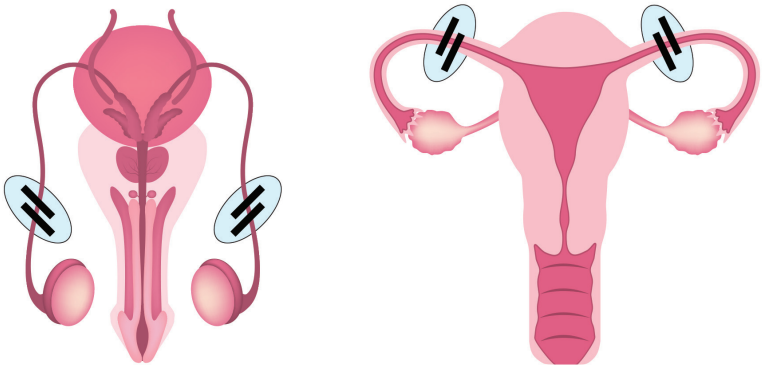
(*iii*) A newly married couple does not want to produce children at least for one year and also not to use any contraceptives. Suggest a method to prevent pregnancy.

Ans. (*i*) CuT increases phagocytosis of sperms within the uterus and the Cu^{2+} ions released suppress sperm motility and the fertilising capacity of sperms.

(*ii*) CuT is copper releasing IUDs and LNG-20 is hormone releasing IUDs. Cu^{2+} ions released suppress sperm motility and thus the fertilising capacity of sperms decreases. While the hormone releasing IUDs make the uterus unsuitable for implantation and the cervix hostile to the sperms.

(*iii*) Periodic abstinence or coitus interruptus

2. Study the diagram of the female reproductive system given below. Answer the questions based on the diagram.



(*i*) What does the diagram depict?

(*ii*) At what stage zygote can be introduced in the fallopian tube in Zygote Intra Fallopian Transfer (ZIFT)?

(*iii*) Mention any two events that are inhibited by the intake of oral contraceptive pills to prevent pregnancy in humans.

Ans. (*i*) The diagram depicts the process of vasectomy and tubectomy.

(*ii*) 8-celled stage

(*iii*) Two events that are inhibited by the intake of oral contraceptive pills to prevent pregnancy in humans are ovulation and implantation.

Very Short Answer Questions [1 mark]

Q. 1. Government of India has raised the marriageable age of female to 18 years and of males to 21 years. Suggest any two more measures adopted by Government for the purpose. ***[CBSE Sample Paper 2016]***

Ans. (*i*) Incentives given to couples with small families.

(*ii*) Media publicity through posters of happy couples with two children (*Hum Do Humare Do*).

(*iii*) Motivation to promote smaller families by using contraceptive methods.

(*iv*) Raising marriageable age of females to 18 years & males to 21 years. (*Any two*)

Q. 2. Give one reason to justify statutory ban on aminocentesis. ***[CBSE 2019 (57/2/1)]***

Ans. Statutory ban on aminocentesis prevents female foeticide.

Q. 3. A doctor has observed the chromosomal disorders in developing foetus and advised the couple to undergo abortion. Suggest the technique by which doctor observed the chromosomal disorders. ***[HOTS]***

Ans. Amniocentesis

Q. 4. Reproductive health refers only to healthy reproductive functions. Comment. ***[NCERT Exemplar]*** ***[HOTS]***

Ans. Reproductive health refers to the total well-being in all aspects of reproduction, *i.e.*, physical, behavioural, psychological and social.

Q. 5. The present population growth rate in India is alarming. Suggest ways to check it. ***[NCERT Exemplar]*** ***[HOTS]***

Ans. (*i*) By increasing marriageable age.

(*ii*) By promoting use of birth control measures.

(*iii*) By educating people about consequences of uncontrolled population growth.

Q. 6. Indiscriminate diagnostic practices, using X-rays, etc., should be avoided. Give one reason. ***[CBSE Delhi 2015]***

Ans. These practices act as carcinogens which convert normal cells to neoplastic cells by harmful mutations or chromosomal aberration.

Q. 7. Why is tubectomy considered a contraceptive method? ***[CBSE (F) 2010]*** ***[HOTS]***

Ans. Tubectomy involves cutting a piece of the fallopian tube and tying its ends. This way, the sperms are not able to reach the egg so fertilisation cannot take place. Thus, it acts as a contraceptive method.

Q. 8. In case of an infertile couple, the male partner can inseminate normally but the mobility of sperms is below 40 percent. Which kind of ART is suitable in this situation to form an embryo in the laboratory conditions, without involving a donor? ***[CBSE Sample Paper 2015, 2017, 2018]***

Ans. Intra Cytoplasmic Sperm Injection

Q. 9. A woman's husband is infertile. So the lady has decided to have baby by taking sperms from sperm bank. Which technique will you suggest for her pregnancy? ***[HOTS]***

Ans. Intra cytoplasmic sperm injection (ICSI)

Q. 10. What technique would you suggest for correcting infertility caused due to very low sperm counts of a male partner? ***[HOTS]***

Ans. Artificial insemination

Short Answer Questions [2 marks]

Q. 1. At the time of Independence, the population of India was 350 million, which exploded to over 1 billion by May 2000. List any two reasons for this rise in population and any two steps taken by the government to check this population explosion. ***[CBSE (F) 2011]***

Ans. Two reasons for increase in population are:

(*i*) A rapid decline in death rate, maternal mortality rate and infant mortality rate.

(*ii*) Increase in number of people in reproducible age.

Two steps for checking population explosion:

(*i*) Statutory raising of marriageable age of the females to 18 years and males to 21 years.

(*ii*) Incentives given to couples with small families.

Q. 2. The alarming population growth is leading to scarcity of basic requirements. Suggest with reasons, any two population control measures other than contraception to address the situation. ***[CBSE Sample Paper 2015, 2017, 2018]***

Ans. Following are the population control measures other than contraception:

(*a*) Advertisements in the media to generate awareness about advantages of small families.

(*b*) Statutory raising of marriageable age of the female to 18 years and that of males to 21 years, to delay the number of births.

(*c*) Incentives given to couples with small families, to motivate others to comply. (Any two)

Q. 3. Comment on the RCH programme of the government to improve the reproductive health of the people. ***[NCERT Exemplar]***

Ans. The basic aims of the RCH programmes are creating public awareness regarding reproduction-related aspects population growth and providing facilities to build up a healthy society with added emphasis on the health of mother and child.

Q. 4. What is amniocentesis? Why has the government imposed a statutory ban in spite of its importance in the medical field? ***[CBSE (F) 2010, 2015]***

Ans. Amniocentesis is a foetal sex determination test based on the chromosomal pattern in cells extracted from the amniotic fluid, surrounding the developing embryo. Amniocentesis is used for sex determination, which most people go for, to kill female foetus. Therefore, it has been banned.

Q. 5. A couple is eager to know the sex of their unborn child. What diagnostic technique will you suggest? What social abuse is associated with the application of this technique? ***[HOTS]***

Ans. Amniocentesis is the suggested diagnostic technique which when applied helps in sex determination of the foetus and may lead to social abuse like female foeticides.

Q. 6. Describe the lactational amenorrhea method of birth control. ***[CBSE (AI) 2011]***

Ans. Lactational amenorrhea is based on the principle that during the period of intense lactation after parturition, menstrual cycle or ovulation does not occur.

Q. 7. Name an oral pill used as a contraceptive by human females. Explain how does it prevent pregnancy. ***[CBSE Delhi 2011]***

Ans. '*Saheli*' is an oral pill used as a contraceptive by females. Oral pills inhibit ovulation and implantation, as well as, alter the quality of cervical mucus to prevent or retard entry of sperms. Thus, fertilisation and further pregnancy is prevented.

Q. 8. Why is '*Saheli*' considered to be an improved form of oral contraceptive for human female? ***[CBSE (F) 2010]*** ***[HOTS]***

Ans. "*Saheli*" contains a non-steroidal preparation and is a once-a-week pill, with high contraceptive value and very less side-effects. Therefore, it is considered an improved form of contraceptive pills.

Q. 9. Explain how do the following act as contraceptives:

(*a*) CuT (*b*) '*Saheli*' ***[CBSE (AI) 2012]***

Ans. (*a*) Cu^{2+} ions released suppress sperm motility, lowers the fertilising capacity of sperms.

(*b*) Inhibit ovulation, implantation, as well as alter the quality of cervical mucus to prevent or retard the entry of sperms.

Q. 10. How do copper and hormone releasing IUDs act as contraceptives? Explain. ***[CBSE (AI) 2010]***

Ans. The copper releasing IUDs release Cu ions, which suppress sperm motility and the fertilising capacity of sperms.

The hormone releasing IUDs make the uterus unsuitable for implantation and the cervix hostile to the sperms.

Q. 11. Why is medical termination of pregnancy (MTP) carried out?

Ans. MTP is carried out to get rid of unwanted pregnancies. It is also essential when the foetus is suffering from an incurable disease or when continuation of the pregnancy could be harmful or even fatal to the mother and/or foetus or terminate pregnancy in rape cases.

Q. 12. All reproductive tract infections (RTIs) are STDs but all STDs are not RTIs. Justify with example. ***[NCERT Exemplar]*** ***[HOTS]***

Ans. Among the common STDs, hepatitis-B and AIDS are not infections of the reproductive organs though their mode of transmission could be through sexual contact also. All other diseases like gonorrhea, syphilis, genital herpes, are transmitted through sexual contact and are also infections of the reproductive tract.

Q. 13. A couple where both husband and wife are producing functional gametes, but the wife is still unable to conceive, is seeking medical aid. Describe any one method that you can suggest to this couple to become happy parents. ***[CBSE (AI) 2014]***

Ans. Methods: IVF/ZIFT/AI

IVF (*In vitro* fertilisation): Ova from wife and sperm from the husband is collected. It is induced to form zygote under simulated laboratory conditions.

Q. 14. An infertile couple is advised to adopt test-tube baby programme. Describe two principle procedures adopted for such technologies. ***[CBSE Delhi 2015]***

Ans. **(*i*) IVF/*In vitro* fertilisation:** It is the fertilisation of gametes outside the body in almost similar conditions as that in the body.

(*ii*) ET/Embryo transfer: Embryos formed by fusion of gametes is transferred into reproductive tract or uterus.

Q. 15. After a brief medical examination a healthy couple came to know that both of them are unable to produce functional gametes and should look for an 'ART' (Assisted Reproductive Technique). Name the 'ART' and the procedure involved that you can suggest to them to help them bear a child. ***[CBSE Delhi 2015]***

Ans. Test tube baby programme can be done.

For explanation refer to Basic Concepts Point 6 (*i*).

Q. 16. The process of GIFT involves the transfer of female gamete to the fallopian tube. Can gametes be transferred to the uterus to achieve the same result? Explain. [*NCERT Exemplar*] [*HOTS*]

Ans. The uterine environment is not congenial for the survival of the gamete. If directly transferred to the uterus, they will undergo degeneration or could be phagocytosed and hence viable zygote would not be formed.

Q. 17. How can childless couples be helped by the following assisted reproductive technologies:

(*a*) GIFT? (*b*) Intracytoplasmic Sperm Injection?

Ans. **(*a*) GIFT (Gamete Intra Fallopian Transfer):** It is the transfer of an ovum collected from a donor into the fallopian tube of another female who cannot produce one, but can provide suitable environment for fertilisation and further development.

(*b*) Intracytoplasmic Sperm Injection (ICSI): It is a process in which an embryo is formed in the laboratory, in which a sperm is directly injected into the ovum.

Q. 18. Following table gives certain terms associated with ART. Fill in the spaces *a*, *b*, *c* and *d*. [*HOTS*]

IVF and ET	*a*
b	Introduction of zygote/embryo with 8 blastomeres into fallopian tube
c	Introduction of ova of a donor into the fallopian tube
d	Introduction of semen from the husband or healthy donor into the uterus

Ans. (*a*) Test tube baby programme

(*b*) ZIFT (Zygote intra fallopian transfer)

(*c*) GIFT (Gamete intra fallopian transfer)

(*d*) IUI (Intra uterine insemination)

IUI (Intra Uterine Insemination): In this method, the semen collected either from the husband or a healthy donor is artificially introduced into the vagina or into the uterus.

This technique is used in cases where the male is unable to inseminate sperms in the female reproductive tract or due to very low sperm counts in the ejaculation.

Long Answer Questions–I [3 marks]

Q. 1. What are the consequences of population explosion?

Ans. Following are the consequences of population explosion:

(*i*) It is causing an absolute scarcity of the basic requirements, *i.e.*, food, clothing, fuel and shelter.

(*ii*) There is greater demand for fossil fuels (oil, gas and coal).

(*iii*) Eco-degradation.

Q. 2. If implementation of better techniques and new strategies are required to provide more efficient care and assistance to people, then why is there a statutory ban on amniocentesis? Write the use of this technique and give reason to justify the ban. [*CBSE (AI) 2014*] [*HOTS*]

Ans. There is a statutory ban on amniocentesis to legally check female foeticide. This sex determination technique has been misused to eliminate girl child before birth.

This technique is also used to detect the abnormal chromosomes or any genetic disorder.

The ban is justified to prevent female foeticide which could lead to change in sex ratio of the population.

Q. 3. (*a*) List any four characteristics of an ideal contraceptive.

(*b*) Name two intrauterine contraceptive devices that affect the motility of sperms.

[*CBSE (AI) 2016*]

Ans. (*a*) The ideal contraceptive should be

(*i*) user-friendly, (*ii*) effective and easily available,

(*iii*) not interfering with the sexual drive, (*iv*) reversible with no or least side effects.

(*b*) CuT, Cu7 and Multiload 375 affect motility of sperms.

Q. 4. A woman has certain queries as listed below, before starting with contraceptive pills. Answer them.

(*a*) What do contraceptive pills contain and how do they act as contraceptives?

(*b*) What schedule should be followed for taking these pills? **[*CBSE (AI) 2014*]**

Ans. (*a*) Contraceptive pills contain progestogen or progestogen-estrogen combination.

They act by either of the following way:

(*i*) inhibit ovulation (*ii*) inhibit implantation

(*iii*) alter quality of cervical mucus to prevent or retard entry of sperms.

(*b*) Contraceptive pills should be taken daily for a period of 21 days starting within first five days of menstrual cycle (to be repeated after a gap of 7 days).

Q. 5. (*a*) Name and explain the mode of action of any two types of IUDs.

(*b*) List the advantages of usng '*Saheli*' as a contraceptive. **[*CBSE 2019 (57/3/1)*]**

Ans. (*a*) Refer to basic concepts point 3 (*iii*).

(*b*) Advantages of *Saheli*:

(*i*) It is non-steroidal (*ii*) It is taken only once a week

(*iii*) It has high contraceptive value (*iv*) It has less side effects.

Q. 6. Name two hormones that are constituents of contraceptive pills. Why do they have high and effective contraceptive value? Name a commonly prescribed non-steroidal oral pill. **[*CBSE (AI) 2016*]**

Ans. Progestogen-estrogen combination, Progestogen or Progesterone are present in contraceptive pills. They inhibit ovulation, implantation and alter quality of cervical mucus to retard entry of sperm. *Saheli* is a commonly prescribed oral pill.

Q. 7. (*a*) Expand IUD.

(*b*) Why is hormone releasing IUD considered a good contraceptive to space children?

Ans. (*a*) IUD—Intra uterine devices.

(*b*) Hormone releasing IUDs are considered a good contraceptives because

(*i*) they make the uterus unsuitable for implantation.

(*ii*) they increase the phagocytosis of sperms within uterus and the Cu ions released, suppress sperm motility and the fertilising capacity of sperms.

Q. 8. Name three incurable sexually transmitted diseases and their causative organisms.

Ans.

Sexually transmitted disease	**Causal agent**
(*i*) Hepatitis-B	Hepatitis-B virus
(*ii*) Genital herpes	Herpes simplex virus
(*iii*) AIDS	HIV (Human Immunodeficiency Virus)

Q. 9. Within what age group sexually transmitted diseases (STDs) are reported to be very high. Mention three practices to avoid them. **[*HOTS*]**

Ans. In the age group of 15–24 years, STDs are reported to be very high. Following are the three practices to avoid them:

(*i*) Abstain sexual contact with unknown partners or multiple partners.

(*ii*) Always use condoms during coitus.

(*iii*) In case of any doubt, medical help should be taken for early detection.

Q. 10. Suggest and explain any three Assisted Reproductive Technologies (ART) to an infertile couple. **[*CBSE (AI) 2013*]**

Ans. Refer to Basic Concepts Point 6.

Q. 11. Explain the zygote intra-fallopian transfer technique (ZIFT). How is intra-uterine transfer technique (IUT) different from it? **[*CBSE (AI) 2010*]**

Ans. Zygote intra fallopian transfer technique (ZIFT) is a technique of *in vitro* fertilisation wherein the zygote or early embryo having up to 8 blastomeres is transferred into the fallopian tube to complete its further development.

Intra uterine transfer (IUT) technique is different from ZIFT as the embryos with more than 8 blastomeres are transferred into the uterus in IUT.

Q. 12. How are Assisted Reproductive Technologies helpful to humans? How are ZIFT and GIFT different from intra-uterine transfers? Explain.

Ans. The infertile couples could be assisted to have children through certain special techniques known as assisted reproductive technologies (ART).

ZIFT: The zygote or early embryo with up to 8 blastomeres is transferred into the fallopian tube. This is called zygote intra fallopian transfer (ZIFT).

GIFT: It is the transfer of an ovum collected from a donor into the fallopian tube of another female, who cannot produce one but can provide suitable environment for fertilisation and further development of the embryo.

Intra-uterine transfer (IUT) refers to the introduction of embryo with more than 8 blastomeres into the uterus of a female to complete its further development.

Q. 13. Briefly explain IVF and ET. What are the conditions in which these methods are advised? ***[NCERT Exemplar]***

Ans. IVF refers to *in vitro* fertilisation and ET refers to embryo transfer. Gametes from the male and female are collected hygienically and induced to fuse in the laboratory set up under simulated conditions. The zygote formed is collected and is introduced into the uterine of a host or surrogate mother at an appropriate time. Early embryos (up to 8 cell) are generally transferred to the fallopian tube whereas embryos with more than 8 cells are transferred to the uterus.

Q. 14. Expand the following and explain any one of them. ***[CBSE Sample Paper 2014]***

(*a*) IVF (*b*) ZIFT (*c*) IUI (*d*) MTP

Ans.
IVF — *In-vitro* Fertilisation
ZIFT — Zygote Intra Fallopian Transfer
IUI — Intra-Uterine Insemination
MTP — Medical Termination of Pregnancy

Long Answer Questions–II [5 marks]

Q. 1. STDs are a threat to reproductive health. Describe any two such diseases and suggest preventive measures. ***[NCERT Exemplar]***

Ans. Refer to Basic Concepts Point 5.

Q. 2. A large number of married couples the world over are childless. It is shocking to know that in India the female partner is often blamed for the couple being childless.

(*a*) Why in your opinion the female partner is often blamed for such situations in India?

(*b*) State any two reasons responsible for the cause of infertility.

(*c*) Suggest a technique that can help the couple to have a child where the problem is with the male partner. ***[CBSE (AI) 2016]***

Ans. (*a*) Female partner is often blamed due to following reasons:

(*i*) Social mind set

(*ii*) Inequality of sexes

(*iii*) Lack of awareness/male dominated society.

(*iv*) Awareness is to be created that abnormality can occur in both male and females and infertility issues with suitable examples

(*v*) Mutual respect towards both the partners in case of the problem and to find the remedy from medical experts

(*vi*) Educate them to find the reason and not believe in superstitions. (*Any two*)

(*b*) Infertility is caused due to physical abnormality in reproductive system, congenital, immunological or psychological problems. (*Any two*)

(*c*) Intra cytoplasmic sperm injection (ICSI), artificial insemination (AI), Intra uterine insemination (IUI) can help couples where the problem is with male partner.

Q. 3. Name and explain the surgical method advised to human males and females as a means of birth control. Mention its one advantage and one disadvantage. **[*CBSE (F) 2014*]**

Ans. Refer to Basic Concepts Point 3 (*vi*).

Advantage : It is the permanent and most effective method of preventing conception as it blocks transport of gametes.

Disadvantage: The process of surgical method is irreversible.

Q. 4. A village health worker was taking a session with women. She tells the women that one has to be very careful while using oral pills as method of birth control. Wrong usage can actually promote conception.

(*a*) Analyse the statement and compare the merits and demerits of using oral pills and surgical methods of birth control.

(*b*) Village women were confused as to how a thin metallic copper loop can provide protection against pregnancy. Justify the use, explaining the mode of action of IUDs.

[*CBSE Sample Paper 2016*]

Ans. (*a*)

	Contraceptive pills	Surgical methods
Merits	1. Pills are effective with lesser side effects and well accepted by females. 2. Reversible method.	1. Surgical intervention block gamete transport. 2. Highly effective.
Demerits	1. If not taken on right days they can promote conception. 2. Can have side effects if taken for a long time.	1. Not reversible. 2. Can affect health of a person if performed in unhygienic condition.

(*b*) Mode of action of IUDs

(*i*) Increased phagocytosis of sperms within the uterus.

(*ii*) Cu^{++} released suppresses sperm motility.

(*iii*) Hormone releasing IUDs make uterus unsuitable for implantation.

Self-Assessment Test

Time allowed: 1 Hour **Max. marks: 30**

1. Choose and write the correct option in the following questions. **(3×1 = 3)**

(i) Match the IUD of Column I with suitable example in Column II.

Column I	Column II
A. Non-medicated	1. Lippes loop
B. Copper releasing	2. Multiload-375
C. Hormone releasing	3. LNG-20

Choose the correct option.

(a) A-3, B-2, C-1 (b) A-1, B-2, C-3

(c) A-1, B-3, C-2 (d) A-2, B-1, C-3

(ii) GIFT is recommended for females who

(a) cannot produce eggs (b) cannot retain foetus in uterus

(c) cannot provide suitable environment for fertilisation

(d) cannot allow sperms to enter cervix

(iii) Which of the following is not a STD?

(a) AIDS (b) Syphilis

(c) Trichomoniasis (d) Encephalitis

2. In the following questions a statement of assertion followed by a statement of reason is given. Choose the correct answer out of the following choices. **(3×1 = 3)**

(a) Assertion and reason both are correct statements and reason is correct explanation for assertion.

(b) Assertion and reason both are correct statements but reason is not correct explanation for assertion.

(c) Assertion is correct statement but reason is wrong statement.

(d) Assertion is wrong statement but reason is correct statement.

(i) Assertion : Health and education of young people is an important attribute to the reproductive health of the society.

Reason : Reproductive health programmes of young men primarily encourages responsible sexual behaviour.

(ii) Assertion : Sterilisation methods stops the production of testosterone.

Reason : It is a permanent method of birth control.

(iii) Assertion : Oral birth control pills contain hormonal formulations.

Reason : Birth control pills do not have any side effects.

3. What is lactational amenorrhea? **(1)**

4. Expand ZIFT. **(1)**

5. Why do some women use "*Saheli*" pills? **(2)**

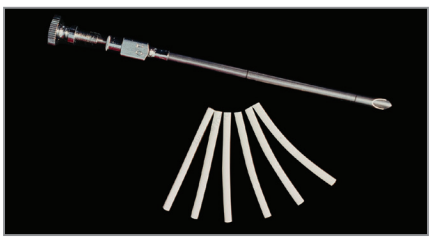
6. How do oral contraceptive pills act in a human female? Explain. **(2)**

7. List any two types of IUDs that are available for human females and state their mode of action. **(2)**

8. Mention any four characteristics that an ideal contraceptive should have. **(2)**

9. Describe the three ways in which fertilisation of human ovum by a sperm can be prevented. **(3)**

10. Given below is the picture of a contraceptive device. Observe it and answer the questions that follow. **(3×1 = 3)**



(i) What is the device used for?

(ii) Why do intensely lactating mothers not generally conceive?

(iii) Our government has intentionally imposed strict conditions for MTP in our country. Justify giving a reason.

11. (i) Name any two copper releasing IUDs.

(ii) Explain how do they act as effective contraceptives in human females. [CBSE (AI) 2014] **(3)**

12. Enumerate and describe any five reasons for introducing sex education to school-going children. **(5)**

Answers

1. (*i*)—(*b*), (*ii*)—(*c*), (*iii*)—(*d*) **2.** (*i*)—(*a*), (*ii*)—(*d*), (*iii*)—(*c*)

Chapter–5

Principles of Inheritance and Variation

basic concepts

- The process by which characters are transferred from one generation to the next generation is called **inheritance/heredity**.
- The differences in traits of individuals of a progeny, from each other and from their parents are called **variations**.
- The branch of science which deals with inheritance and variation is called **genetics**.

1. Mendel's Experiment

- Gregor Johann Mendel (1822–1884) is known as **'Father of Genetics'**.
- Mendel performed his experiments with garden pea plant (*Pisum sativum*).
- He conducted artificial pollination/cross-pollination experiments using several true-breeding varieties having contrasting traits as shown in Fig. 5.1.
- He observed one trait at a time.
- He hybridised plants with alternate forms of a single trait (**Monohybrid cross**). The seeds thus produced were grown to develop into plants of **first filial generation (F_1)**.
- Mendel then self-pollinated the F_1 plants to generate plants of **second filial generation (F_2)**.
- Later, Mendel also crossed pea plants that differed in two characters **(Dihybrid cross)**.

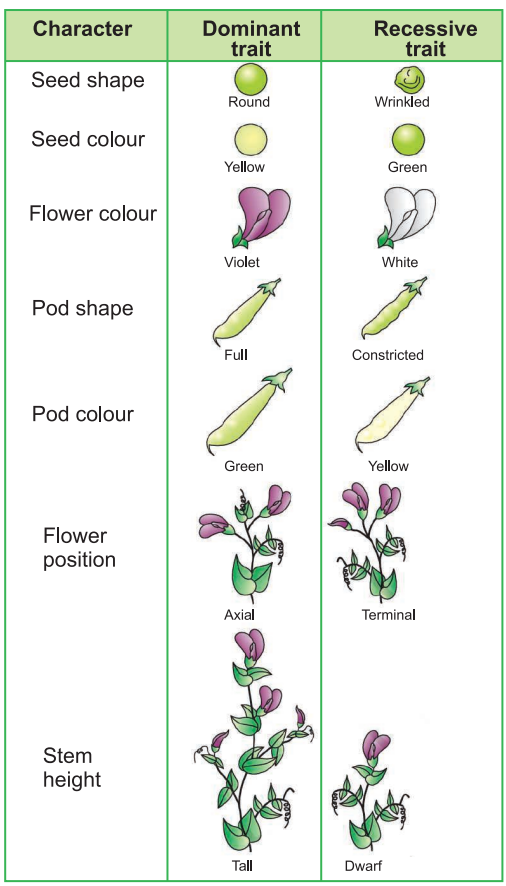


Fig. 5.1 Seven pairs of contrasting characters of pea plant selected by Mendel

2. Mendel's Experimental Plant

- Mendel selected garden pea as his experimental material because of the following reasons:
  - (*i*) It is an annual plant with a short life-cycle. So, several generations can be studied within a short period.
  - (*ii*) It has perfect bisexual flowers containing both male and female parts.

(*iii*) The flowers are predominantly self-pollinating. It is easy to get pure line for several generations.

(*iv*) It is easy to cross-pollinate them because pollens from one plant can be introduced to the stigma of another plant by removing the anthers.

(*v*) Pea plant produces a large number of seeds in one generation.

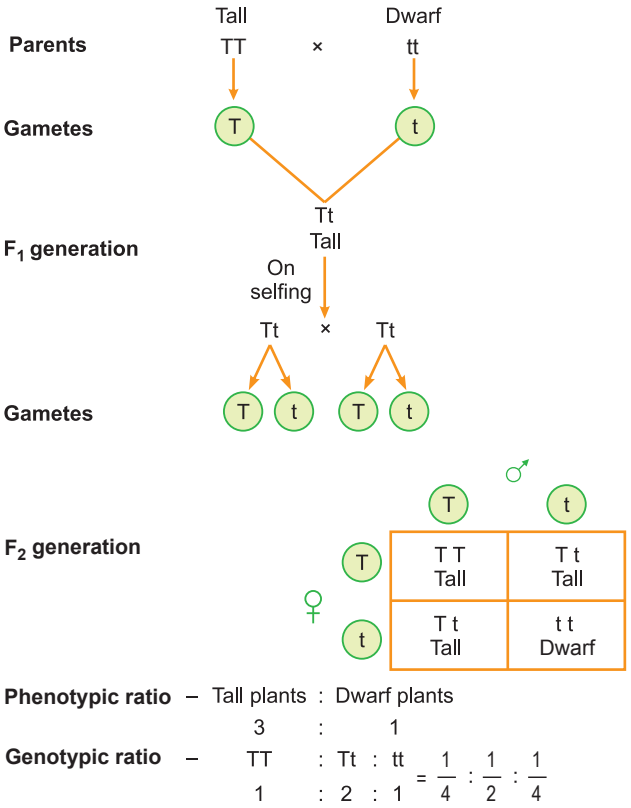
(*vi*) Pea plants could easily be raised, maintained and handled.

(*vii*) A number of easily detectable contrasting characters/traits were available.

3. Mendel's Observations

- **Phenotype:** Visible expression of genetic constitution *e.g.*, Tall/dwarf.
- **Genotype:** Genetic constitution of individual *e.g.*, TT, Tt, tt.
- **Monohybrid Cross:** Cross involving study of inheritance of one character, *e.g.*, height of plant.
- **Dihybrid Cross:** Cross between plants differing in two traits/cross involving study of inheritance of two genes or characters, *e.g.*, colour and shape of seeds.
- **Homozygous:** The individual carrying similar alleles for a trait, *e.g.*, TT or tt.
- **Heterozygous or hybrid:** The individual carrying different alleles for a trait, *e.g.*, Tt.

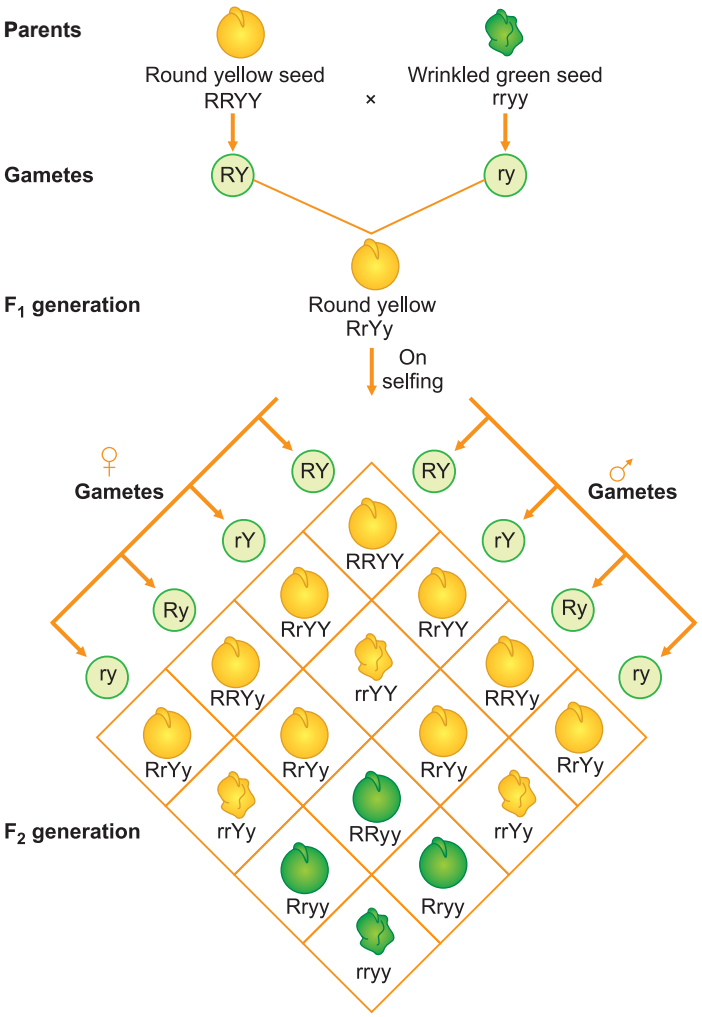
- F_1 progenies always resembled one of the parents and trait of the other parent was not seen.
- In monohybrid cross, F_2 generation stage expressed both the parental traits in the proportion 3 : 1.
- The contrasting traits did not show any blending in either F_1 or F_2 generations.
- In dihybrid cross, he got identical results as in monohybrid cross.
- He found that the phenotypes in F_2 generation appeared in the ratio 9 : 3 : 3 : 1 in dihybrid cross.



$\frac{1}{4}:\frac{1}{2}:\frac{1}{4}$ ratio of TT : Tt : tt is mathematically condensable in the form of binomial expression $(ax+by)^2$, with gametes bearing genes, T or t in equal frequency of $\frac{1}{2}$. Expansion of expression gives –

$$\left(\frac{1}{2}T+\frac{1}{2}t\right)^2=\frac{1}{4}TT+\frac{1}{2}Tt+\frac{1}{4}tt.$$

Fig. 5.2 Monohybrid cross of true-breeding pea plant



Ratio of 9 : 3 : 3 : 1 can be derived as a combination series of ratio of two monohybrid crosses (3 Round : 1 wrinkled) (3 yellow : 1 green) = (9 Round yellow : 3 wrinkled yellow : 3 Round green: 1 wrinkled green).

Phenotypic ratio–	Round yellow			:	Round green			:	Wrinkled yellow			:	Wrinkled green			
		9		:		3		:		3		:		1		
Genotypic ratio–	1	:	2	:	2	:	4	:	1	:	2	:	1	:	2	: 1

Fig. 5.3 Results of a dihybrid cross where the two parents differed in two pairs of contrasting traits: seed colour and seed shape

4. Mendel's Laws of Inheritance

- Based on his hybridisation experiments, Mendel proposed the laws of inheritance.
- His theory was rediscovered by Hugo de Vries of Holland, Carl Correns of Germany and Eric von Tschermak of Austria in 1901.
- Hugo de Vries, Correns and Tschermark are thus referred to as rediscoverers of Mendelism.

(i) Law of dominance

- This law states that when two alternative forms of a trait or character (genes or alleles) are present in an organism, only one factor expresses itself in F_1 progeny and is called dominant while the other that remains masked is called recessive.
- Characters are controlled by discrete units called factors. Factors occur in pairs.

(ii) Law of segregation or law of purity of gametes

- This law states that the factors or alleles of a pair segregate from each other during gamete formation, such that a gamete receives only one of the two factors. They do not show any blending but simply remain together.
- Homozygous parent produces all gametes that are similar, heterozygous parent produces two types of gametes, each having one allele in equal proportion.

(iii) Law of independent assortment

- According to this law the two factors of each character assort or separate out independent of the factors of other characters at the time of gamete formation and get randomly rearranged in the offsprings producing both parental and new combinations of characters.
- When two pairs of traits are combined in a hybrid, segregation of one pair of characters is independent of the other pair of characters.

5. Incomplete Dominance

- It is a phenomenon in which the F_1 hybrid exhibits characters intermediate of the parental genes.
- Here, the phenotypic ratio deviates from the Mendel's monohybrid ratio.
- It is seen in flower colours of *Mirabilis jalapa* (4 O′ clock plant) and *Antirrhinum majus* (snapdragon), where red colour is due to genetic constitution *RR*, white colour is due to genetic constitution *rr* and pink colour is due to genetic constitution *Rr*.

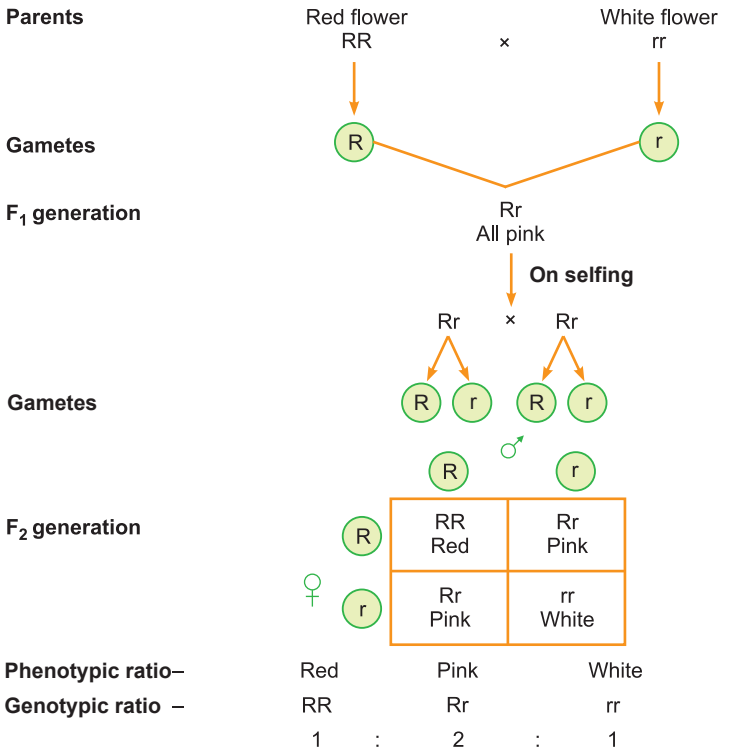


Fig. 5.4 Monohybrid cross in snapdragon, where one allele is incompletely dominant over the other allele

6. Co-dominance

- The alleles which are able to express themselves independently, even when present together are called co-dominant alleles and this biological phenomenon is called co-dominance.

For example, ABO blood grouping in humans.

- ABO blood groups are controlled by gene *I*. Gene *I* has three alleles I^A, I^B and I^O/i.
- I^A and I^B produce RBC surface antigens which are sugar polymers A and B, respectively, whereas *i* does not produce any antigen.
- I^A and I^B are dominant over *i* hence I^A and I^B are dominant alleles and *i* is recessive allele as in I^Ai and I^Bi.
- When I^A and I^B are present together, both express equally and produce both the surface antigens A and B, hence show co-dominance.
- Since humans are diploid, each person possesses any two of the three '*I*' gene alleles, resulting into six different genotypic combinations and four phenotypic expressions.

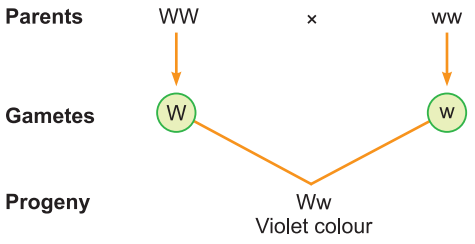
Table 5.1: Genetic basis of blood groups in human population

Allele from Parent 1	Allele from Parent 2	Genotype of offspring	Blood groups of offspring	Antigen present	Antibody
I^A	I^A	I^AI^A	A	A	B
I^A	I^B	I^AI^B	AB	A and B	No antibody
I^A	*i*	I^Ai	A	A	B
I^B	I^B	I^BI^B	B	B	A
I^B	*i*	I^Bi	B	B	A
i	*i*	*i i*	O	No antigen	Both A and B

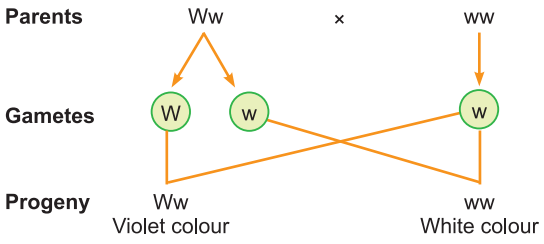
7. Test Cross

- It is a method devised by Mendel to determine the genotype of an organism.
- In this cross, the organism with dominant phenotype (but unknown genotype) is crossed with the recessive individual.
- In a monohybrid cross between violet colour flower (W) and white colour flower (w), the F_1 hybrid was violet colour flower. The test crosses are:

Case I.



Case II.



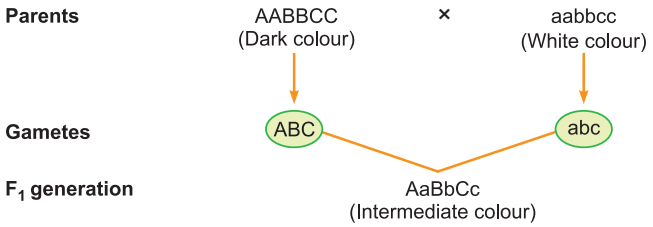
- If all the F_1 progeny are violet coloured, then the plant is homozygous dominant, *i.e.*, WW and if the progenies are in 1 : 1 ratio, then the plant is heterozygous, *i.e.*, Ww.

8. Pleiotropy

- It is the phenomenon in which a single gene exhibits or controls multiple phenotypic expressions.
- The pleiotropic gene affects the metabolic pathways, resulting in different phenotypes.
- For example, phenylketonuria is caused by mutation in the gene coding for the enzyme phenylalanine hydroxylase. The affected individuals show mental retardation as well as reduction in hair and skin pigmentation.
- In *Drosophila*, gene for wing size influences nature of balancers, colour of eye, dorsal bristles, fertility and longivity.

9. Polygenic Inheritance

- It is a type of inheritance, in which a trait is controlled by three or more genes. Such traits are called **polygenic traits**.
- The phenotype reflects contribution of each allele and is also influenced by the environment.
- For example, human skin colour. Suppose three genes A, B and C control skin colour with A, B, C being the dominant alleles and a, b, c being the recessive alleles. Then,



- The F_2 generation will have varied skin tones, with each type of allele in the genotype determining the darkness or lightness of the skin.

10. Chromosomal Theory of Inheritance

- The chromosomal theory of inheritance was proposed independently by **Walter Sutton** and **Theodore Boveri** in 1902. They stated that behaviour of chromosomes was parallel to behaviour of genes and used chromosome movement to explain Mendel's laws. According to this theory,
  - (*i*) The hereditary factors are carried in the nucleus. Nucleus contains chromosomes.
  - (*ii*) Like the Mendelian alleles, chromosomes are also found in pairs.
  - (*iii*) The sperm and egg having haploid sets of chromosomes fuse to re-establish the diploid state.
  - (*iv*) The two alleles of a gene pair are located on homologous sites on homologous chromosomes in a linear order. As there are two chromosomes of each kind in somatic (diploid) cell there must be two genes of each kind, one in each of the two homologous chromosomes.
  - (*v*) Homologous chromosomes synapse during meiosis and get separated to pass into different cells. This forms the basis for segregation and independent assortment. A gamete receives only one chromosome of each type and thus has only one gene for a trait. The paired condition is restored by fusion of gametes.

Table 5.2: A comparison between the behaviour of genes and chromosomes

S.No.	Genes	Chromosomes
(*i*)	Occur in pairs	Occur in pairs
(*ii*)	Segregate at the time of gamete formation such that only one of each pair is transmitted to a gamete	Segregate at gamete formation and only one of each pair is transmitted to a gamete
(*iii*)	Independent pairs segregate independently of each other	One pair segregates independently of another pair

11. Linkage and Recombination

- **T. H. Morgan** carried out several dihybrid crosses in *Drosophila* to study the genes that are sex-linked. He observed that when the two genes in a dihybrid cross are located on the same chromosome, the proportion of parental gene combinations in the progeny was much higher than the non-parental or recombination of genes.
- Reason for selecting *Drosophila melanogaster* (fruit fly):
  - (*i*) They could be grown on simple synthetic medium in the laboratory.
  - (*ii*) They complete their life cycle in two weeks.

(*iii*) A single mating could produce a large number of progeny.

(*iv*) There was clear differentiation of the sexes, *i.e.*, male and female flies are easily distinguishable.

(*v*) It has many types of hereditary variations that can be seen with low power microscopes.

- Morgan hybridised yellow bodied and white eyed females with brown bodied and red eyed males (wild type) (cross-A) and inter-crossed their F_1 progeny.
- F_2 generation ratio deviated from 9:3:3:1.

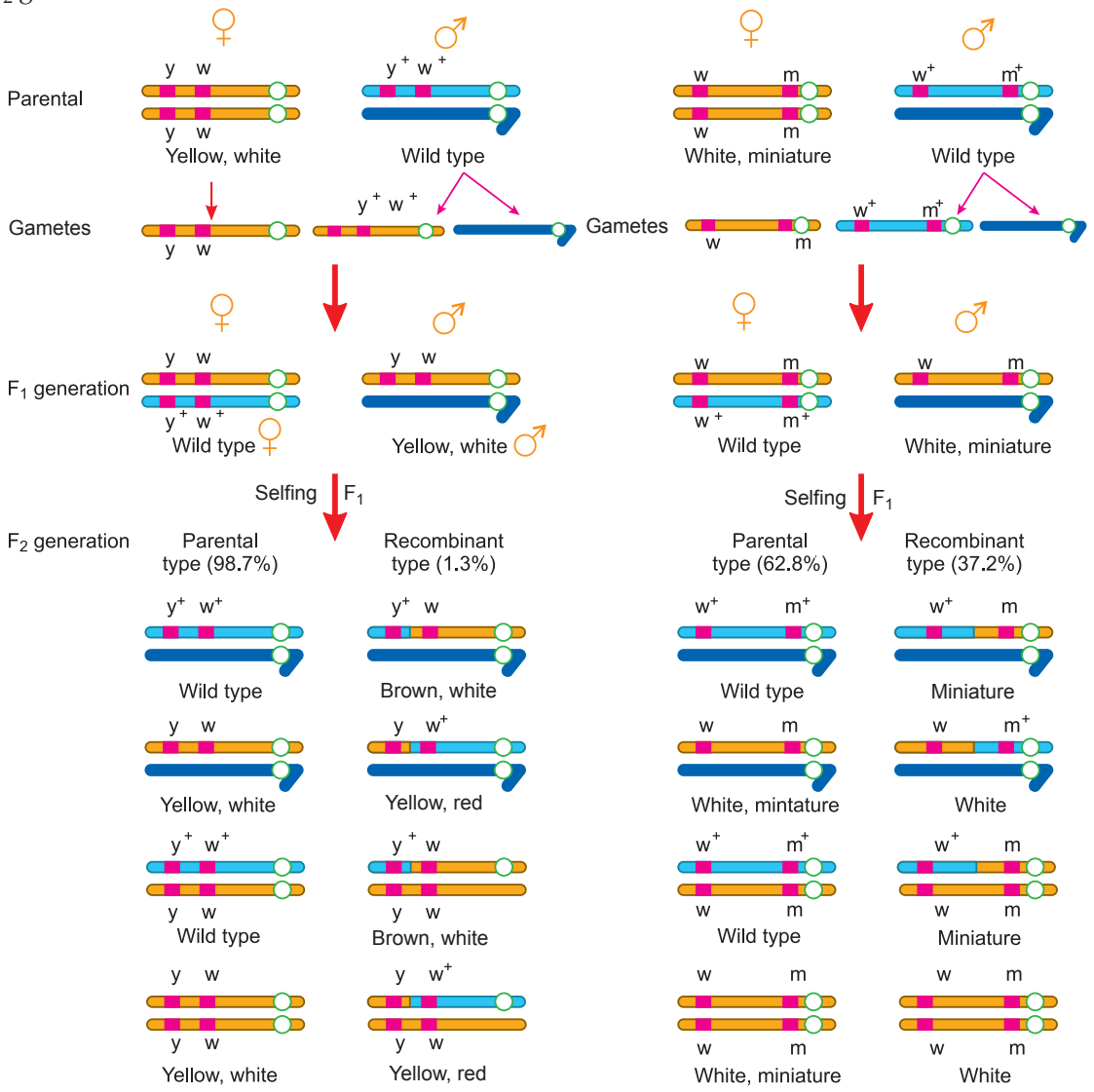


Fig. 5.5 Linkage: Results of two dihybrid crosses conducted by Morgan. Cross A shows crossing between genes y and w; Cross B shows crossing between genes w and m. Here dominant wild type alleles are represented with (+) sign in superscript. Strength of linkage between y and w is higher then w and m.

- **Morgan's observations:**

(*i*) Genes are present on the chromosomes in a linear fashion.

(*ii*) When genes are grouped on the same chromosome, they are always inherited together. These are said to be linked.

(*iii*) Some genes are tightly linked or associated and show little recombination.

(*iv*) When the genes are loosely linked they show higher percentage of recombination.

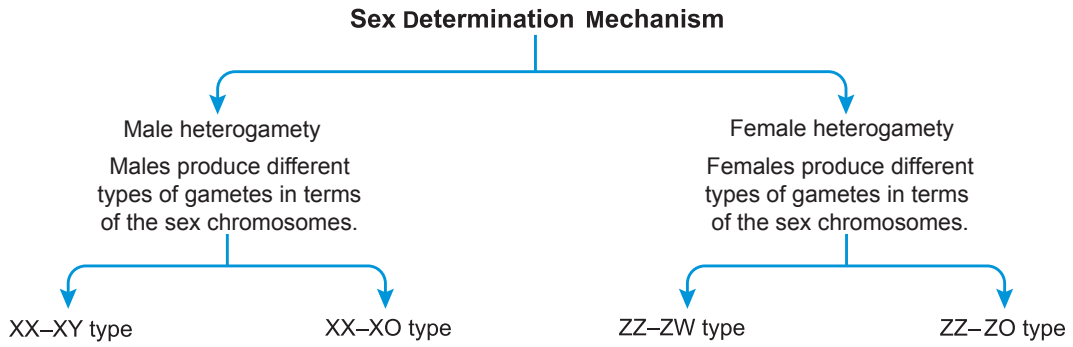
(*v*) Strength of linkage between genes is inversely proportional to the distance between them.

- Alfred Sturtevant determined that genes of *Drosophila* are arranged in a linear order. He measured the distance between genes and prepared **chromosome maps** with the position of genes on the chromosomes based on percentage of recombinants. These are also called **genetic maps**.

> Linkage = Physical association of genes on a chromosome.
>
> Recombination = Generation of non-parental gene combinations, arising from crossing over between non-homologous chromosomes.

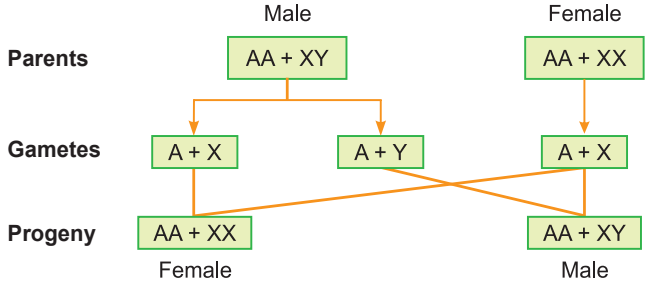
12. Sex Determination Mechanism

- Finalisation of sex at the time of zygote formation is called **sex determination**.
- Two types of chromosomes are present in individuals – **sex chromosomes** (which determine the sex of individuals) and **autosomes**.



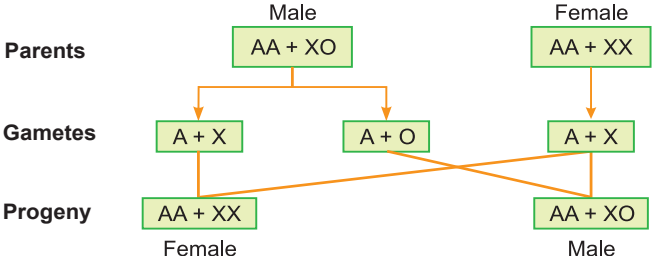
(i) XX–XY type

- Seen in many insects and mammals including humans, *Drosophila melanogaster*.
- Males have X and Y chromosomes along with autosomes [A] and females have a pair of X chromosomes.



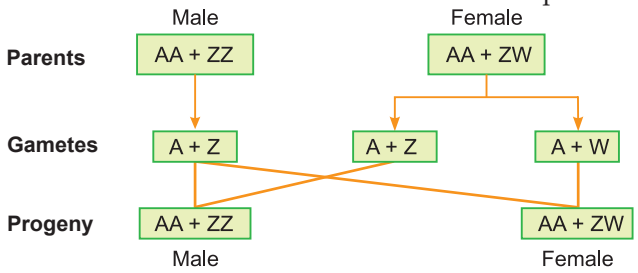
(ii) XX–XO type

- Seen in grasshopper and cockroach.
- Males have only one X chromosome besides autosomes and females have a pair of X chromosomes.



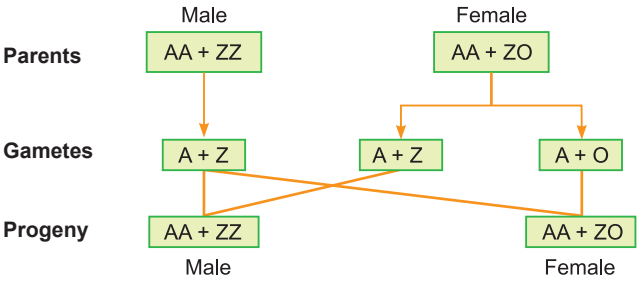
(iii) ZZ–ZW type

- Seen in birds, fowl and fishes.
- Females have one Z and one W chromosome whereas males have a pair of Z chromosomes.



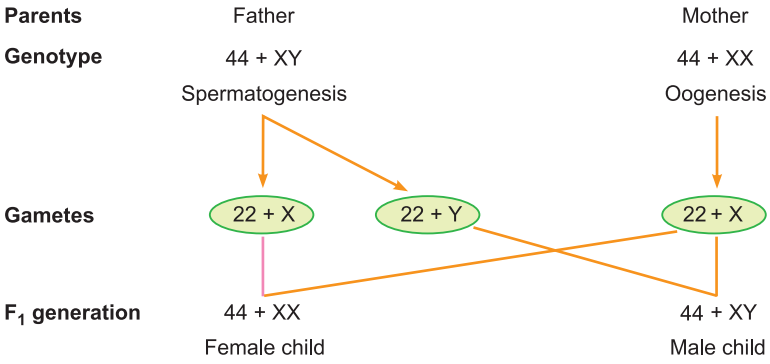
(iv) ZO–ZZ type

- Seen in butterflies and moths.
- Females have only one Z chromosome besides autosomes and males have a pair of Z chromosomes.



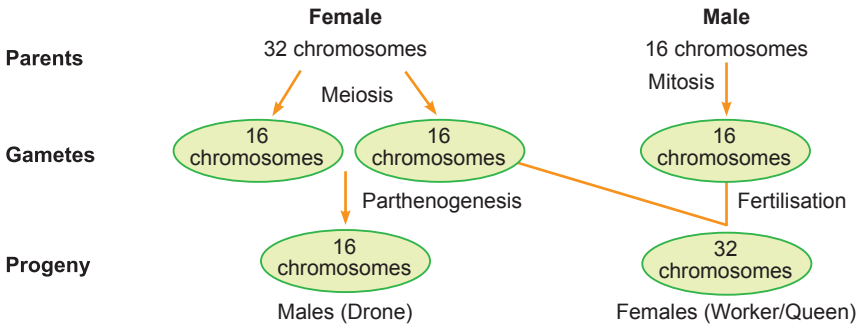
13. Sex Determination in Humans

- Humans show XY type of sex determining mechanism.
- Out of 23 pair of chromosomes, 22 are autosomes (same in both males and females).
- Females have a pair of X-chromosomes.
- Males have an X and a Y chromosome.
- During spermatogenesis males produce two types of gametes with equal probability – sperm carrying either X or Y chromosome.
- During oogenesis, females produce only one types of gamete – having X chromosome.
- An ovum fertilised by the sperm carrying X-chromosome develops into a female (XX) and an ovum fertilised by the sperm carrying Y-chromosome develops into a male (XY).



- Hence, it is evident that genetic constitution of sperm determines the sex of the child. In every pregnancy, there is always 50% probability of either male or female child. So it is not correct to blame women for producing female child.

14. Sex Determination in Honeybee (Haplodiploidy Sex Determination System)



- Honeybees show haplodiploid sex determination system.
- Offsprings formed from union of a sperm and an egg develops as a female (**queen or worker**), which are diploid, having 32 chromosomes.
- Unfertilised eggs developed by parthenogenesis form male (**drone**), which are haploid having 16 chromosomes.
- Males produce sperms by mitosis, so they, neither have fathers nor sons but have grandfathers and grandsons.

15. Pedigree Analysis

- The study of inheritance of genetic traits in several generations of a human family in the form of a family tree diagram is called **pedigree analysis**.
- **Advantages:**
  - (*i*) It helps in genetic counselling to avoid disorders in future generations.
  - (*ii*) It shows the origin of a trait and flow of a trait in a family.
  - (*iii*) It is important to know the possibility of expressive recessive allele that can cause genetic disorders like colour blindness, haemophilia, *etc*.
  - (*iv*) Control crosses cannot be made in humans, so pedigree analysis helps us to study inheritance pattern of a trait.
  - (*v*) It helps us to understand whether the trait is dominant or recessive autosomal or sex-linked.
  - (*vi*) It predicts the harmful effects of marriage between close relatives.
  - (*vii*) It is extensively used in medical research.

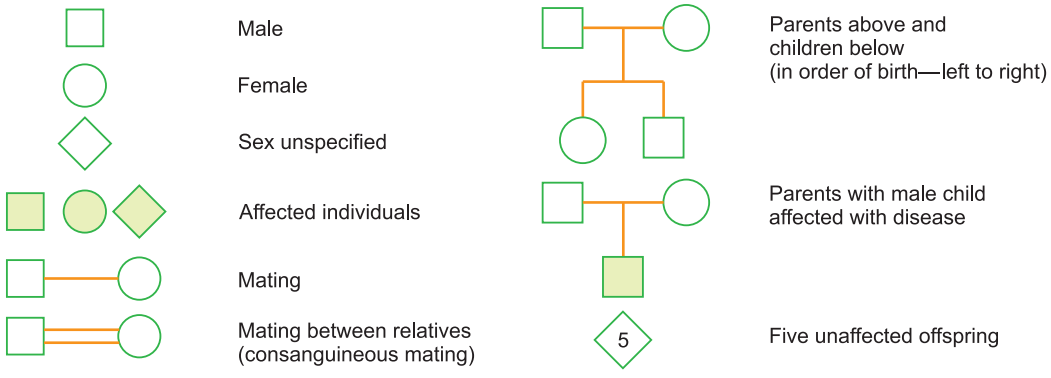


Fig. 5.6 Symbols used in the pedigree analysis

16. Mutations

- Mutation is defined as the sudden inheritable change in the genetic material. It can be of the following two major types:

  (*i*) Point mutation: It is the mutation in a single base pair, which is replaced by another base pair. For example, in sickle-cell anaemia, point mutation in β-globin chain results in change of glutamate to valine.

  (*ii*) Frameshift mutation: It is the change in the reading frame because of insertion or deletion of base pairs.

  (*a*) Insertion: It is the addition of one or more nucleotides in the DNA segment. Insertion of three or its multiple bases do not change the reading frame but add a new amino acid.

  (*b*) Deletion: It is the removal of one or more nucleotides from the DNA segment. Deletion of three or its multiple bases do not change the reading frame but remove one or more amino acids.

  Normal DNA: ATC GAT CGA

  Insertion: ATC C[G]A TCG

  Deletion: ATC ATC GA

  Example:

  RAM HAS RED CAP

  If we insert a letter B in between HAS and RED and rearrange the statement, it would read as follows:

  RAM HAS BRE DCA P

  Similarly, if we now insert two letters at the same place, say BI. Now it would read:

  RAM HAS BIR EDC AP

  Now we insert three letters together, say BIG, the statement would read:

  RAM HAS BIG RED CAP

  The same exercise can be repeated, by deleting the letters R, E and D, one by one and rearranging the statement to make a triplet word.

  RAM HAS EDC AP

  RAM HAS DCA P

  RAM HAS CAP

17. Mendelian Disorders

- Mendelian disorders are caused due to alteration or mutation in single gene.
- These follow Mendel's principles of inheritance.

(i) Haemophilia

(*i*) It is a sex-linked recessive disorder. It is also known as bleeder's disease.

(*ii*) Patient continues to bleed even with a minor cut because of a defect in blood coagulation.

(*iii*) The gene for haemophilia is located on X chromosome.

(*iv*) More males suffer from haemophilia than females because in males single gene for the defect is able to express as males have only one X chromosome.

(*v*) The defective alleles produce non-functional proteins which later form a non-functional cascade of proteins involved in blood clotting.

(*vi*) Females suffer from this disease only in homozygous condition, *i.e.*, X^hX^h.

(*vii*) Queen Victoria was a carrier of this disease and produced haemophilic offsprings.

(ii) Sickle-cell anaemia

(*i*) It is an autosome-linked recessive trait.

(*ii*) The disease is controlled by a single pair of allele Hb^A and Hb^S.

(*iii*) Only the homozygous individuals for Hb^S, *i.e.*, Hb^SHb^S show the diseased phenotype.

(*iv*) The heterozygous individuals are carriers (Hb^AHb^S).

(*v*) Due to point mutation, glutamic acid (Glu) is replaced by valine (Val) at the sixth position of β-globin chain of haemoglobin molecule.

(*vi*) It occurs due to single base substitution at 6th codon of β-globin gene from GAG to GUG. Mutated hemoglobin molecule undergoes polymerisation under low oxygen tension causing the change in the shape of RBC from biconcave disc to elongated sickle like structure. As a result, the cells cannot pass through narrow capillaries. Blood capillaries are clogged and thus affect blood supply to different organs.

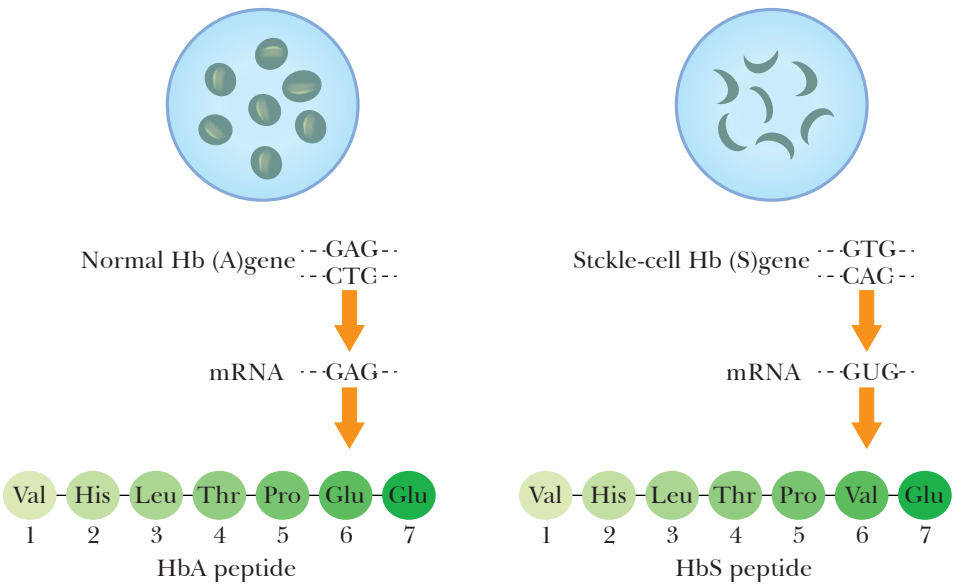


Fig. 5.7 Micrograph of the red blood cells and the amino acid composition of the relevant portion of b-chain of haemoglobin: (a) From a normal individual; (b) From an individual with sickle-cell anaemia

(iii) Phenylketonuria

(*i*) It is an inborn error of metabolism and is inherited as autosomal recessive trait.

(*ii*) The affected individual lacks an enzyme called phenylalanine hydroxylase that converts the amino acid phenylalanine into tyrosine in liver.

(*iii*) Phenylalanine is accumulated and gets converted into phenylpyruvic acid and other derivatives. This affects the brain, resulting in mental disorder.

(*iv*) Phenylalanine is also excreted through urine because of its poor absorption by kidney.

(iv) Thalassemia

(*i*) It is an autosome-linked recessive disease.

(*ii*) It occurs due to either mutation or deletion resulting in reduced rate of synthesis of one of globin chains of haemoglobin.

(*iii*) Anaemia is the characteristic of this disease.

(*iv*) Thalassemia is classified into two types:

- α-thalassemia—Production of α-globin chain is affected. It is controlled by the closely linked genes *HbA1* and *HbA2* on chromosome 16. It occurs due to mutation or deletion of one or more of the four genes.

- β-thalassemia—Production of β-globin chain is affected. It occurs due to mutation of one or both *HbB* genes on chromosome 11.

(v) Colour blindness

(*i*) It is a sex-linked recessive disorder.
(*ii*) It results in defect in either red or/and green cone of eye, resulting in failure to discriminate between red and green colour.
(*iii*) The gene for colour blindness is present on X chromosome.
(*iv*) It is observed more in males (X^cY) because of presence of only one X chromosome as compared to two chromosomes of females. It occurs in 8% males and 0.4% females.

18. Chromosomal Disorders

- Chromosomal disorders are caused due to excess, absence or abnormal arrangement of one or more chromosomes.
- **Aneuploidy:** Sometimes the chromatids fail to segregate during cell division, resulting in gain or loss of a chromosome. This is called **aneuploidy**. It is of two types:
  - **(*i*) Trisomy:** Additional copy of a chromosome in an individual, *i.e.*, $(2n+1)$.
  - **(*ii*) Monosomy:** Lack of copy of a chromosome in an individual, *i.e.*, $(2n-1)$.
- **Polyploidy:** Failure of cytokinesis after telophase stage of cell division results in an increase in whole set of chromosomes in an organism. It is called **polyploidy**. It is often seen in plants.

(i) Down's syndrome

Cause: Additional copy of chromosome number 21 or trisomy of chromosome 21.

Symptoms:

(*i*) Short statured with small round head.
(*ii*) Partially open mouth with protruding furrowed tongue.
(*iii*) Palm is broad with characteristic palm crease.
(*iv*) Physical, psychomotor and mental development retarded.

(ii) Klinefelter's syndrome

Cause: Presence of an additional copy of X chromosome resulting in the karyotype 44+XXY. *i.e.*, 47 chromosomes.

Symptoms:

(*i*) Sex of the individual is masculine but possess feminine characters.
(*ii*) Gynaecomastia, *i.e.*, development of breasts.
(*iii*) Poor beard growth and often sterile.
(*iv*) Feminine pitched voice.
(*v*) They are sterile.
(*vi*) Tall stature.

(iii) Turner's syndrome

Cause: Absence of one of the X chromosomes, resulting in the karyotype 44+XO *i.e.*, have 45 chromosomes.

Symptoms:

(*i*) Sterile female with rudimentary ovaries.
(*ii*) Lack of other secondary sexual characters.
(*iii*) Underdeveloped feminine characters.
(*iv*) Poor development of breasts.
(*v*) Short stature, small uterus, puffy fingers.

NCERT Textbook Questions

Q. 1. Mention the advantages of selecting pea plant for experiment by Mendel.

Ans. Refer to Basic Concepts Point 2.

Q. 2. Differentiate between the following:

(*a*) Dominance and recessiveness

(*b*) Homozygous and heterozygous

(*c*) Monohybrid and dihybrid

Ans. (*a*)

Table 5.3: Differences between dominance and recessiveness

S. No.	Dominance	Recessive
(*i*)	The phenomenon where one allele expresses itself even in the presence of other allele.	The phenomenon where an allele expresses itself in the absence of its dominant allele but remains masked in its presence.
(*ii*)	Dominant allele forms a complete functional enzyme due to which complete polypeptide is formed to express completely.	Recessive allele forms incomplete or defective, or non-functional polypeptide enzyme, due to which non-functional polypeptide is formed and fails to express completely.

(*b*)

Table 5.4: Differences between homozygous and heterozygous

S. No.	Homozygous	Heterozygous
(*i*)	When both alleles of a gene are similar, then the individual is called homozygous.	When both alleles of a gene are dissimilar, then the individual is called heterozygous.
(*ii*)	The genotype is expressed as TT or tt, *i.e.*, they contain either both dominant alleles or both recessive alleles.	The genotype is expressed as Tt, *i.e.*, they contain one dominant allele and one recessive allele.
(*iii*)	They are true breeding, leading to pure lines.	They are not true breeding.
(*iv*)	The gametes produced by them are similar in genotype.	The gametes produced by them are of two types, one with dominant allele and other with recessive allele.

(*c*)

Table 5.5: Differences between monohybrid and dihybrid

S. No.	Monohybrid	Dihybrid
(*i*)	It is the cross between two individuals considering a single contrasting trait or character at a time.	It is the cross between two individuals taking two contrasting traits or characters at a time.
(*ii*)	It helps to study the inheritance of a pair of allele.	It helps to study the inheritance of two pairs of allele.
(*iii*)	The phenotypic ratio in F_2 generation is 3 : 1.	The phenotypic ratio in F_2 generation is 9 : 3 : 3 : 1.
(*iv*)	The genotypic ratio in F_2 generation is 1 : 2 : 1.	The genotypic ratio in F_2 generation is 1 : 2 : 2 : 4 : 1 : 2 : 1 : 2 : 1.

Q. 3. A diploid organism is heterozygous for 4 loci, how many types of gametes can be produced?

Ans. Here, we apply the formula 2^n where n = number of loci.

The organism is heterozygous for 4 loci,

$$n = 4$$

So, $$2^n = 2^4 = 2 \times 2 \times 2 \times 2 = 16$$

$\therefore$ The organism will produce 16 types of gametes.

Q. 4. Explain the law of dominance using a monohybrid cross.

Ans. Law of dominance states that when two different allelomorphic forms (genes) are present in an organism, only one expresses itself in F_1 generation which is called dominant gene while the other which does not show its effect and remains masked is called recessive gene.

When a cross is performed between two individuals taking a single contrasting character at a time, it is called a monohybrid cross.

The character 'height' in pea plant has two alleles 'T' and 't'. 'T' exhibits tallness whereas 't' exhibits dwarfness. When a pure tall (TT) pea plant is crossed with a pure dwarf (tt) plant, in the F_1 generation hybrid (heterozygous) 'Tt' is obtained, which is tall due to the presence of allele 'T'. This shows that tallness is dominant over dwarfness which remain unexpressed in generation. Thus, this cross explains law of dominance.

For cross refer to Fig. 5.2.

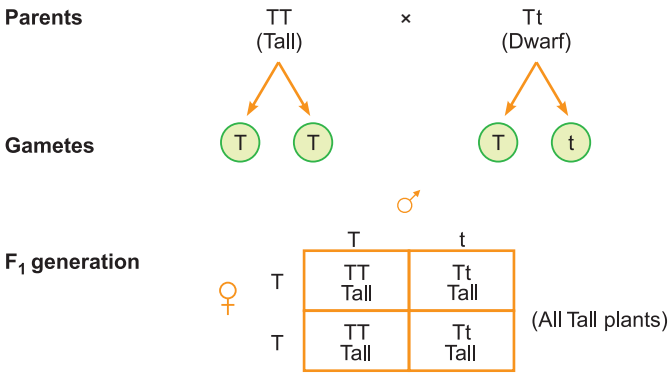
Q. 5. Define and design a test cross.

Ans. Refer to Basic Concepts Point 7.

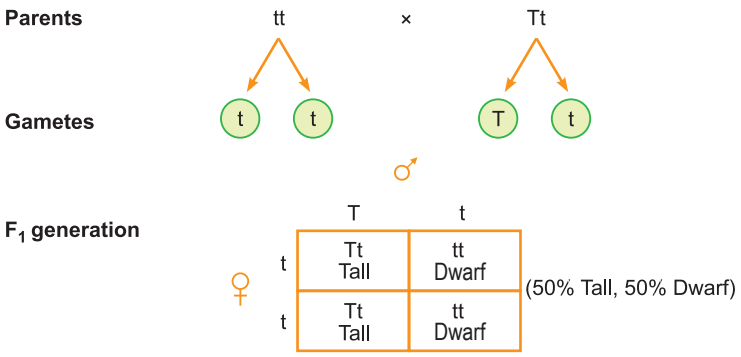
Q. 6. Using a Punnett square, workout the distribution of phenotypic features in the first filial generation after a cross between a homozygous female and a heterozygous male for a single locus.

Ans. A cross between a homozygous female and heterozygous male follow two conditions:

Condition 1: Homozygous female: TT (Tall)
Heterozygous male: Tt (Tall)



Condition 2: Homozygous female: tt (Dwarf)
Heterozygous male: Tt (Tall)



Q. 7. When a cross is made between tall plant with yellow seed (TtYy) and tall plant with green seed (Ttyy), what proportions of phenotype in the offspring could be expected to be (*a*) tall and green (*b*) dwarf and green?

Ans.

Parents Tall with yellow seed × Tall with green seed

Genotype TtYy × Ttyy

Gametes TtYy → TY, Ty, tY, ty; Ttyy → Ty, ty

F_2 generation

♀ \ ♂	Ty	ty
TY	TTYy Tall, yellow	TtYy Tall, yellow
Ty	TTyy Tall, green	Ttyy Tall, green
tY	TtYy Tall, yellow	ttYy Dwarf, yellow
ty	Ttyy Tall, green	ttyy Dwarf, green

Phenotypic ratio

Tall and green = 3 : 8

Dwarf and green = 1 : 8

Q. 8. Two heterozygous parents are crossed. If the two loci are linked what would be the distribution of phenotypic features in F_1 generation for a dihybrid cross?

Ans. If the two loci are completely linked, then there would be no segregation and the F_1 generation will exhibit parental characteristics only. But if the two loci are incompletely linked, then segregation would occur partly and the F_1 generation will exhibit both parental and recombinant characteristics but the recombinants will be in a very small proportion depending on distance between gases.

Q. 9. Briefly mention the contribution of T. H. Morgan in genetics.

Ans. T. H. Morgan (1866–1945) was given the Nobel Prize in 1933. His contributions are:

(*i*) Morgan worked on fruit fly *Drosophila melanogaster* and proposed the chromosomal theory of linkage.

(*ii*) He stated and established that genes are located on the chromosome.

(*iii*) He established the principle of linkage, crossing over, sex-linked inheritance and discovered the relationship between gene and chromosome.

(*iv*) He established the technique of chromosome mapping.

(*v*) He observed and worked on mutation.

Q. 10. What is pedigree analysis? Suggest how such an analysis can be useful.

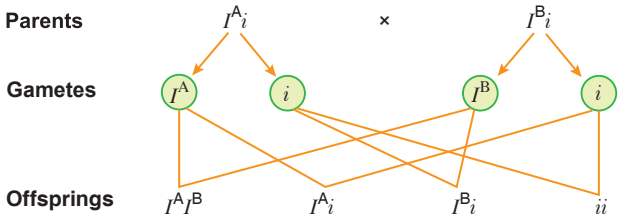
Ans. Refer to Basic Concepts Point 15.

Q. 11. How is sex determined in human beings?

Ans. Refer to Basic Concepts Point 13.

Q. 12. A child has blood group O. If the father has blood group A and mother has blood group B, workout the genotypes of the parents and the possible genotypes of the offsprings.

Ans. The child will have blood group O only when the parents are heterozygous. Thus, the genotype of the parents would be I^Ai and I^Bi and that of the child will be $i\ i$. The cross of the parents is depicted below.



Thus the other possible genotype are I^AI^B (AB blood group) I^Ai, (A blood group), I^Bi (B blood group)

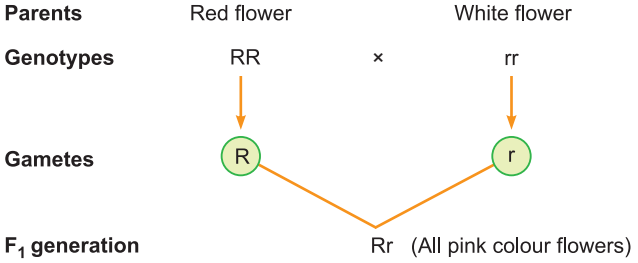
Q. 13. Explain the following terms with example

(*i*) Co-dominance **(*ii*) Incomplete dominance**

Ans. **(*i*) Co-dominance:** When the F_1 generation resembles both the parents, and both the parental characters are expressed simultaneously, then the phenomenon is called co-dominance.

For example, 'AB' type blood group is possible when allele 'A' and 'B' come together. Since both the alleles are expressing their effects in F_1 generation, they are said to be co-dominant.

(*ii*) Incomplete dominance: In incomplete dominance, the genes of allelomorphic pairs are not expressed as dominant and recessive but instead express themselves partially when present together in the hybrid. As a result, F_1 hybrids show characters intermediate of the parental genes. For example, *Mirabilis jalapa* (4 O' clock plant) exhibits two types of flowers, red and white and the hybrids are pink coloured flowers.



Q. 14. What is point mutation? Give one example.

Ans. Point mutation is a gene mutation that arises due to change in a single base pair of DNA.

Example: Sickle-cell anaemia.

$$\underset{\text{Glutamic acid}}{G\boxed{A}G} \xrightarrow{\text{Mutation}} \underset{\text{Valine}}{G\boxed{U}G}$$

A substitution of a single nitrogen base (GAG → GUG) at the sixth codon of the β-globin chain of haemoglobin molecule causes substitution of Glutamic acid by Valine at 6^{th} position & thus the change in the shape of the RBC from biconcave disc to elongated spindle shaped, structure which results in sickle-cell anaemia.

Q. 15. Who had proposed the chromosomal theory of inheritance?

Ans. In 1902, Walter Sutton and Theodore Boveri proposed the chromosomal theory of inheritance.

Q. 16. Mention any two autosomal genetic disorders with their symptoms.

Ans. Two autosomal genetic disorders are:

(*a*) Down's Syndrome: It was first described by Langdon Down (1866). It is caused due to the presence of an additional copy of the chromosome number 21, *i.e.*, trisomy ($2n + 1$).

Symptoms:

(*i*) Short stature with small round head

(*ii*) Partially open mouth

(*iii*) Protruding furrowed tongue

(*iv*) Short neck

(*v*) Retarded mental development

(*b*) **Phenylketonuria:** It is an inborn error of metabolism. The affected individual lack an enzyme called phenylalanine hydroxylase that converts the amino acid phenylalanine into tyrosine. As a result, phenylalanine gets accumulated and converted into phenylpyruvic acid and other derivatives in brain, causing mental retardation. These are also excreted through urine due to their poor absorption by kidney.

Multiple Choice Questions [1mark]

Choose and write the correct option in the following questions.

1. Which one of the following is an example of polygenic inheritance?

(*a*) Skin colour in humans. (*b*) Flower colour in *Mirabilis jalapa*.

(*c*) Production of male honey bee. (*d*) Pod hsape in garden pea.

2. In Mendel's experiments with garden pea, round seed shape (RR) was dominant over wrinkled seeds (rr), yellow cotyledon (YY) was dominant over green cotyledon (yy). What are the expected phenotypes in the F_2 generation of the cross RRYY × rryy?

(*a*) Round seeds with yellow cotyledons, and wrinkled seeds with yellow cotyledons.

(*b*) Only round seeds with green cotyledons.

(*c*) Only wrinkled seeds with yellow cotyledons.

(*d*) Only wrinkled seeds with green cotyledons.

3. Test cross involves

(*a*) crossing between two genotypes with dominant trait

(*b*) crossing between two genotypes with recessive trait

(*c*) crossing between two F_1 hybrids

(*d*) crossing the F_1 hybrid with a double recessive genotype.

4. If a colour blind woman marries a normal visioned man, their sons will be

(*a*) all colour blind

(*b*) all normal visioned

(*c*) one-half colour blind and one-half normal

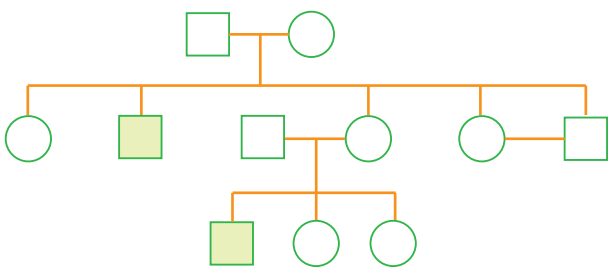
(*d*) three-fourths colour blind and one-fourth normal

5. Inheritance of skin colour in humans is an example on

(*a*) point mutation (*b*) polygenic inheritance

(*c*) codominance (*d*) chromosomal aberration.

6. Study the pedigree chart given below. What does it show?



(*a*) Inheritance of a condition like phenylketonuria as an autosomal recessive trait.

(*b*) The pedigree chart is wrong as this is not possible.

(*c*) Inheritance of a recessive sex-linked disease like haemophilia.

(*d*) Inheritance of a sex-linked inborn error of metabolism like phenylketonuria.

7. All genes located on the same chromosome [*NCERT Exemplar*]

(*a*) form different groups depending upon their relative distance

(*b*) form one linkage group

(*c*) will not from any linkage groups

(*d*) form interactive groups that affect the phenotype

8. Conditions of a karyotype $2n + 1$, $2n - 1$ and $2n + 2$, $2n - 2$ are called [*NCERT Exemplar*]

(*a*) aneuploidy (*b*) polyploidy

(*c*) allopolyploidy (*d*) monosomy

9. Distance between the genes and percentage of recombination shows [*NCERT Exemplar*]

(*a*) a direct relationship (*b*) an inverse relationship

(*c*) a parallel relationship (*d*) no relationship

10. If a genetic disease is transferred from a phenotypically normal but carrier female to only some of the male progeny, the disease is [*NCERT Exemplar*]

(*a*) autosomal dominant (*b*) autosomal recessive

(*c*) sex-linked dominant (*d*) sex-linked recessive

11. If a plant heterozygous for tallness is selfed, the F_2 generation has both tall and dwarf plants. It proves the principle of

(*a*) dominance (*b*) segregation

(*c*) independent assortment (*d*) incomplete dominance

12. In sickle cell anaemia glutamic acid is replaced by valine. Which one of the following triplets codes for valine? [*NCERT Exemplar*]

(*a*) G G G (*b*) A A G (*c*) G A A (*d*) G U G

13. Person having genotype $I^A I^B$ would show the blood group as AB. This is because of [*NCERT Exemplar*]

(*a*) pleiotropy (*b*) co-dominance

(*c*) segregation (*d*) incomplete dominance

14. Z Z/ZW type of sex determination is seen in [*NCERT Exemplar*]

(*a*) platypus (*b*) snails (*c*) cockroach (*d*) peacock

15. A cross between two tall plants resulted in offspring having few dwarf plants. What would be the genotypes of both the parents? [*NCERT Exemplar*]

(*a*) TT and Tt (*b*) Tt and Tt

(*c*) TT and TT (*d*) Tt and tt

16. In a dihybrid cross, if you get 9:3:3:1 ratio it denotes that [*NCERT Exemplar*]

(*a*) the alleles of two genes are interacting with each other

(*b*) it is a multigenic inheritance

(*c*) it is a case of multiple allelism

(*d*) the alleles of two genes are segregating independently.

17. Which of the following will not result in variations among siblings?

(*a*) Independent assortment of genes (*b*) Crossing over

(*c*) Linkage (*d*) Mutation

18. What will never be father's blood group if the mother has blood group B and child blood group O?

(*a*) A (*b*) B (*c*) AB (*d*) O

19. Mendel's Law of independent assortment holds good for genes situated on the [*NCERT Exemplar*]

(*a*) non-homologous chromosomes (*b*) homologous chromosomes

(*c*) extra nuclear genetic element (*d*) same chromosome

20. Occasionally, a single gene may express more than one effect. The phenomenon is called *[NCERT Exemplar]*

(*a*) multiple allelism (*b*) mosaicism (*c*) pleiotropy (*d*) polygeny

21. In a certain taxon of insects some have 17 chromosomes and the others have 18 chromosomes. The 17 and 18 chromosome bearing organisms are *[NCERT Exemplar]*

(*a*) males and females, respectively (*b*) females and males, respectively

(*c*) all males (*d*) all females

22. The inheritance pattern of a gene over generations among humans is studied by the pedigree analysis. Character studied in the pedigree analysis is equivalent to *[NCERT Exemplar]*

(*a*) quantitative trait (*b*) Mendelian trait (*c*) polygenic trait (*d*) maternal trait

23. It is said that Mendel proposed that the factor controlling any character is discrete and independent. His proposition was based on the *[NCERT Exemplar]*

(*a*) results of F_3 generation of a cross.

(*b*) observations that the offspring of a cross made between the plants having two contrasting characters shows only one character without any blending.

(*c*) self pollination of F_1 offsprings.

(*d*) cross pollination of F_1 generation with recessive parent.

24. Which of the following represents a pair of contrasting characters?

(*a*) Allele (or allelomorphs) (*b*) Phenotype

(*c*) Homozygous (*d*) Heterozygous

25. Two genes 'A' and 'B' are linked. In a dihybrid cross involving these two genes, the F_1 heterozygote is crossed with homozygous recessive parental type (aa bb). What would be the ratio of offspring in the next generation? *[NCERT Exemplar]*

(*a*) 1 : 1 : 1: 1 (*b*) 9 : 3 : 3 : 1 (*c*) 3 : 1 (*d*) 1 : 1

26. In the F_2 generation of a Mendelian dihybrid cross the number of phenotypes and genotypes are *[NCERT Exemplar]*

(*a*) phenotypes - 4; genotypes - 16 (*b*) phenotypes - 9; genotypes - 4

(*c*) phenotypes - 4; genotypes - 8 (*d*) phenotypes - 4; genotypes - 9

Answers

1. (*a*)	**2.** (*a*)	**3.** (*d*)	**4.** (*a*)	**5.** (*b*)	**6.** (*a*)	**7.** (*b*)	**8.** (*a*)	**9.** (*a*)	**10.** (*d*)
11. (*b*)	**12.** (*d*)	**13.** (*b*)	**14.** (*d*)	**15.** (*b*)	**16.** (*d*)	**17.** (*c*)	**18.** (*c*)	**19.** (*b*)	**20.** (*c*)
21. (*a*)	**22.** (*b*)	**23.** (*b*)	**24.** (*a*)	**25.** (*d*)	**26.** (*d*)				

Assertion-Reason Questions

In the following questions a statement of assertion followed by a statement of reason is given. Choose the correct answer out of the following choices.

(a) Assertion and reason both are correct statements and reason is correct explanation for assertion.

(b) Assertion and reason both are correct statements but reason is not correct explanation for assertion.

(c) Assertion is correct statement but reason is wrong statement.

(d) Assertion is wrong statement but reason is correct statement.

1. Assertion : The law of independent assortment can be studied through dihybrid cross.

Reason : Only those genes show independent assortment which are linked.

2. Assertion : Mendel successfully conducted his hybridisation experiments.

Reason : Garden pea was an ideal experimental material.

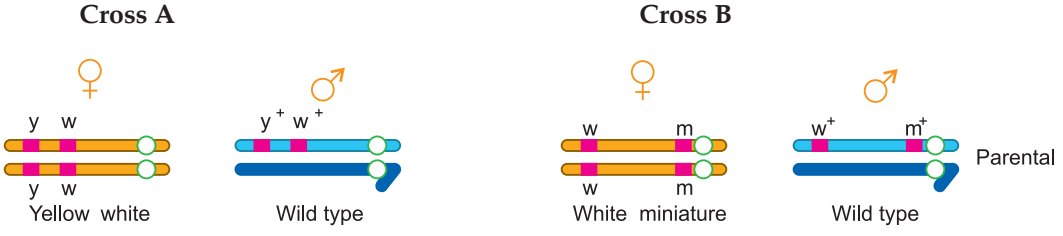
3. **Assertion :** In a monohybrid cross, only dominant characters exhibit themselves in the F_1 generation
   Reason : Dominant trait is expressed only in the heterozygous condition.
4. **Assertion :** ABO blood group system is a good example of pleiotropic genes.
   Reason : In ABO blood group system, when I^A and I^B alleles are present together, both express themselves.
5. **Assertion :** In birds, females are heterogametic and males are homogametic.
   Reason : In birds, females have ZW sex chromosomes and males have ZZ sex chromosomes.
6. **Assertion :** The maximum frequency of recombination that results from crossing over of linked genes is 50 percent.
   Reason : If distance between linked genes is longer, they show higher frequency of crossing over.
7. **Assertion :** Down's syndrome is caused due to absence of either X or Y sex chromosome.
   Reason : Such individuals show mental retardation and broad head with characteristic features.
8. **Assertion :** Sickle-cell anaemia is an autosome-linked recessive disorder.
   Reason : It appears only in human male which can be transferred to their grandson through carrier daughter.
9. **Assertion :** Haemophilia never occurs in women.
   Reason : Gene for haemophilia is located on X chromosome.
10. **Assertion :** The genetic complement of an organism is called genotype.
    Reason : Genotype is the type of hereditary properties of an organism.

Answers

1. (*c*) **2.** (*b*) **3.** (*c*) **4.** (*d*) **5.** (*a*) **6.** (*b*) **7.** (*d*) **8.** (*c*) **9.** (*c*) **10.** (*a*)

Case-based/Source-based Question

1. Study the figures given below and answer the questions that follow.



(*i*) In a dihybrid cross, when would the proportion of parental gene combinations be much higher than non-parental types, as experimentally shown by Morgan and his group?

(*ii*) If two genes are located far apart from each other on a chromosome, how the frequency of recombination will get affected?

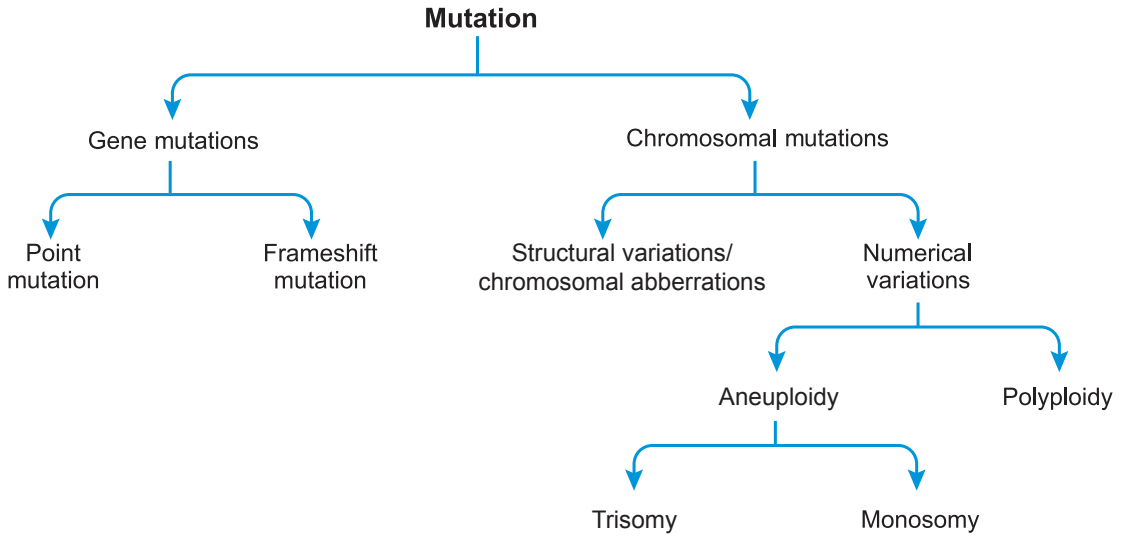
(*iii*) What are 'true breeding lines' that are used to study inheritance pattern of traits in plants?

Ans. (*i*) When the genes are linked.

(*ii*) Frequency of recombination will be higher.

(*iii*) True breeding lines are plants which have undergone continuous self-pollination for several generations. These are homozygous for traits.

2. Study the flowchart given below and answer the questions that follow.



(*i*) What is a mutagen? Name a physical factor that can be mutagen.

(*ii*) What is point mutation? Give one example.

(*iii*) Mention two causes of frame-shift mutation.

Ans. (*i*) All the physical and chemical factors that induce mutation are called mutagens. UV radiation and X-rays are physical mutagens.

(*ii*) Mutation arising due to change in a single base pair of DNA is called point mutation.

(*iii*) Insertion and deletion of three bases or multiples of three bases cause frame-shift mutation because the reading frame remains unaltered from that point onwards.

3. A relevant portion of β-chain of haemoglobin of a normal human is given below:

The codon for the sixth amino acid is GAG. The sixth codon GAG mutates to GAA as a result of mutation 'A' and into GUG as a result of mutation 'B'. Haemoglobin structure did not change as a result of mutation 'A' whereas haemoglobin structure changed because of mutation 'B' leading to sickle shaped RBCs.

(*i*) Explain giving reasons how could mutation 'B' change the haemoglobin structure and not mutation 'A'.

(*ii*) Write the genotype of (*i*) an individual who is carrier of sickle cell anaemia gene but apparently unaffected, and (*ii*) an individual affected with the disease.

Ans. (*i*) Due to mutation 'A', GAG mutates to GAA. But both GAG and GAA code for glutamic acid and hence there is no change in RBCs. Whereas GUG formed due to mutation 'B' codes for valine and so the RBCs become sickle-shaped.

(*ii*) (*a*) Hb^AHb^S (*b*) Hb^SHb^S

Very Short Answer Questions [1 mark]

Q. 1. State a difference between a gene and an allele. ***[CBSE Delhi 2016]***

Ans. Gene contains information that is required to express a particular trait whereas alleles are alternating forms of a gene and are the code for a pair of contrasting traits for *e.g.*, for plant height has two alleles – for tallness and dwarfness.

Q. 2. Name the respective pattern of inheritance where F_1 phenotype
(*a*) does not resemble either of the two parents and is in between the two.
(*b*) resembles only one of the two parents. **[*CBSE (AI) 2012*]**

Ans. (*a*) Incomplete dominance (*b*) Dominance

Q. 3. A garden pea plant (A) produced inflated yellow pod, and another plant (B) of the same species produced constricted green pods. Identify the dominant traits. **[*CBSE Delhi 2012*]**

Ans. Inflated green pod is the dominant trait.

Q. 4. A garden pea plant produced axial white flowers. Another of the same species produced terminal violet flowers. Identify the dominant traits. **[*CBSE (AI) 2012*]**

Ans. Axial, violet flower.

Q. 5. A garden pea plant produced round green seeds. Another of the same species produced wrinkled yellow seeds. Identify the dominant traits. **[*CBSE (F) 2012*] [*HOTS*]**

Ans. Round, yellow seed are the dominant traits.

Q. 6. A geneticist interested in studying variations and patterns of inheritance in living beings prefers to choose organisms for experiments with shorter life cycle. Provide a reason. **[*CBSE Delhi 2015*] [*HOTS*]**

Ans. This is because many generations can be obtained (in a short time) and selection of character becomes faster.

Q. 7. Write the possible genotypes, Mendel got when he crossed F_1 tall pea plants with a dwarf pea plant. **[*CBSE (F) 2012*]**

Ans. Possible genotypes: Tt and tt.

Q. 8. How many kinds of phenotypes would you expect in F_2 generation in a monohybrid cross? **[*CBSE (AI) 2014*]**

Ans. Two (*e.g.*, Tall and dwarf).

Q. 9. Mention any two contrasting traits with respect to seeds in pea plant that were studied by Mendel. **[*CBSE (AI) 2014*] [*HOTS*]**

Ans. Round/Wrinkled, Yellow/Green

Q. 10. When a tall pea plant was self-pollinated, one-fourth of the progeny were dwarf. Give the genotype of the parent and dwarf progenies. **[*HOTS*]**

Ans. Genotype of parent is Tt and the genotype of dwarf progenies is tt.

Q. 11. Discuss is the genetic basis of wrinkled phenotype of pea seeds. **[*NCERT Exemplar*] [*HOTS*]**

Ans. Wrinkled seed shape is a recessive trait. It expresses only under homozygous condition of alleles.

Q. 12. How many type of gametes are produced by the individual with genotype AABBCCDD and AaBbCcDd? **[*HOTS*]**

Ans. One type of gamete by individual (AABBCCDD) ABCD and sixteen (= 2^4 = 16) type of gametes by individual AaBbCcDd.

Q. 13. Mention the type of allele that expresses itself only in homozygous state in an organism. **[*CBSE (F) 2011*] [*HOTS*]**

Ans. Recessive allele.

Q. 14. Write the percentage of F_2 homozygous and heterozygous populations in a typical monohybrid cross. **[*CBSE (F) 2010*] [*HOTS*]**

Ans. The ratio of a typical monohybrid cross is 1 : 2 : 1 where 50% are homozygous and 50% are heterozygous populations. (25% homozygous dominant, 25% homozygous recessive)

Q. 15. Name the type of cross that would help to find the genotype of a pea plant bearing violet flowers. **[*CBSE (AI) 2017*]**

Ans. Test cross.

Q. 16. A cross was carried out between two pea plants showing the contrasting traits of height of the plant. The result of the cross showed 50% of parental characters. Name the type of cross. **[*CBSE Sample Paper 2018*]**

Ans. Test cross

Q. 17. Why, in a test cross, did Mendel cross a tall pea plant with a dwarf pea plant only? ***[CBSE (F) 2012]*** ***[HOTS]***

Ans. To determine the genotype of the tall plant, whether it is homozygous dominant or heterozygous, as dwarfness is a recessive trait which is expressed only in homozygous condition and he was sure of genotype of dwarf plant.

Q. 18. Name the stage of cell division where segregation of an independent pair of chromosomes occurs. ***[CBSE (AI) 2014]*** ***[HOTS]***

Ans. Anaphase-I of Meiosis-I.

Q. 19. If the frequency of a parental form is higher than 25% in a dihybrid test cross, what does that indicate about the two genes involved? ***[HOTS]***

Ans. It shows that the two genes are linked.

Q. 20. For the expression of traits, genes provide only the potentiality and the environment provides the opportunity. Comment on the veracity of the statement. ***[NCERT Exemplar]***

Ans. Phenotype = Genotype + Environment
(Trait) (Potentiality) (Opportunity)

Q. 21. Mention the combination(s) of sex chromosomes in a male and a female bird. ***[CBSE (F) 2017]***

Ans. Male bird – ZZ, Female bird – ZW

Q. 22. Write the types of sex determination mechanisms the following crosses show. Give an example of each type.

(*i*) Female XX with Male XO

(*ii*) Female ZW with Male ZZ ***[CBSE Delhi 2014]***

Ans. (*i*) Male heterogamety, Grasshopper
(*ii*) Female heterogamety, Birds

Q. 23. How many chromosomes do drones of honeybee possess? Name the type of cell division involved in the production of sperms by them. ***[CBSE (AI) 2015]***

Ans. Drones possess 16 chromosomes. Mitosis is involved in the production of sperms.

Q. 24. A male honeybee has 16 chromosomes whereas its female has 32 chromosomes. Give one reason. ***[CBSE (AI) 2016]*** ***[HOTS]***

Ans. Male honeybee develops from unfertilised female gamete (Parthenogenesis) and thus has 16 chromosomes whereas female develops by fertilisation and thus has 32 chromosomes.

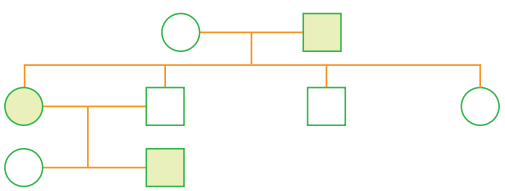
Q. 25. Give an example of a human disorder that is caused due to a single gene mutation. ***[CBSE Delhi 2016]***

Ans. Sickle-cell anaemia.

Q. 26. The egg of an animal contains 10 chromosomes, of which one is X-chromosome. How many autosomes would there be in the karyotype of this animal? ***[HOTS]***

Ans. There will be 9 pairs of autosomes in the karyotype of this animal.

Q. 27. Observe the pedigree chart and answer the following questions:



(*a*) Identify whether the trait is sex-linked or autosomal.

(*b*) Give an example of a disease in human beings which shows such a pattern of inheritance. ***[CBSE Sample Paper 2016]*** ***[HOTS]***

Ans. (*a*) The trait is sex-linked.
(*b*) Haemophilia, Colour blindness (*Any one*)

Q. 28. A haemophilic man marries a normal homozygous woman. What is the probability that their daughter will be haemophilic? *[HOTS]*

Ans. 0% because only one X chromosome will carry the haemophilia gene. So, she will be a carrier.

Q. 29. A haemophilic son was born to normal parents. Give the genotypes of the parents and son. *[HOTS]*

Ans. Father : 44 + XY
Mother : 44 + XX^h
Son : 44 + X^hY.
(X^h= X chromosome with gene for haemophilia)

Q. 30. State the chromosomal defect in individuals with Turner's syndrome. *[CBSE Delhi 2015]*

Ans. Monosomy of sex chromosome in females (XO condition).

Q. 31. Name the event, during cell division cycle that results in the gain or loss of chromosome. *[CBSE Delhi 2011]*

Ans. Failure of segregation of chromosomes.

Q. 32. Name one autosomal dominant and one autosomal recessive Mendelian disorder in humans. *[CBSE (AI) 2010]*

Ans. Huntington's disease is an autosomal dominant disorder and sickle-cell anaemia is an autosomal recessive disorder.

Q. 33. A human being suffering from Down's syndrome shows trisomy of 21st chromosome. Mention the cause of this chromosomal abnormality. *[CBSE (AI) 2010]*

Ans. Due to non-disjunction *i.e.*, 21st pair of chromosomes fail to separate during gametogenesis. Therefore, the gamete possesses 24 chromosomes instead of 23. When such a gamete fuses with another gamete, the zygote will have three copies of chromosome 21 causing trisomy.

Q. 34. Why is it that the father never passes on the gene for haemophilia to his sons? Explain. *[CBSE (AI) 2012] [HOTS]*

Ans. Haemophilia is a sex-linked recessive disease and the defective gene is present on X chromosome only and not on Y chromosome. Father never passes X chromosome to the son as father only contributes Y chromosome to the son.

Q. 35. Why do normal red blood cells become elongated sickle shaped structures in a person suffering from sickle cell anaemia? *[CBSE (F) 2014] [HOTS]*

Ans. Due to point mutation, glutamic acid (Glu) is replaced by valine (Val) at the sixth position of β-globin chain of haemoglobin molecule. Under oxygen stress erythrocytes lose their circular shape and become sickle-shaped.

Q. 36. Give an example of a chromosomal disorder caused due to non-disjunction of autosomes. *[CBSE Sample Paper 2016]*

Ans. Down's Syndrome.

Q. 37. Name a human genetic disorder due to the following: *[CBSE 2019 (57/2/1)]*

(*i*) An additional X-chromosome in a male

(*ii*) Deletion of one X-chromosome in a female

Ans. (*i*) Klinefelter's Syndrome (*ii*) Turner's Syndrome

Q. 38. State what does aneuploidy lead to. *[CBSE 2019 (57/2/1)]*

Ans. Aneuploidy leads to individuals with abnormal number of chromosomes. Some disorder due to aneuploidy are Down's Syndrome, Turner's Syndrome, Klinefelter's Syndrome.

Short Answer Questions [2 marks]

Q. 1. What are the characteristic features of a true-breeding line? *[NCERT Exemplar]*

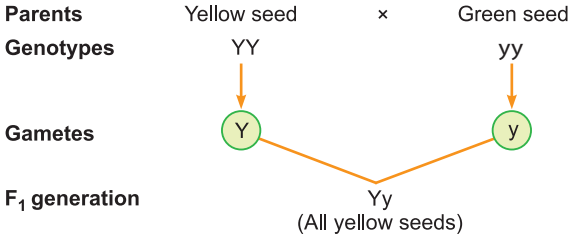
Ans. A true-breeding line for a trait is one that has undergone continuous self-pollination, showing a stability in the inheritance of the trait for several generations.

Q. 2. In order to obtain the F_1 generation, Mendel pollinated a true-breeding, say, tall plant with a true-breeding dwarf plant. But for getting the F_2 generation, he simply self-pollinated the tall F_1 plants. Why? *[NCERT Exemplar]*

Ans. All the F_1 offsprings of the cross are heterozygous so allowing self-pollination is sufficient to raise F_2 offspring. Also he intended to understand the inheritance of the selected trait over generations.

Q. 3. Mendel crossed plants that bred true for yellow seeds with plants that bred true for green seeds. All seeds in the F_1 generation were yellow. Work out the inheritance involved in this cross by using symbols for the trait. Which trait was dominant?

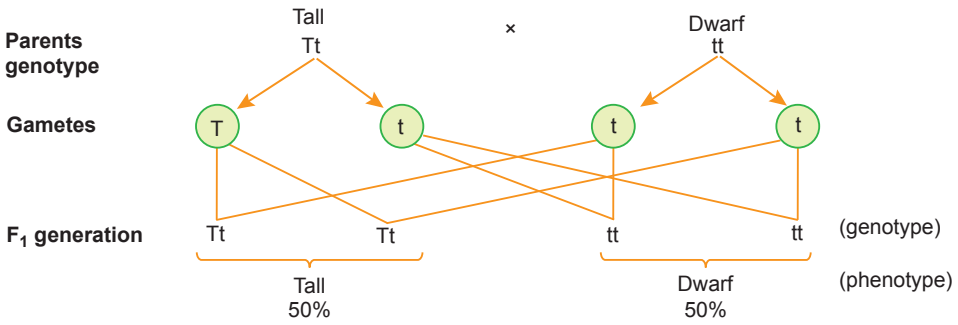
Ans.



Conclusion: The yellow seed colour is dominant over green as it is expressed in the F_1 generation.

Q. 4. During a monohybrid cross involving a tall pea plant with a dwarf pea plant, the offspring populations were tall and dwarf in equal ratio. Work out a cross to show how it is possible. *[CBSE (AI) 2015]*

Ans.



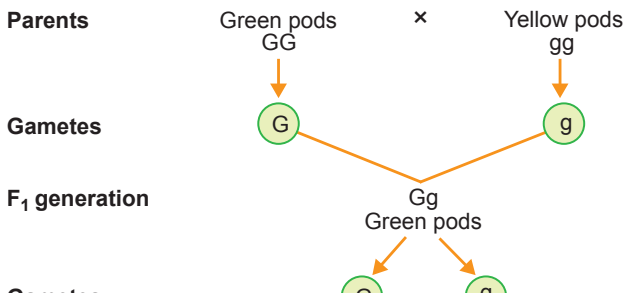
Q. 5. With the help of a Punnett square, find the percentage of homozygous talls in a F_2 population involving a true breeding tall and a true breeding dwarf pea plant. *[CBSE (F) 2013]*

Ans. Refer to Fig. 5.2.

Percentage of homozygous tall = $1/4 \times 100 = 25\%$

Q. 6. With the help of a Punnett square, find the percentage of heterozygous individuals in a F_2 population in a cross involving a true breeding pea plant with green pods and a true breeding pea plant with yellow pods respectively. *[CBSE (F) 2013]*

Ans.



F_2 generation

♀ \ ♂	G	g
G	GG Green	Gg Green
g	Gg Green	gg Yellow

% age of heterozygous individuals: $\frac{2}{4} \times 100 = 50\%$

Q. 7. In peas, tallness is dominant over dwarfness, and red colour of flowers is dominant over the white colour. When a tall plant bearing red flowers was pollinated by a dwarf plant bearing white flowers, the different phenotypic groups were obtained in the progeny in numbers mentioned against them.

Tall, Red = 138 **Tall, White = 132**

Dwarf, Red = 136 **Dwarf, White = 128**

Mention the genotypes of the two parents and of the types of four offsprings.

[*NCERT Exemplar*] [*HOTS*]

Ans. The result shows that the four types of offspring are in a ratio of 1 : 1 : 1 : 1. Such a result is observed in a test cross progeny of a dihybrid cross.

The cross can be represented as:

Parents: Tall and red (TtRr) × Dwarf and white (ttrr)

Offsprings:

♀ ♂	**TR**	**Tr**	**tR**	**tr**
tr	TtRr Tall and red	Ttrr Tall and white	ttRr Dwarf and red	ttrr Dwarf and white

Q. 8. In a typical monohybrid cross the F_2 population ratio is written as 3:1 for phenotype but expressed as 1:2:1 for genotype. Explain with the help of an example. **[*CBSE (AI) 2013*]**

Ans. This is a case of Mendel's monohybrid cross.

Refer to the cross in Fig. 5.2.

Q. 9. In snapdragon, a cross between true-breeding red flowered (RR) plants and true-breeding white flowered (rr) plants showed a progeny of plants with all pink flowers.

(*a*) The appearance of pink flowers is not known as blending. Why?

(*b*) What is this phenomenon known as? **[*CBSE (AI) 2014*]**

Ans. (*a*) R (dominant allele red colour) is not completely dominant over r (recessive allele white colour). r maintains its originality and reappears in F_2 generation. Therefore, it is not blending.

(*b*) Incomplete dominance.

Q. 10. The phenotypic and genotypic ratio in F_2 generation are same in a certain kind of inheritance. Name an organism in which it occurs and mention the kind of inheritance involved. **[*HOTS*]**

Ans. This kind of inheritance occurs in *Mirabilis jalapa* (4 O'clock plant) and the type of inheritance is called incomplete dominance.

Q. 11. In a particular plant species, majority of the plants bear purple flowers. Very few plants bear white flowers. No intermediate colours are observed. If you are given a plant bearing purple flowers, how would you ascertain that it is a pure breed for that trait? Explain.

[*CBSE Sample Paper 2014*]

Ans. By test cross. Cross, purple flower plant with a (homozygous) recessive plant with white flowers, if all the flowers of the progeny are purple, the plant is homozygous dominant, *i.e.* pure breed.

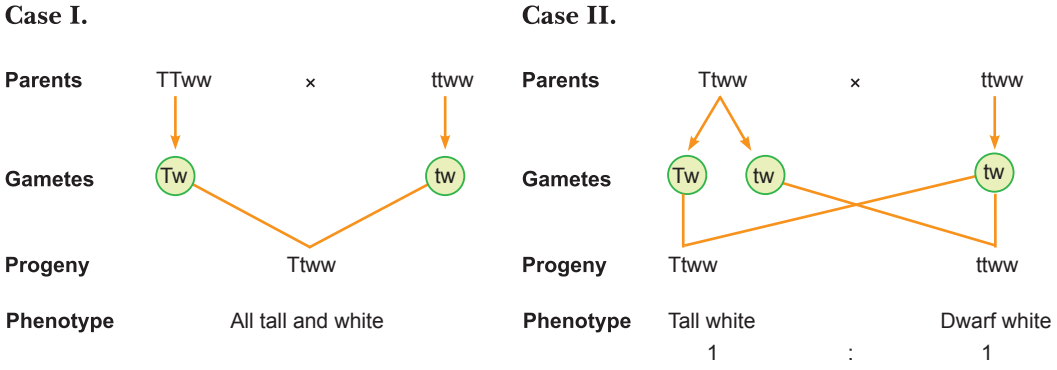
Q. 12. In snapdragon (*Antirrhinum majus*), a cross between varieties with red and white flowers produces all pink progeny. Explain how it is a case of incomplete dominance and not of blending inheritance.

Ans. In incomplete dominance, the genes of an allelomorphic pair are not expressed as dominant and recessive, but express themselves partially when present together in a hybrid and is an intermediate between the two genes. As a result an intermediate character is obtained. *e.g.*, Two types of flowers occur in *Mirabilis jalapa* (4 o' clock plant) and *Antirrhinum majus* (snapdragon/ dog flower). The red flower colour is due to gene RR, white flower colour is due to gene rr but pink flower colour appears in case of genotype Rr.

It is not a case of blending inheritance because the parental characters reappear in the F_2 generation without any modification.

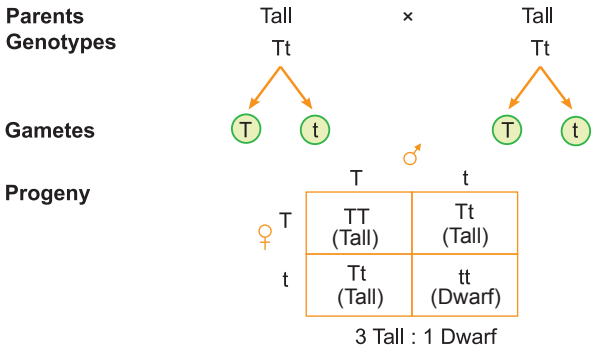
Q. 13. How would you find genotype of a tall pea plant bearing white flowers? Explain with the help of a cross. Name the type of cross you would use. ***[CBSE Delhi 2016] [HOTS]***

Ans. It can be done by a test cross. This is done by crossing the plant with homozygous recessive parent. If the ratio of progeny is 1 : 1, then the genotype of the plant is heterozygous.



Q. 14. When a tall pea plant was selfed, it produced one-fourth of its progeny as dwarf. Explain with the help of a cross. ***[CBSE Delhi 2010]***

Ans. Production of one-fourth dwarf progeny on selfing of a tall pea plant indicates that the plant is heterozygous. This can be explained with the cross as follows:



Q. 15. A teacher wants his/her students to find the genotype of pea plants bearing purple coloured flowers in their school garden. Name and explain the cross that will make it possible. ***[CBSE Delhi 2015]***

Ans. Test cross will be done.
Refer to Basic Concepts Point 7.

Q. 16. Explain co-dominance with the help of one example. ***[CBSE (F) 2017]***

Ans. Refer to Basic Concepts Point 6.

Q. 17. When does a geneticist need to carry a test cross? How is it carried? ***[CBSE (F) 2015]***

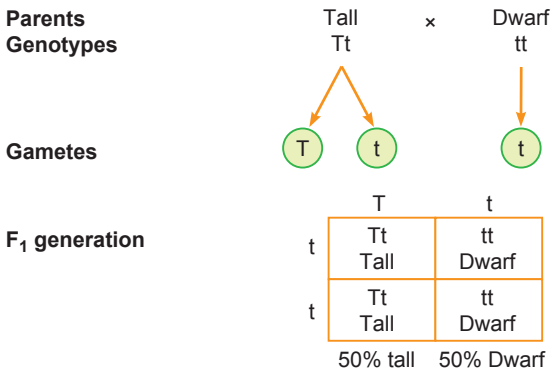
Ans. Geneticists carry out a test cross to find out the genotype of the unknown parent. This is carried out by crossing the progeny with the homozygous recessive parent.

Q. 18. A cross was carried out between two pea plants showing the contrasting traits of height of the plant. The result of the cross showed 50% of parental characters.

(*i*) Work out the cross with the help of a Punnett square.

(*ii*) Name the type of the cross carried out. ***[CBSE Delhi 2014]***

Ans. (*i*)



(*ii*) Test cross

Q. 19. What is a test cross? How can it decipher the heterozygosity of a plant? ***[CBSE (AI) 2016]***

Ans. A cross to analyse whether genotype of dominant individual is homozygous or heterozygous is called test cross.

On crossing with a recessive parent, if 50% of progeny have dominant trait and 50% have recessive trait then the plant is said to he heterozygous.

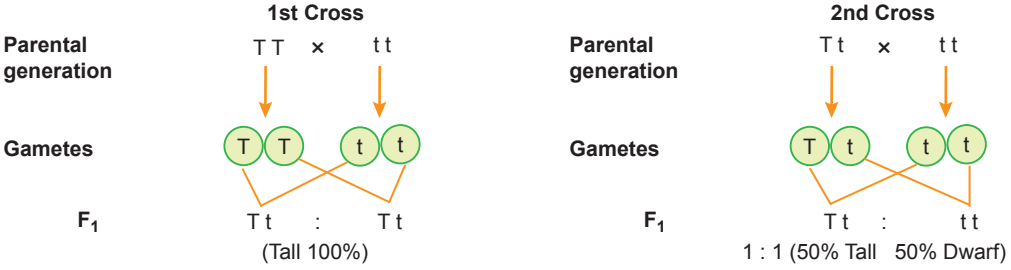
Q. 20. Two independent monohybrid crosses were carried out involving a tall pea plant with a dwarf pea plant. In the first cross, the offspring population had equal number of tall and dwarf plants, whereas in the second cross it was different. Work out the crosses, and explain giving reasons for the difference in the offspring populations. ***[CBSE (AI) 2015]***

OR

Work out a cross to find the genotype of a tall pea plant. Name the type of cross.

[CBSE Delhi 2010; (AI) 2013]

Ans. This type of cross called a test cross.



In the first cross the tall parent plant is heterozygous for the trait, in second cross tall parent plant is homozygous for the trait, hence the respective observation.

Q. 21. How does a test cross help to determine the genotype of an individual? ***[CBSE (F) 2016]*** ***[HOTS]***

Ans. In a test cross the individual of unknown genotype is crossed with the recessive parent. If all progenies are dominant, then the genotype exhibits homozygosity and if the progenies have a dominant to recessive ratio 1 : 1, then the genotype exhibits heterozygosity.

Q. 22. With the help of one example, explain the phenomena of co-dominance and multiple allelism in human population. ***[CBSE (AI) 2014]***

Ans. ABO blood group in human being is an example of multiple allelism and co-dominance. There are three alleles for the gene *I*, *i.e.*, I^A, I^B, and *i*, thus, exhibiting multiple allelism.

When I^A and I^B are present together the blood group is *AB*. Both *A* and *B* blood groups are expressed. This is called co-dominance.

Q. 23. Explain pleiotropy with the help of an example. ***[CBSE (F) 2014]***

Ans. Pleiotropy is the phenomenon in which a single gene exhibits multiple phenotypic expression. The pleiotropic gene affects the metabolic pathways, resulting in different phenotypes. For example, phenylketonuria is caused by mutation in the gene coding the enzyme phenylalanine hydroxylase. It also leads to mental retardation & reduction in hair & skin pigmentation.

Q. 24. Who proposed chromosomal theory of inheritance? Point out any two similarities in the behaviour of chromosomes and genes.

Ans. It was proposed by Sutton and Boveri.

Similarities:

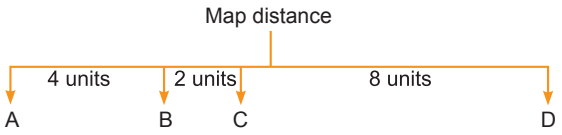
(*i*) Both genes and chromosomes occur in pairs in a diploid cell (2n).

(*ii*) Both of them separate out during gametogenesis to enter into different gametes.

(*iii*) Paired condition is again restored by fusion of gametes. (*Any two*)

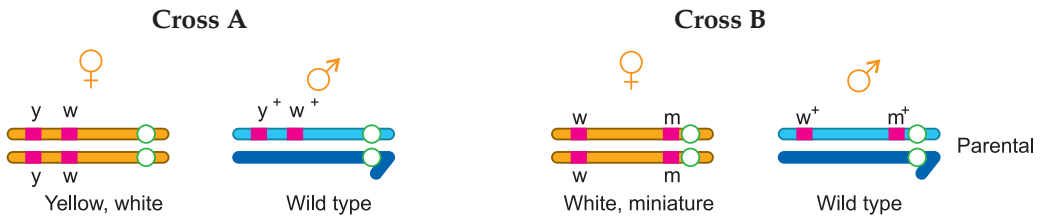
Q. 25. The map distance in certain organisms between gene A and B is 4 units, B and C is 2 units and between C and D is 8 units which one of these gene pairs will show more recombination frequency? Give reasons in support of your answer. [*HOTS*]

Ans.



The recombination frequency is directly proportional to the distance between the genes. The distance between C and D is more, *i.e.*, 8 units in the above condition, so recombination frequency will be more between them.

Q. 26. Study the figures given below and answer the question.



Identify in which of the crosses is the strength of linkage between the genes higher. Give reasons in support of your answer. [*CBSE (F) 2014*] [*HOTS*]

Ans. In Cross A because the genes are closely placed. Lesser the distance between genes greater is the strength of linkage as lesser is the chance of crossing over between them.

Q. 27. Write the scientific name of the fruitfly. Why did Morgan prefer to work with fruitflies for his experiments? State any three reasons. [*CBSE (AI) 2014; (F) 2015*]

Ans. *Drosophila melanogaster* is the scientific name of fruitfly.

Morgan preferred work with fruitflies because: Refer to Basic Concepts Point 11

Q. 28. In a dihybrid cross white eyed, yellow bodied female *Drosophila* crossed with red eyed, brown bodied male *Drosophila* produced in F_2 generation, 1.3 per cent recombinants and 98.7 per cent progeny with parental type combinations. This observation of Morgan deviated from Mendelian F_2 phenotypic dihybrid ratio. Explain, giving reasons, Morgan's observations. [*CBSE (F) 2011*]

Ans. Morgan saw that when the two genes in a dihybrid cross were situated on the same chromosome, the proportion of parental gene combinations were much higher than the non-parental type. Morgan attributed this due to physical association or linkage of two genes and coined the term linkage to describe this physical association of genes on a chromosome and the term recombination to describe the generation of non-parental gene combinations. %of recombinants depends on distance between genes. More is the distance more is % of recombinants and vice versa.

Q. 29. Linkage and crossing-over of genes are alternatives of each other. Justify with the help of an example. ***[CBSE (AI) 2014]***

Ans. In *Drosophila* a yellow bodied white eyed female was crossed with brown bodied red eyed male. The F_1 progeny produced, when intercrossed, it was observed that the F_2 phenotypic ratio of *Drosophila* deviated significantly from Mendel's 9 : 3 : 3 : 1. The genes for eye colour and body colour are closely located on the 'X' chromosome, showing linkage and therefore, these are inherited together. Recombinants were formed due to crossing over but at low percentage.

Q. 30. How does the gene 'I' control ABO blood groups in humans? Write the effect the gene has on the structure of red blood cells. ***[CBSE Delhi 2014]***

Ans. Gene '*I*' has three different alleles I^A, I^B, i

(*a*) I^A produces A type of sugar polymer on surface of RBC which results in A group

(*b*) I^B produces B type of sugar polymer on surface of RBC which results in B group

(*c*) i produces no sugar which result in O blood group

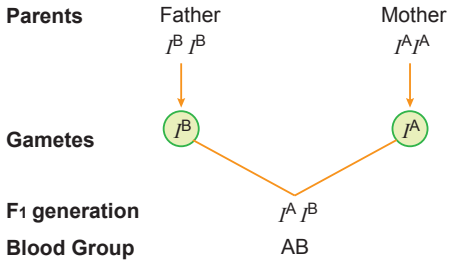
The sugar polymers protrude from the surface of plasma membrane of RBCs which are characteristics of each blood group.

Q. 31. (*a*) Why is human ABO blood group gene considered a good example of multiple alleles?

(*b*) Work out a cross up to F_1 generation only, between a mother with blood group A (Homozygous) and the father with blood group B (Homozygous). Explain the pattern of inheritance exhibited. ***[CBSE Delhi 2013]***

Ans. (*a*) This is because more than two alleles govern the human ABO blood group gene.

(*b*)



The cross exhibits co-dominance. When the two alleles I^A and I^B are present together, both the alleles express each other equally forming the blood group AB.

Q. 32. A man with blood group A married a woman with B group. They have a son with AB blood group and a daughter with blood group O. Work out the cross and show the possibility of such inheritance.

Ans.

Parents	Man (A group)	×	Woman (B group)
Genotype	$I^A i$		$I^B i$
Gametes	I^A, i		I^B, i

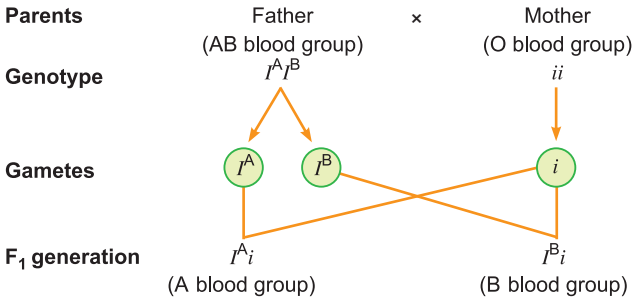
F_1 generation

♂ \ ♀	I^B	i
I^A	$I^A I^B$ Blood group AB	$I^A i$ Blood group A
i	$I^B i$ Blood group B	ii Blood group O

Thus, the F_1 progeny can have all the four possible blood groups, *i.e.*, A, B, AB and O.

Q. 33. A woman with blood group O married a man with AB group. Show the possible blood groups of the progeny. List the alleles involved in this inheritance.

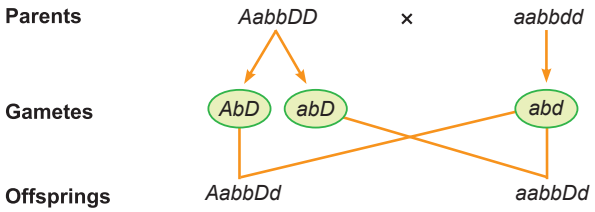
Ans.



The alleles involved in this inheritance are: I^A, I^B and i.

Q. 34. *A, B* and *D* are three independently assorting genes with their recessive alleles *a, b* and *d*, respectively. A cross was made between individuals of *AabbDD* genotype and *aabbdd*. Explain the type of genotypes of the offspring produced. [*NCERT Exemplar*]

Ans.



Q. 35. Human blood group is a good example of multiple allelism and co-dominance. Justify. [*CBSE (F) 2016*] [*HOTS*]

Ans. **Multiple allelism:** Generally in an individual or population, only two alleles of a trait govern the character, but in case of ABO blood group, three alleles I^A, I^B and i are found to govern blood group in human population. This is multiple allelism.

Co-dominance: Allele I^A and I^B when present in an individual, both being dominant express their own types of sugars or traits. Thus, exhibiting co-dominance.

Q. 36. Give an example of a gene responsible for multiple phenotypic expressions. What are such genes called? State the cause that is responsible for such an effect. [*CBSE (F) 2015*]

Ans. Gene causing phenylketonuria causes multiple phenotypic expressions. Such genes are called pleiotropic genes. This effect of multiple phenotypic expressions is caused because pleiotropic gene affects metabolic pathways, resulting in different phenotypes.

Q. 37. Differentiate between male and female heterogamety. [*CBSE Delhi 2015*]

Ans. **Table 5.6: Differences between male heterogamety and female heterogamety**

S.No.	Male heterogamety	Female heterogamety
(*i*)	Male produces two types of gametes (while female produces only one type of gamete)	Female produces two types of gametes (while male produces only one type of gamete)
(*ii*)	XY and XO type are two types of male heterogamety	ZW type is a type of heterogamety
(*iii*)	Example, male grasshopper produce gametes of two types—X and O.	Example, female birds produce gametes of two types—Z and W.

Q. 38. Explain mechanism of sex determination in birds. [*CBSE Delhi 2015*]

Ans. In birds, females are heterogemetic and males are homogametic. Females have one Z sex chromosome and one W sex chromosome. Males have a pair of Z sex chromosome. If Z sperm fertilises Z ovum, a male offspring is produced, and if Z sperm fertilises W ovum a female offspring is produced.

Q. 39. Explain the mechanism of sex determination in insects like *Drosophila* and grasshopper.
[*CBSE (AI) 2010*]

Ans. In grasshopper, the mechanism of sex determination is of the XO type. In females, the eggs bear a pair of X chromosomes along with the autosomes. Males contain only 1 X chromosome with autosomes. On the other hand, there are two types of sperms formed in males–one having a X chromosome and other without X chromosome. Hence, grasshopper shows male heterogamety.

Q. 40. Differentiate between "ZZ" and "XY" type of sex-determination mechanisms.
[*CBSE Delhi 2015*]

Ans. ZZ type is seen in birds. The males are homogametic (ZZ) and females are heterogametic (ZY). Sex is determined by the type of egg getting fertilised.

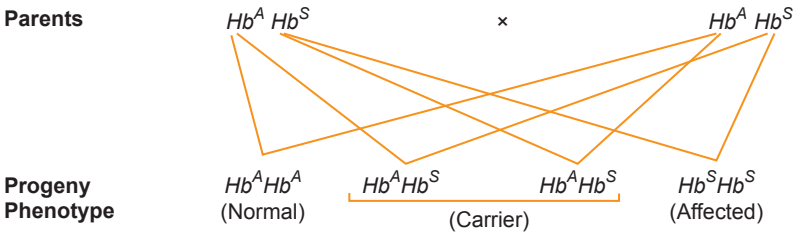
XY type is seen in human beings The males are heterogametic (XY) and females homogametic (XX). Sex is determined by the type of sperm fertilising the ovum.

Q. 41. Why is pedigree analysis done in the study of human genetics? State the conclusions that can be drawn from it.
[*CBSE (AI) 2014*]

Ans. Pedigree analysis is done because control crosses are not possible in case of humans beings. This can be useful for analysis of traits, in several generations of a family, to trace pattern of inheritance to check whether the trait is dominant or recessive or sex-linked or not.

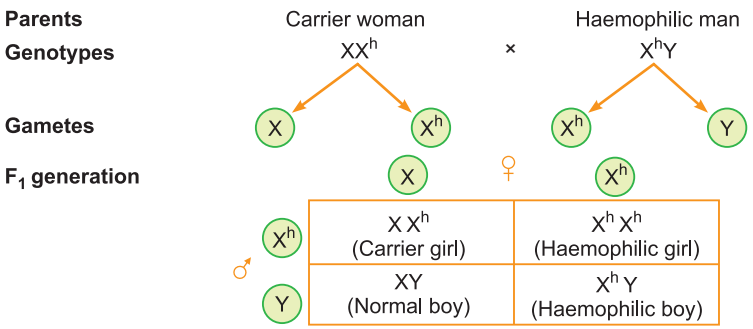
Q. 42. Give an example of an autosomal recessive trait in humans. Explain its pattern of inheritance with the help of a cross.
[*CBSE Delhi 2016*]

Ans. Sickle cell anaemia is an autosomal recessive trait in humans. The disease is controlled by a single pair of alleles Hb^A and Hb^S. Only the homozygous individuals $Hb^S Hb^S$ show the diseased phenotype. The heterozygous individuals ($Hb^A Hb^S$) are carriers.



Q. 43. Recently a baby girl has been reported to suffer from haemophilia. How is it possible? Explain with the help of a cross.

Ans. It is possible to have a haemophilic girl if a carrier woman married a haemophilic man as shown here:

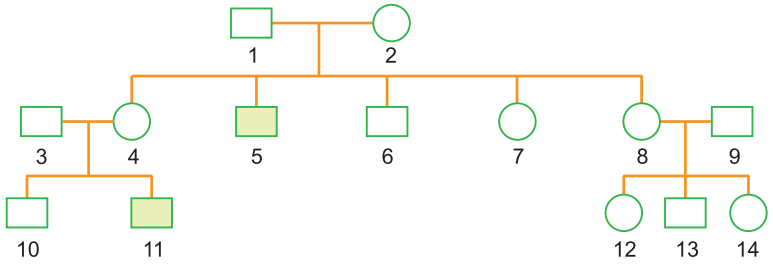


Q. 44. Why are human females rarely haemophilic? Explain. How do haemophilic patients suffer?
[*CBSE (AI) 2013; (F) 2014*]

Ans. Haemophilia is a sex-linked recessive disorder. The females haves XX chromosomes and the males have XY chromosomes. If one of the two X chromosomes is normal, she remains a carrier

and not diseased. Female will be haemophilic only when both the X chromosomes carry the haemophilia gene and this is possible only when the mother is a carrier and father is haemophilic. Haemophillic patients suffer from non-stop bleeding and no clotting in case of injury.

Q. 45. Haemophilia is a sex-linked inheritance condition in humans where a simple cut causes non-stop bleeding. Study the pedigree chart showing the inheritance of haemophilia in a family. Answer the questions that follow:



Give reasons which explain that haemophilia is

(*i*) sex-linked, and

(*ii*) caused by 'X'-linked gene. **[*CBSE (F) 2011*]**

Ans. (*i*) Haemophilia is sex-linked because it shows transmission from unaffected carrier female to some of the male progeny.

(*ii*) Haemophilia is caused by 'X'-linked gene because the heterozygous female for haemophilia may transmit the disease to sons. It appears more in males because of only one X chromosome.

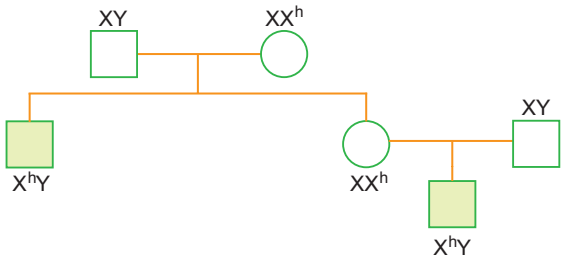
Q. 46. Marriage between a normal couple resulted in a son who was haemophilic and a normal daughter. In course of time, when the daughter was married to a normal man, to their surprise, the grandson was also haemophilic.

(*a*) Represent this cross in the form of a pedigree chart. Give the genotypes of the daughter and her husband.

(*b*) Write the conclusion you draw from the inheritance pattern of this disease.

[*CBSE Delhi 2014*]

Ans. (*a*)



(*b*) Sex-linked recessive inheritance pattern.

Q. 47. (*a*) Sickle celled anaemia in humans is a result of point mutation. Explain.

(*b*) Write the genotypes of both the parents who have produced a sickle celled anaemic offspring. **[*CBSE Delhi 2011*]**

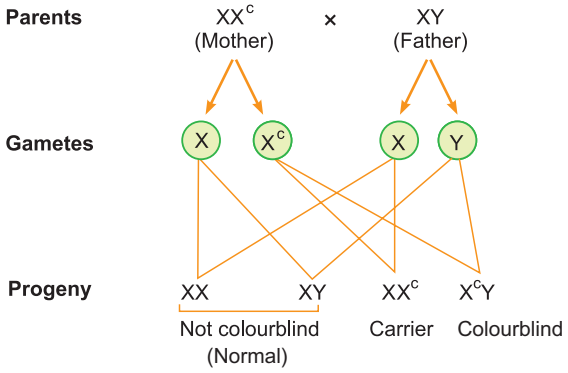
Ans. (*a*) In sickle cell anaemia, due to point mutation there is a substitution of a single nitrogen base at the sixth codon of the β-globin chain of haemoglobin that leads to substitution of valine in place of glutamic acid.

$$\underset{\text{Glutamic acid}}{\text{GAG}} \xrightarrow{\text{Mutation}} \underset{\text{Valine}}{\text{GUG}}$$

(*b*) The genotypes of both the parents would be Hb^AHb^S and Hb^AHb^S.

Q. 48. A couple with normal vision bear a colour blind child. Work out a cross to show how it is possible and mention the sex of the affected child. [*CBSE Delhi 2014, 2016; (AI) 2014*] [*HOTS*]

Ans.



The colour blind child will be a male.

Q. 49. Name a disorder, give the karyotype and write the symptoms, a human suffers from as a result of monosomy of the sex chromosome. [*CBSE (F) 2011*]

Ans. Turner's syndrome is a disorder caused by the absence of one of the X-chromosomes. Its karyotype will be 45 + XO. Symptoms are:

(*i*) Sterile females

(*ii*) Rudimentary ovaries

(*iii*) Lack of secondary sexual characters.

Q. 50. Name a disorder, give the karyotype and write the symptoms where a human male suffers as a result of an additional X-chromosome. [*CBSE (F) 2011*]

Ans. Klinefelter's syndrome. The karyotype is 44 + XXY. Symptoms are:

(*i*) Sex of the individual is masculine but possesses feminine characters.

(*ii*) Gynaecomastia, *i.e.*, development of breasts.

(*iii*) Poor beard growth and often sterile.

(*iv*) Feminine pitched voice.

Q. 51. Name the phenomenon that leads to situations like 'XO' abnormality in humans. How do humans with 'XO' abnormality suffer? Explain. [*CBSE (F) 2012*]

Ans. Absence of one X chromosome due to non segregation of chromatids during cell division leads to XO abnormality. These are sterile female with rudimentary ovaries. They have shield-shaped thorax, webbed neck, poor development of breasts, short stature, small uterus and puffy fingers.

Q. 52. Which chromosome carries the mutated gene causing β-thalassemia? What are the problems caused by the mutation? [*CBSE Delhi 2015*]

Ans. Chromosome number 11 carries the mutant gene causing β-thalassemia. It causes formation of abnormal haemoglobin molecules, resulting into anaemia.

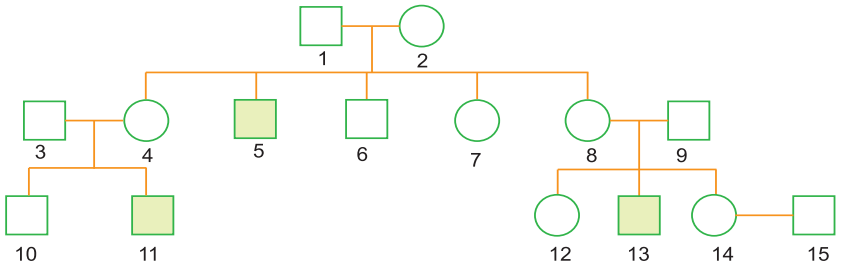
Q. 53. Both haemophilia and thalassemia are blood related disorders in humans. Write their causes and the difference between the two. Name the category of genetic disorder they both come under. [*CBSE (AI) 2017*]

Ans.

Table 5.7: Differences between haemophilia and thalassemia

S.No.		Haemophilia	Thalassemia
(*i*)	Cause	Single protein is involved in the clotting of blood is affected.	Defects in the synthesis of globin leading to formation of abnormal haemoglobin.
(*ii*)	Genetic disorder	Sex-linked recessive disorder.	Autosomal recessive disorder.
(*iii*)	Difference	Blood does not clot due to lack of clotting factors.	Results in anaemia (abnormal or lack of haemoglobin).

Q. 54. Haemophilia is a sex-linked recessive disorder of humans. The pedigree chart given below shows the inheritance of haemophilia in one family. Study the pattern of inheritance and answer the questions given.



(*a*) Give all the possible genotypes of the members 4, 5 and 6 in the pedigree chart.

(*b*) A blood test shows that the individual 14 is a carrier of haemophilia. The member numbered 15 has recently married the member numbered 14. What is the probability that their first child will be a haemophilic male?

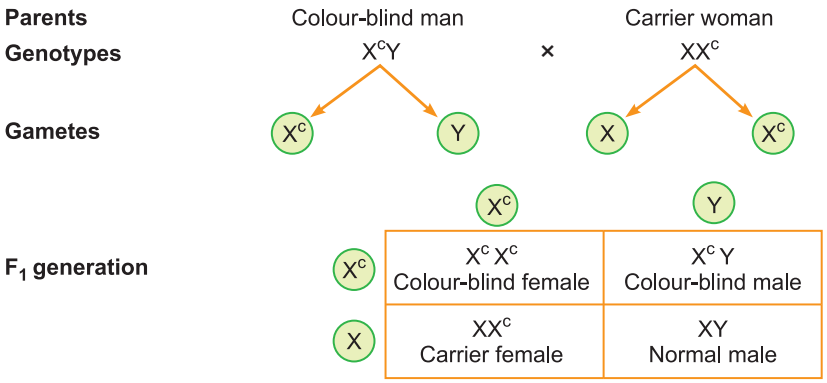
Ans. (*a*) Genotypes of member 4—XX or XX^h

Genotype of member 5—X^hY and Genotype of member 6—XY

(*b*) The probability of first child to be a haemophilic male is 25%.

Q. 55. A colour-blind man marries a woman with normal vision whose father was colour-blind. Work out a cross to show the genotype of the couple and their respective sons.

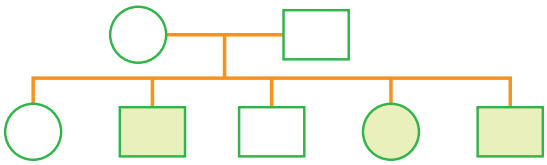
Ans. The father of normal woman is colour-blind, so the woman will be carrier, *i.e.*, XX^C.



50% sons will be colour-blind and rest 50% will be normal.

50% daughters will be colour-blind and rest 50% will be carriers.

Q. 56. The pedigree chart given below, present a particular generation which shows a trait irrespective of sexes (*i.e.*, present in both male and female). Neither of the parents of the particular generation shows the trait. Draw your conclusion on the basis of the pedigree. [*NCERT Exemplar*]



Ans. The trait is autosome linked and recessive in nature. Both the parents are carriers (*i.e.*, heterozygous). Hence, among the offsprings only few show the trait irrespective of sex. The other offsprings are either normal or carrier.

Q. 57. Give the chromosomal constitution and the resulting sex in each of the following syndromes:

(*i*) Turner's syndrome

(*ii*) Klinefelter's syndrome **[*HOTS*]**

Ans. (*i*) XO, female

(*ii*) XXY, male with female characters

Long Answer Questions–I [3 marks]

Q. 1. The F_2 progeny of a monohybrid cross showed phenotypic and genotypic ratio as 1 : 2 : 1, unlike that of Mendel's monohybrid F_2 ratio. With the help of a suitable example, work out a cross and explain how it is possible. **[*CBSE (AI) 2015*] [*HOTS*]**

Ans. This kind of cross is observed in *Mirabilis jalapa*/Four o'clock plant/*Antirrhinum majus*.

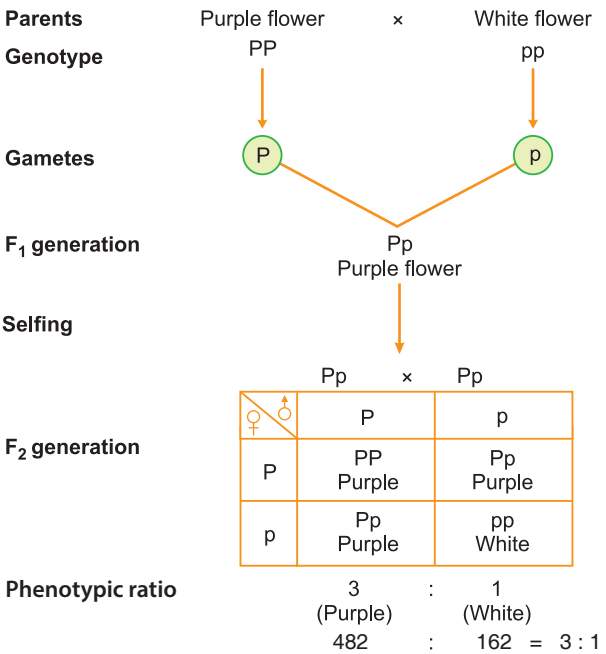
For cross, refer to Fig. 5.4.

In heterozygous condition a single dominant gene is not sufficient to produce red colour therefore it is a case of incomplete dominance.

Q. 2. A pea plant with purple flowers was crossed with white flowers producing 50 plants with only purple flowers. On selfing, these plants produced 482 plants with purple flowers and 162 with white flowers. What genetic mechanism accounts for these results? Explain.

[*CBSE Delhi 2011*]

Ans. The gene for purple flowers is dominant over that of white flowers. So, when two pure varieties are crossed, the F_1 generation has only purple flowers and on selfing, the flowers are produced in a 3 : 1 ratio in F_2 generation.



This result is obtained due to segregation of the alleles at the time of gametogenesis. The alleles remain together in a zygote but during gamete formation, they segregate such that the gametes carry only one allele.

Q. 3. Snapdragon shows incomplete dominance for flower colour. Work out a cross and explain the phenomenon. How is this inheritance different from Mendelian pattern of inheritance? Explain. ***[CBSE (F) 2012]***

OR

In snapdragon (*Antirrhinum majus*), a plant with red flowers was crossed with a plant with white flowers. Work out all the possible genotypes and phenotypes of F_1 and F_2 generations. Comment on the pattern of inheritance in this case. ***[CBSE (F) 2010]***

Ans. For the cross, refer to Fig. 5.4.

Q. 4. A cross is made between different homozygous pea plants for contrasting flower positions.

(*a*) Find out the position of flowers in F_1 generation on the basis of genotypes.

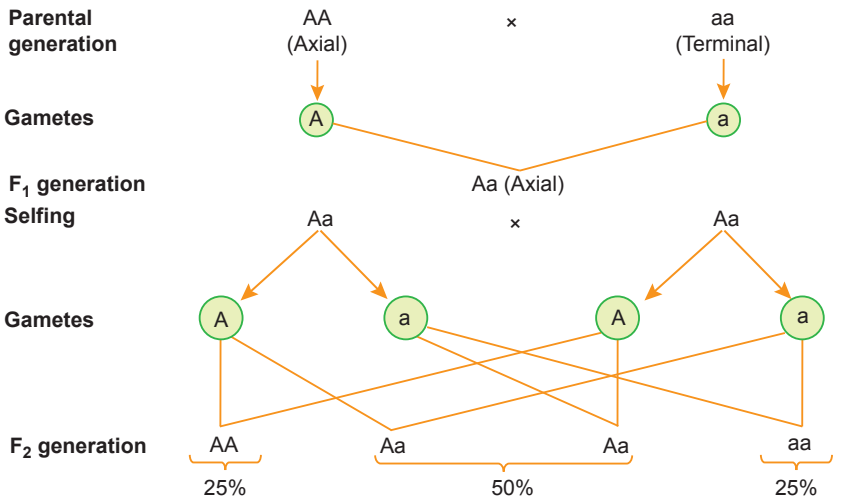
(*b*) Work out the cross upto F_2 generation.

(*c*) Compute the relative fraction of various genotypes in the F_2 generation?

[CBSE Sample Paper 2015, 2017]

Ans. (*a*) Axial position

(*b*)



(*c*) $AA = \frac{25}{100} = \frac{1}{4}$, $Aa = \frac{50}{100} = \frac{1}{2}$, $aa = \frac{25}{100} = \frac{1}{4}$

Q. 5. When snapdragon plant bearing pink colour flower was selfed, it was found that; 69 plants were having red coloured flowers. What would be the number of plants bearing pink flower and white flower? Show with the help of Punnett square. Identify the principle of inheritance involved in this experiment. ***[CBSE Sample Paper 2018]***

Ans. (*a*) There will be 138 pink flower bearing plants and 69 white flower bearing plants according to the ratio 1 : 2 : 1.

(*b*) Pink (Rr) selfing

Gametes	R	r
R	RR (Red)	Rr (Pink)
r	Rr (Pink)	rr (White)

Phenotypic ratio— red : pink : white

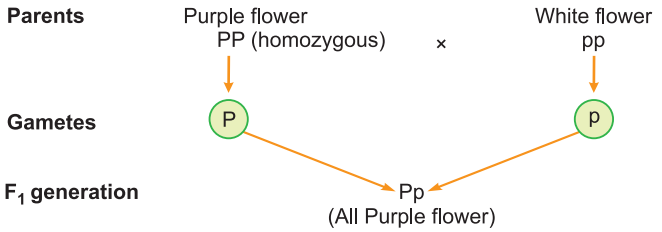
1 : 2 : 1

(*c*) The principle involved in the experiment is incomplete dominance.

Q. 6. For flower colour in pea, the allele for purple flower (P) is dominant to the allele for white flower (p). A purple flowered plant therefore could be of genotype PP or Pp. What genetic cross would you make to determine the genotype of a purple flowered plant? Explain how your cross gives you the correct genotype of the purple flowered plant? [HOTS]

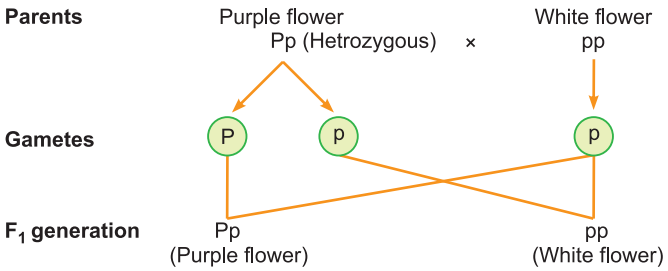
Ans. The genotype of a purple flowered plant can be determined by conducting a test cross *i.e.*, crossing the purple flowered plant with homozygous recessive individual *i.e.*, pp.

Case I



If the F_1 generation produces all purple flowers, the parent would be homozygous dominant, *i.e.*, PP.

Case II



Purple flower	:	White flower
1	:	1

If the F_1 generation produces purple and white flowers in 1:1 ratio, the parent would be heterozygous, *i.e.*, Pp.

Q. 7. How are dominance, co-dominance and incomplete dominance patterns of inheritance different from each other? [CBSE Delhi 2011]

Ans. **Dominance:** It is a phenomenon in which when two contrasting alleles are present together, only one expresses itself and is called dominant whereas the other which does not express itself is called recessive *e.g.*, Tt – 'T' is dominant over t (dwarfness).

Co-dominance: It is a phenomenon in which when two contrasting alleles are present together, both the alleles express themselves *e.g.*, I^A I^B genotype gives blood group AB.

Incomplete dominance: It is a phenomenon in which when two contrasting alleles are present together neither of the alleles is dominant over other and the phenotype formed is intermediate of the two alleles. *e.g.*,

Red flower × White flower ⟶ Pink flower colour

RR × rr → Rr

Q. 8. (*a*) Explain the phenomena of dominance, multiple allelism and co-dominance taking ABO blood group as an example.

(*b*) What is the phenotype of the following?

(*i*) I^Ai (*ii*) *ii* [CBSE (AI) 2012]

Ans. **(*a*) Dominance:** The alleles I^A and I^B both are dominant over allele *i* as I^A and I^B form antigens A and B, respectively, but *i* does not form any antigen.

Multiple allelism: It is the phenomenon of occurrence of a gene in more than two allelic

forms on the same locus. In ABO blood group in humans, one gene *I* has three alleles I^A, I^B and I^O/i.

Co-dominance: It is the phenomena in which both alleles express themselves when present together. We inherit any two alleles for the blood group. When the genotype is I^AI^B the individual has AB blood group since both I^A and I^B equally influence the formation of antigens A and B.

(*b*) (*i*) I^Ai — A blood group.

(*ii*) *ii* — O blood group.

Q. 9. During his studies on genes in *Drosophila* that were sex-linked. T.H. Morgan found population phenotypic ratios deviated from expected 9 : 3 : 3 : 1. Explain the conclusion he arrived at.

[*CBSE Delhi 2010*]

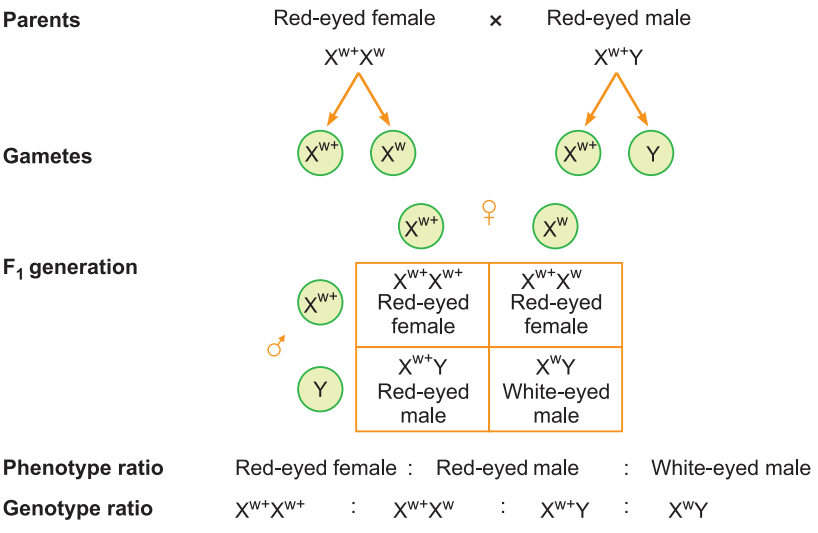
Ans. (*i*) He observed that when the two genes in a dihybrid cross are located on the same chromosome, the proportion of parental gene combinations in the progeny was much higher than the non-parental or recombination of genes.

(*ii*) Morgan and his group found that when genes were grouped on the same chromosome, some genes are tightly linked and show less recombination.

(*iii*) When the genes are loosely linked they show higher recombination.

Q. 10. A red-eyed heterozygous female fruit fly is crossed with a red-eyed male. Work out all possible genotypes and phenotypes of the progeny. Comment on the pattern of inheritance of eye colour in fruit flies.

Ans. (*i*)



Phenotype ratio Red-eyed female : Red-eyed male : White-eyed male

Genotype ratio $X^{w+}X^{w+}$: $X^{w+}X^{w}$: $X^{w+}Y$: $X^{w}Y$

(*ii*) The gene for eye colour is sex-linked and is present on X chromosome.

The character passes into the male from female and the male passes it to the female in the next generation. Male has only one X-chromosome and one Y-chromosome with no corresponding allele.

Q. 11. (*a*) Explain sex determination in humans.

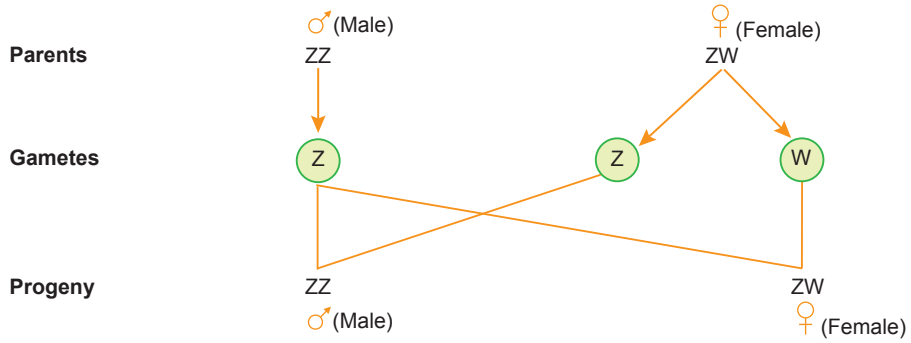
(*b*) How do human males with 'XXY' abnormality suffer? **[*CBSE (F) 2012*]**

Ans. (*a*) Refer to Basic Concepts Point 13.

(*b*) The XXY individual suffers from Klinefelter's syndrome.

Q. 12. Explain the mechanism of 'sex determination' in birds. How does it differ from that of human beings? ***[CBSE 2018]***

Ans. In birds, female heterogamety is observed. They exhibit ZW type of sex determination.



In humans, male heterogamety is observed. They exhibit XY type of sex determination.

Q. 13. (*a*) How does mutation occur?

(*b*) Differentiate between point mutation and frameshift mutation. ***[CBSE 2019 (57/2/1)]***

Ans. (*a*) Mutation occurs due to loss by deletion or gain by insertion/duplication/addition or change in position of DNA segments or chromosomes.

(*b*) Mutation due to change in a single base pair of DNA is point mutation.

Insertion or deletion of one or two bases change the reading frame from the point of insertion or deletion. This is called as frameshift mutation.

Q. 14. (*i*) Why are grasshopper and *Drosophila* said to show male heterogamety? Explain.

(*ii*) Explain female heterogamety with the help of an example. ***[CBSE (AI) 2010]***

Ans. (*i*) *Drosophila* exhibits XY type of sex determination. Males produce two types of sperms, one having X chromosome and the other having Y chromosome whereas females have only X-type of chromosomes. Grasshoppers exhibit XO type of sex determination. Males produce two types of gametes, one with X chromosome and other without any sex chromosome. Thus, both show male heterogamety.

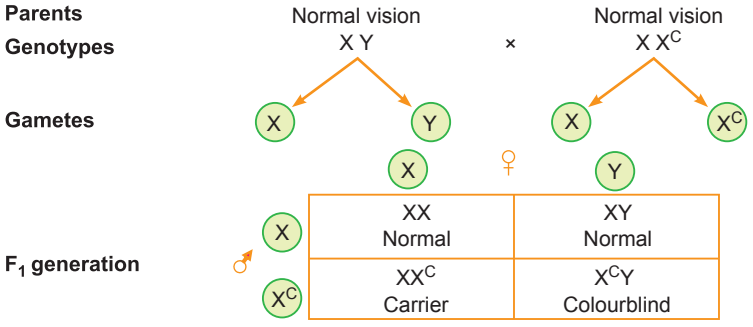
(*ii*) Female heterogamety can be seen in female birds. In these, the females have one Z and one W chromosome whereas males have a pair of Z chromosomes besides the autosomes.

Q. 15. Explain how does trisomy of 21st chromosome occur in humans. List any four characteristic features in an individual suffering from it. ***[CBSE (F) 2012]***

Ans. Refer to Basic Concepts Point 18(*i*) (Down's syndrome).

Q. 16. One of the twins born to parents having normal colour vision was Down's blind whereas the other twin had normal vision. Work out the cross. Give two reasons how it is possible. ***[CBSE (F) 2017]***

Ans.



It is possible when the mother is carrier of colour blindness gene. She will have normal vision but can pass on the gene to her child. Another possibility is that there is a mutation on the X-chromosome of one of the twins.

Q. 17. (*a*) Name the kind of diseases/disorders that are likely to occur in humans if

(*i*) mutation in the gene that codes for an enzyme phenylalanine hydrolase occurs,

(*ii*) there is an extra copy of chromosome 21,

(*iii*) the karyotype is XXY.

(*b*) Mention any one symptom of the diseases/disorders named above. **[*CBSE (F) 2015*]**

Ans.

	Disease/disorder	Symptoms
(*i*)	Phenylketonuria	Mental retardation
(*ii*)	Down's syndrome	Short stature/furrowed tongue
(*iii*)	Klinefelter's syndrome	Overall masculine development with feminine features (enlarged breast)

Q. 18. Explain the causes, inheritance pattern and symptoms of any two Mendelian genetic disorders. **[*CBSE Delhi 2010*]**

Ans. Refer to Basic Concepts Point 17(*i*) and (*ii*).

Q. 19. Write the symptoms of haemophilia and sickle-cell anaemia in humans. Explain how the inheritance pattern of the two diseases differs from each other. **[*CBSE Delhi 2010*]**

Ans. **Symptoms of Haemophilia:** Patient continues to bleed even on a minor cut as the patient does not possess natural phenomenon of blood clotting.

Symptoms of Sickle-cell Anaemia: Hb behaves as normal haemoglobin except under oxygen stress where erythrocytes lose their circular shape and become sickle-shaped. As a result, the cells cannot pass through narrow capillaries. Blood capillaries are clogged and thus affects blood supply to different organs.

Q. 20. What is Down's syndrome? Give its symptoms and cause. Why is it that the chances of having a child with Down's syndrome increases if the age of the mother exceeds forty years? **[*NCERT Exemplar*]**

Ans. Down's syndrome is a human genetic disorder caused due to trisomy of chromosome 21. Such individuals are aneuploid and have 47 chromosomes (2n + 1). The symptoms include mental retardation, growth abnormalities, constantly open mouth, dwarfness, etc. The reason for the disorder is the non-disjunction (failure to separate) of homologous chromosome of pair 21 during meiotic division in the ovum.

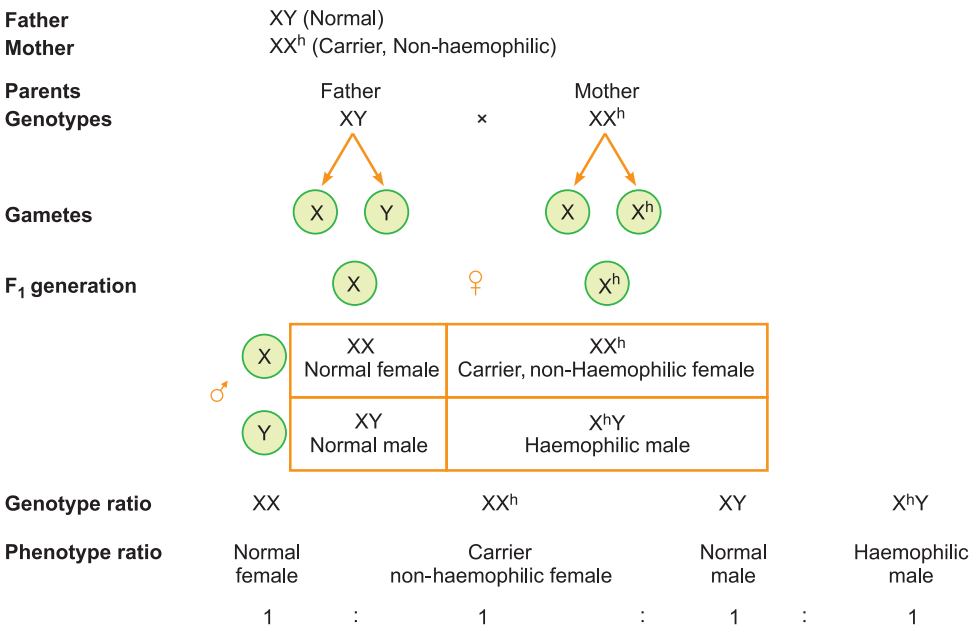
The chance of having a child with Down's syndrome increase with the age of the mother (40+) because ova are present in females since their birth and therefore older cells are more prone to chromosomal non-disjunction because of various physicochemical exposures during the mother's life-time.

Q. 21. List any four symptoms shown by Klinefelter's syndrome sufferer. Explain the cause of this disease.

Ans. Refer to Basic Concepts Point 18(*ii*).

Q. 22. A non-haemophilic couple was informed by their doctor that there is possibility of a haemophilic child be born to them. Explain the basis on which the doctor conveyed this information. Give the genotypes and the phenotypes of all the possible children who could be born to them. **[*HOTS*]**

Ans. On the basis of pedigree analysis, the doctor conveyed this information. Pedigree analysis is a strong tool, which is utilised to trace the inheritance of a specific trait, abnormality or disease. Since, both the parents are non-haemophilic, their genotypes will be:



Q. 23. Both Down's syndrome and Turner's syndrome are examples of chromosomal disorders. Cite the differences between the two. ***[CBSE Sample Paper 2015, 2017]***

Ans. **Table 5.8: Differences between Down's syndrome and Turner's syndrome**

S.No.	Down's syndrome	Turner's syndrome
(*i*)	It is a trisomy of chromosome number 21.	It is a monosomy of the X-chromosome.
(*ii*)	It can occur in either males or females.	It can occur only in females.
(*iii*)	The total number of chromosomes in the genome is 47.	The total number of chromosomes in the genome is 45.

(*Any two*)

Long Answer Questions–II [5 marks]

Q. 1. (*a*) State and explain the law of segregation as proposed by Mendel in a monohybrid cross.

(*b*) Write the Mendelian F_2 phenotypic ratio in a dihybrid cross. State the law that he proposed on the basis of this ratio. How is this law different from the law of segregation? ***[CBSE (F) 2015]***

Ans. (*a*) Refer to Basic Concepts Point 4(*ii*) and Fig. 5.3.

(*b*) The F_2 phenotypic ratio is 9:3:3:1. On the basis of this ratio Mendel proposed Law of Independent Assortment. Refer to Basic Concepts Point 4(*iii*).

Q. 2. (*a*) State and explain the law of dominance as proposed by Mendel.

(*b*) How would phenotypes of monohybrid F_1 and F_2 progeny showing incomplete dominance in snapdragon and co-dominance in human blood group be different from Mendelian monohybrid F_1 and F_2 progeny? Explain. ***[CBSE (F) 2015]***

Ans. (*a*) This law states that when two alternative forms of a trait or character (genes or alleles) are present in an organism, only one factor expresses itself in F_1 progeny and is called dominant while the other that remains masked is called recessive.

The characters are controlled by discrete units called factors. These factors occur in pairs.

(*b*)

Progeny	Mendelian monohybrid cross	Incomplete dominance	Co-dominance
F_1	All members resemble the parent with dominant trait.	All members do not resemble either of the two parents but show an intermediate trait.	Blood groups of all members resemble combination of dominant traits of both the parents.
F_2	Both the parental traits reappear.	Both the parental traits and an intermediate trait appear.	Both the parental traits as well as the co-dominant trait appear.

Q. 3. (*a*) Explain Mendel's law of independent assortment by taking a suitable example.

(*b*) How did Morgan show the deviation in inheritance pattern in *Drosophila* with respect to this law? ***[CBSE (AI) 2013]***

Ans. (*a*) According to this law, the two factors of each character assort or separate out independent of the factors of other characters at the time of gamete formation and get randomly rearranged in the offsprings producing both parental and new combinations of characters.

The Punnett square can be effectively used to understand the independent segregation of the two pairs of genes during meiosis and the production of eggs and pollen in the F_1 (RrYy) plant. Consider the segregation of one pair of genes R and r. Fifty per cent of the gametes have the gene R and the other 50 per cent have gene r. Now besides each gamete having either R or r, it should also have the allele Y or y. The important thing to remember here is that segregation of 50 per cent R and 50 per cent r is independent from the segregation of 50 per cent Y and 50 per cent y. Therefore, 50 per cent of the r bearing gamete has Y and the other 50 per cent has y. Similarly, 50 per cent of the R bearing gamete has Y and the other 50 per cent has y. Thus there are four genotypes of gametes (four types of pollen and four types of eggs). The four types are RY, Ry, rY and ry each with a frequency of 25 per cent or 1/4th of the total gametes produced.

(*b*) Refer to Basic Concepts Point 11

Q. 4. Work out a typical Mendelian dihybrid cross and state the law that he derived from it. ***[CBSE (AI) 2014]***

Ans. For the cross, refer to Fig. 5.3.

For the dihybrid cross Mendel derived the law of Independent Assortment: It states that when two pairs of traits are combined in a hybrid, segregation of one pair of character is independent of the other pair of characters.

Q. 5. (*a*) State the law of independent assortment.

(*b*) Using Punnett square demonstrate the law of independent assortment in a dihybrid cross involving two heterozygous parents. ***[CBSE (AI) 2010]***

Ans. (*a*) According to this law the two factors of each character assort or separate out independent of the factors of other characters, at the time of gamete formation and get randomly rearranged in the offsprings, producing both parental and new combinations of characters.

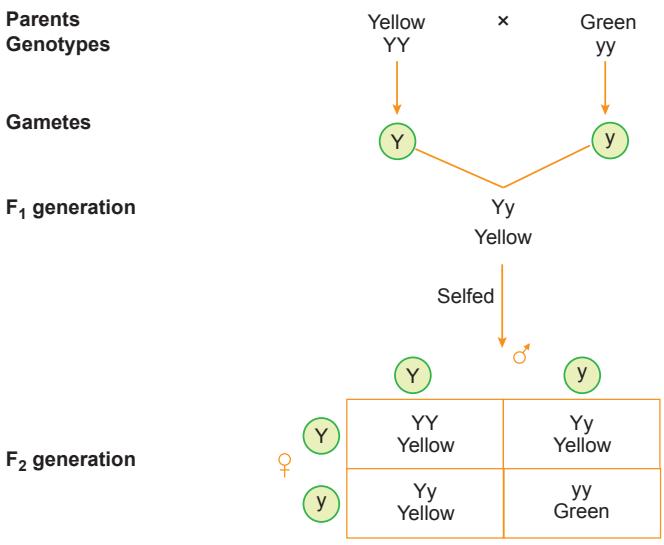
(*b*) Refer to Fig. 5.3.

Q. 6. (*a*) Explain a monohybrid cross taking seed coat colour as a trait in *Pisum sativum*. Work out the cross up to F_2 generation.

(*b*) State the laws of inheritance that can be derived from such a cross.

(*c*) How is the phenotypic ratio of F_2 generation different in a dihybrid cross? ***[CBSE (AI) 2012]***

Ans. (*a*)



F_2 Phenotypic ratio = 3 : 1; F_2 Genotypic ratio = 1 : 2 : 1

(*b*) **Law of Dominance:** In a contrasting pair of factors, one member of the pair dominates (dominant) the other is recessive.

Law of Segregation: Factors or allele of pair separate from each other such that gamete receives only one of the two factors.

(*c*) Phenotypic ratio of F_2 in monohybrid cross is 3 : 1 whereas in a dihybrid cross the phenotypic ratio is 9 : 3 : 3 : 1.

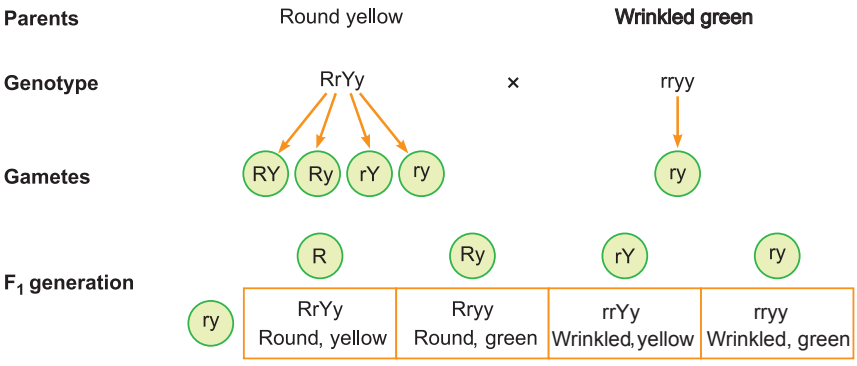
Q. 7. A cross was carried out between a pea plant heterozygous for round and yellow seeds with a pea plant having wrinkled and green seeds.

(*a*) Show the cross in a Punnett square.

(*b*) Write the phenotype of the progeny of this cross.

(*c*) What is this cross known as? State the purpose of conducting such a cross. [*CBSE (F) 2014*]

Ans. (*a*)



(*b*) Both the phenotypic and genotypic ratio are same, *i.e.*, 1: 1 : 1 : 1.

(*c*) This cross is known as test cross.

Q. 8. (*a*) A true breeding homozygous pea plant with green pods and axial flowers as dominant characters, is crossed with a recessive homozygous pea plant with yellow pods and terminal flowers. Work out the cross up to F_2 generation giving the phenotypic ratios of F_1 and F_2 generation respectively.

(*b*) State the Mendelian principle which can be derived from such a cross and not from monohybrid cross. [*CBSE (AI) 2011*]

Ans. (*a*)

Parents Green axial GGAA × Yellow terminal ggaa

Gametes GA, ga

F_1 generation GgAa

Selfing

GgAa × GgAa
(hybrid of green axial)

F_2 generation

	GA	Ga	gA	ga
GA	GGAA Green axial	GGAa Green axial	GgAA Green axial	GgAa Green axial
Ga	GGAa Green axial	GGaa Green terminal	GgAa Green axial	Ggaa Green terminal
gA	GgAA Green axial	GgAa Green axial	ggAA Yellow axial	ggAa Yellow axial
ga	GgAa Green axial	Ggaa Green terminal	ggAa Yellow axial	ggaa Yellow terminal

Phenotypic ratio

Green axial	:	Green terminal	:	Yellow axial	:	Yellow terminal
9	:	3	:	3	:	1

(*b*) From the above cross law of independent assortment can be derived which states that when two pairs of traits are combined in a hybrid, segregation of one pair of character is independent of the other pair of characters.

Q. 9. (*a*) A pea plant bearing axial flowers is crossed with a pea plant bearing terminal flowers. The cross is carried out to find the genotype of the pea plant bearing axial flowers. Work out the cross to show the conclusions you arrive at.

(*b*) State the Mendel's law of inheritance that is universally acceptable. ***[CBSE (AI) 2017]***

Ans. (*a*) (*i*) If the plant is homozygous for the dominant trait.

Parental generation AA (Axial Flower) × aa (Terminal Flower)

Gametes A, A, a, a

F_1 generation Aa, Aa, Aa, Aa (All plants with axial flower)

(*ii*) If the plant is heterozygous for the dominant trait.

Parental generation Aa (Axial Flower) × aa (Terminal Flower)

Gametes A, a, a, a

F_1 generation Aa, aa, Aa, aa (50% plants are with axial flower and 50% plants are with terminal flower)

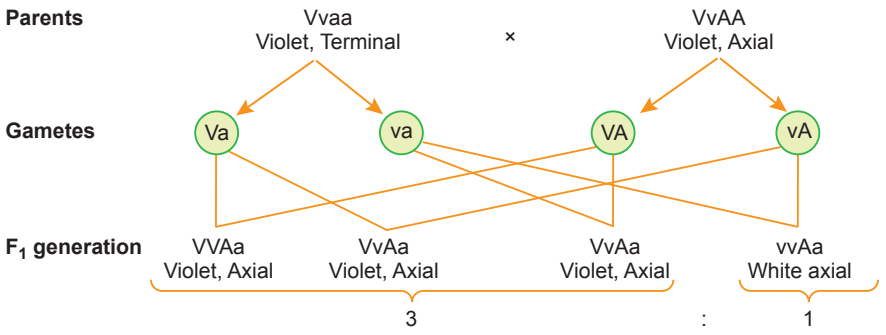
Conclusion: If all progeny show axial flowers (dominant) the plant is homozygous (AA), If 50% of progeny show axial flower (Dominant) and 50% terminal flower (Recessive) the plant is heterozygous.

(*b*) Law of Segregation is universally accepted. It states that allelic pair segregate (separates) during gamete formation.

Q. 10. (*a*) A garden pea plant bearing terminal, violet flowers, when crossed with another pea plant bearing axial, violet flowers, produced axial, violet flower and axial, white flowers in the ratio of 3 : 1. Work out the cross showing the genotypes of the parent pea plants and their progeny.

(*b*) Name and state the law that can be derived from this cross and not from a monohybrid cross. ***[CBSE (AI) 2012]***

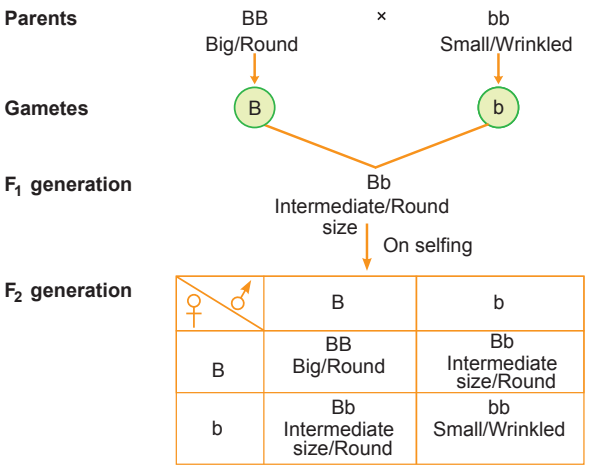
Ans. (*a*)



(*b*) Law of Independent Assortment: When two pairs of traits are combined in a hybrid, segregation of one pair of characters is independent of the other pair of character.

Q. 11. What is the inheritance pattern observed in the size of starch grains and seed shape of *Pisum sativum*? Workout the monohybrid cross showing the above traits. How does this pattern of inheritance deviate from that of Mendelian law of dominance? ***[CBSE Delhi 2012]***

Ans. A single gene controls the size of the starch grains and seed shape of *Pisum sativum*.



♀ \ ♂	B	b
B	BB Big/Round	Bb Intermediate size/Round
b	Bb Intermediate size/Round	bb Small/Wrinkled

With respect to size of starch grains it shows 3 forms-big, Intermediate and small as in incomplete dominance but with respect to seed shape it follows Mendelian law of Dominance showing either round or wrinkled.

Q. 12. (*a*) During a cross involving true breeding red-flowered and true breeding white-flowered snapdragon plants, the F_1 progeny did not show any of the parental traits, while they reappeared in F_2 progenies. Explain the mechanism using Punnett Square.

(*b*) Explain polygenic inheritance with the help of an example. ***[CBSE (F) 2015]***

Ans. (*a*) Refer to Basic Concepts Point 5 and Fig. 5.4.

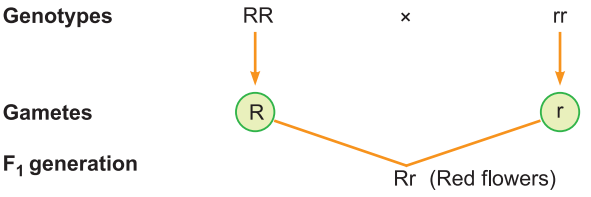
(*b*) Refer to Basic Concepts Point 9.

Q. 13. You are given a red flower-bearing pea plant and a red flower-bearing snapdragon plant. How would you find the genotypes of these two plants with respect to the colour of the flower? Explain with the help of crosses. Comment upon the pattern of inheritance seen in these two plants.

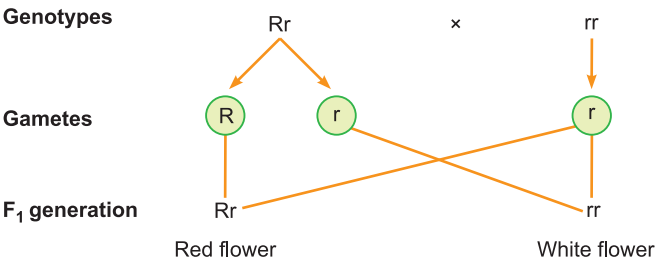
Ans. A test cross is required to find out the genotype of both the plants.

(*a*) Garden pea

(Homozygous red)

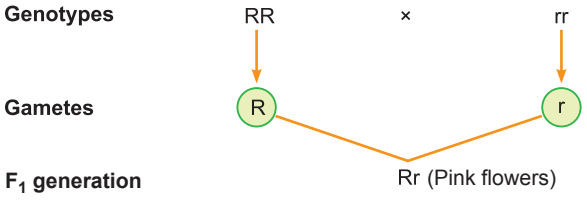


(Heterozygous red)



If the F_1 generation plants have all red flowers, the genotype of the parent plant will be homozygous dominant and if the F_1 generation plants have red and white flowers in the ratio of 1 : 1, then the genotype of the parent plant is heterozygous dominant. This inheritance follows the Mendelian law of dominance.

(*b*) In snapdragon:



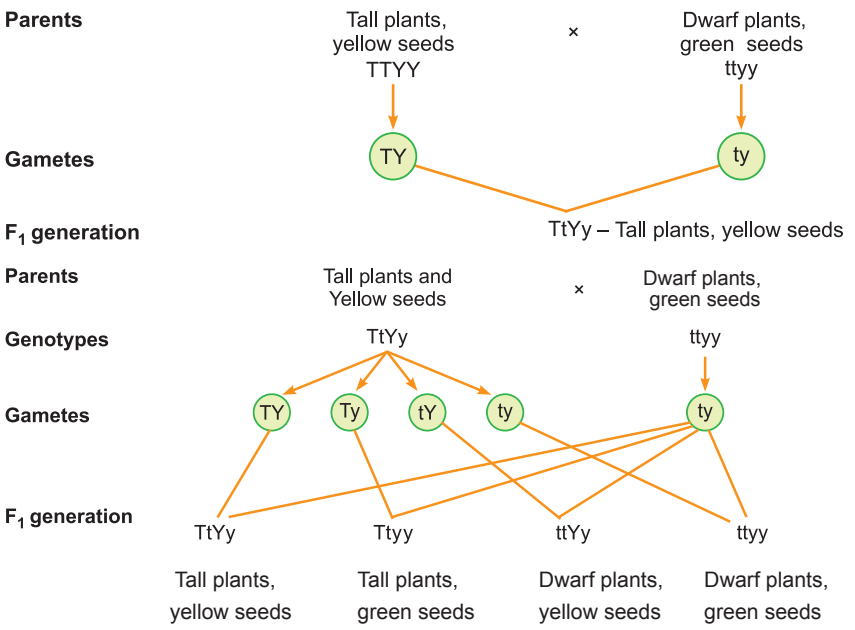
The parent plant will be homozygous for flower colour because a heterozygous plant will have pink flowers due to the phenomenon of incomplete dominance.

Q. 14. (*a*) You are given tall pea plants with yellow seeds whose genotypes are unknown. How would you find the genotype of these plants? Explain with the help of cross.

(*b*) Identify *a*, *b* and *c* in the table given below:

S. No.	Pattern of inheritance	Monohybrid F_1 phenotypic expression
(*i*)	Co-dominance	*a*
(*ii*)	*b*	The progeny resembled only one of the parents
(*iii*)	Incomplete dominance	*c*

Ans. (*a*) Test cross will be performed to know the genotype of these plants.



If all the plants of F_1 generation are tall with yellow seeds, then the phenotype of the parent is homozygous dominant (case *i*). If the plants in F_1 generation are in the ratio of 1 : 1 : 1 : 1, then the parent plant is heterozygous dominant.

(*b*) *a*–Both the forms of a trait are equally expressed in F_1 generation.

b–Dominance.

c–Phenotypic expression of F_1 generation is somewhat intermediate between the two parental forms of a trait.

Q. 15. With the help of one example each, provide genetic explanation for the following observations:

(*i*) F_1-generation resembles both the parents.

(*ii*) F_1-generation does not resemble either of the parents.

Ans. (*i*) F_1 generation resembles both the parents: This happens in the case of co-dominance where both alleles express themselves fully in heterozygous condition. For example: different types of red blood cells determine ABO blood grouping in human beings. For details refer to Basic Concepts Point 6.

(*ii*) F_1 generation does not resemble either of the parents: In incomplete dominance, a heterozygous organism carrying two alleles wherein one is dominant and the other one is recessive, (*e.g.*, Aa). Hence, the heterozygote (Aa) will have an intermediate phenotype and will not resemble any parent. For details refer to Basic Concepts Point 5.

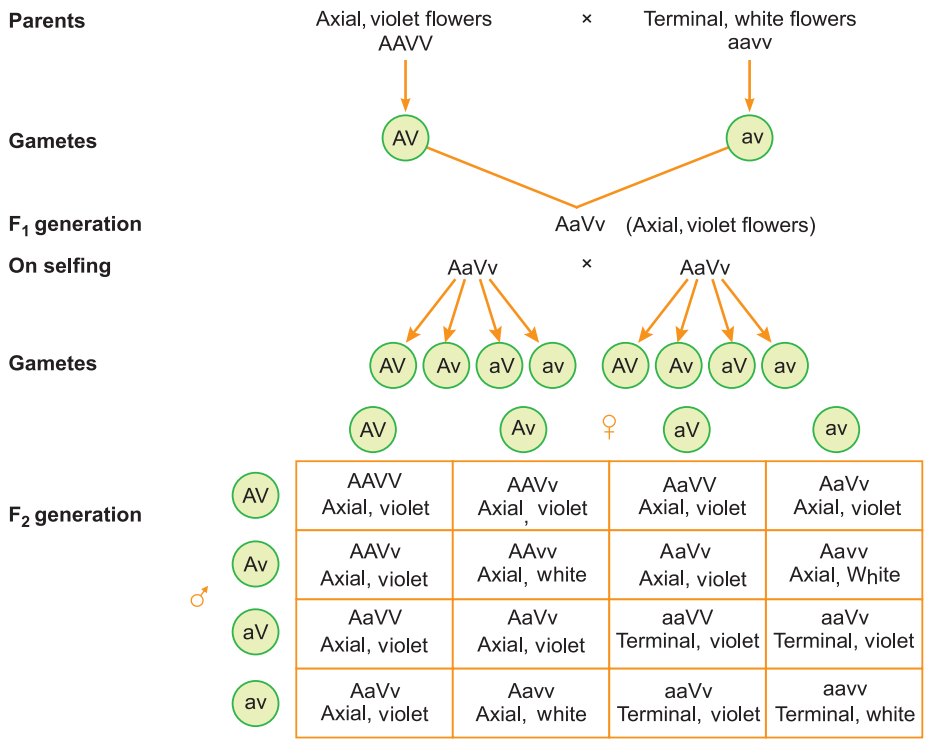
Q. 16. A true breeding pea plant homozygous for axial violet flowers is crossed with another pea plant with terminal white flowers (aavv).

(*a*) What would be the phenotype and genotype of F_1 and F_2 generations?

(*b*) Give the phenotypic ratio of F_2 generation.

(*c*) List the Mendel's generalisations that can be derived from the above cross.

Ans.



(*a*) Phenotype of F_1 generation—All axial, violet flowers.
Genotype of F_1 generation—AaVv.

(*b*) Phenotypic ratio of F_2 generation:

Axial violet flowers	:	Axial white flowers	:	Terminal violet flowers	:	Terminal white flowers
9		3		3		1

(*c*) Law of Independent Assortment: This law states that the different factors or allelomorphic pair in gametes and zygotes assort themselves and segregate independently of one another.

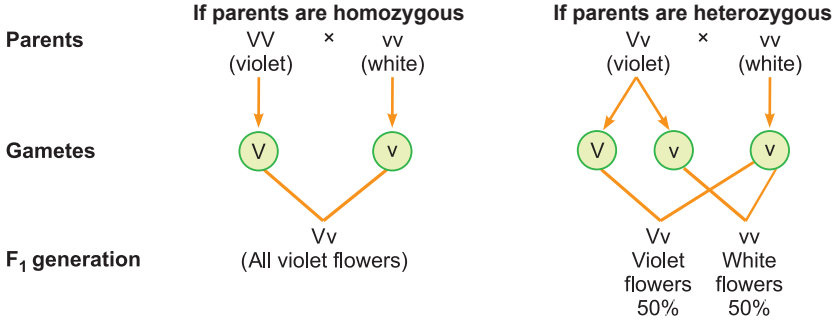
Q. 17. A particular garden pea plant produces only violet flowers.

(*a*) Is it homozygous dominant for the trait or heterozygous?

(*b*) How would you ensure its genotype? Explain with the help of crosses. ***[HOTS]***

Ans. (*a*) It could be homozygous dominant.

(*b*) By performing test cross, genotype can be determined.



Q. 18. Inheritance pattern of flower colour in garden pea plant and snapdragon differs. Why is this difference observed? Explain showing the crosses up to F_2 generation.

Ans. Inheritance pattern of flower colour in garden pea follows principle of dominance whereas inheritance in snapdragon shows incomplete dominance.

Inheritance of flower colour in garden pea plant:

Refer to Fig. 5.2.

Phenotypic ratio—3 : 1

Genotypic ratio—1 : 2 : 1.

Inheritance of flower colour in snapdragon: Refer to Fig. 5.4.

Phenotypic ratio—1 : 2 : 1

Genotypic ratio—1 : 2 : 1.

Q. 19. (*a*) Write the conclusions Mendel arrived, at on dominance of traits on the basis of monohybrid crosses that he carried out in pea plants.

(*b*) Explain why a recessive allele is unable to express itself in a heterozygous state.

[*CBSE (F) 2014*] [*HOTS*]

Ans. (*a*) Mendel concluded that:

(*i*) Characters are controlled by discrete units called factors.

(*ii*) Factors occur in pair.

(*iii*) In a dissimilar pair of factors one member of the pair dominates/only one of the parental character is expressed in a monohybrid cross in the F_1 and both are expressed in the F_2.

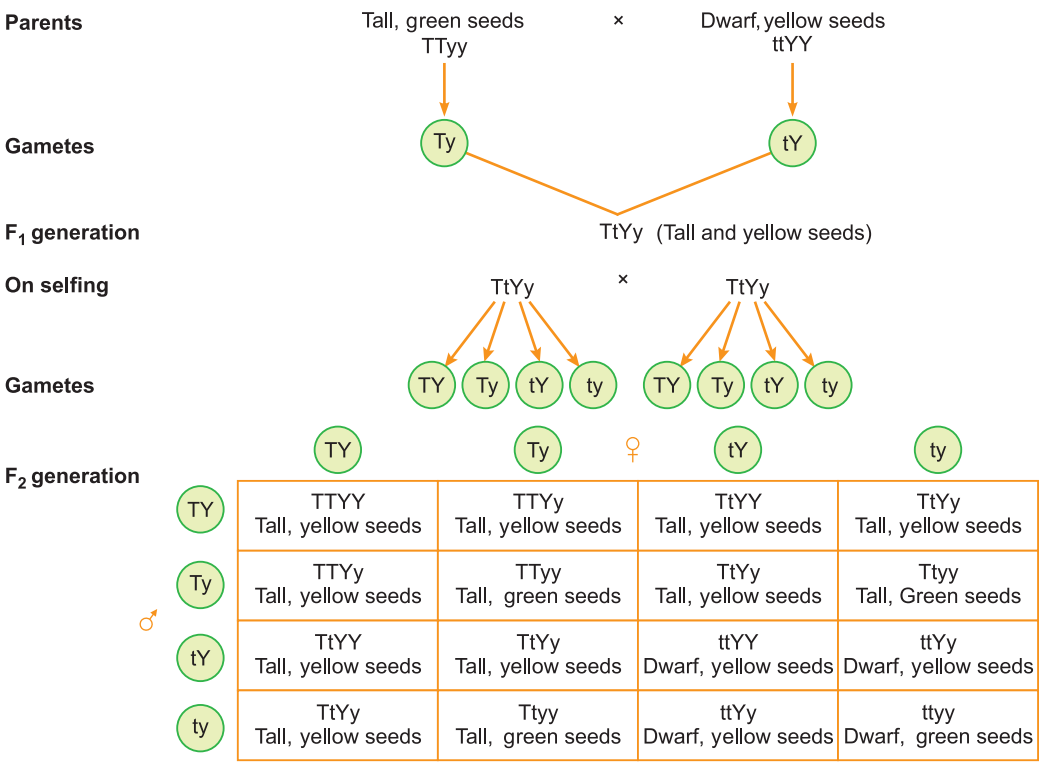
(*b*) The alleles are present on homologous chromosomes. The recessive allele does not code for its product or codes for a defective product. The other allele remains normal and thus expresses itself.

Q. 20. A homozygous tall pea plant with green seeds is crossed with a dwarf pea plant with yellow seeds:

(*i*) What would be the phenotype and genotype of F_1?

(*ii*) Work out the phenotypic ratio of F_2 generation with the help of a Punnett square.

Ans.



(*i*) Phenotype of F_1—Tall plants with yellow seeds.

Genotype of F_1—TtYy.

(*ii*) Phenotypic ratio of F_2 generation:

Tall, yellow seeds	:	Tall, green seeds	:	Dwarf, yellow seeds	:	Dwarf, green seed
9	:	3	:	3	:	1

Q. 21. State and explain the "law of independent assortment" in a typical Mendelian dihybrid cross. **[*CBSE Delhi 2017*]**

Ans. Refer to Basic Concepts Point 4(*iii*) and Fig. 5.3.

Q. 22. Let us assume in a given plant the genotype symbol "Y" stands for dominant yellow seed colour and "y" for recessive green seed colour; symbol "R" for round seed shape and "r" for wrinkled seeds. Two homozygous parents (plants) with genotypes "RRYY" and "rryy" are crossed and their F_1-generation progeny is then selfed. What shall be the

(*a*) Phenotype of F_1-progeny

(*b*) Genotype of F_1-progeny

(*c*) Gamete genotypes of F_1-progeny

(*d*) Phenotypic ratio of F_2 population

(*e*) Phenotypic ratio of yellow seed to green seed and round seed to wrinkled seed in F_2 population.

Ans. Refer to Fig. 5.3.

(*a*) Phenotype of F_1-progeny: Round seeds that are yellow in colour

(*b*) Genotype of F_1-progeny: RrYy

(*c*) Gamete genotypes of F_1-progeny: RY, Ry, rY and ry

(*d*) Phenotypic ratio of F_2 population: 9 : 3 : 3 : 1.

Nine round-yellow seeds; three round-green seeds; three wrinkled-yellow seeds; one wrinkled-green seed.

(*e*) Phenotypic ratio of yellow seed to green seed and round seed to wrinkled seed in F_2 population:

Yellow seed to green seed = 3 : 1

Round seed to wrinkled seed = 3 : 1

Q. 23. In the case of snapdragon (*Antirrhinum majus*) a plant with red flowers was crossed with another plant with white flowers. Trace the inheritance of flower colour up to F_2 generation indicating the genotype and phenotype at each level. What special feature do you notice in the genotype and phenotype ratio in F_2 generation?

Ans. Refer to Fig. 5.4.

Comment: This is a case of Mendelian deviation and that shows incomplete dominance as red and white both are not expressed but produce pink trait in F_1. Here, both the genotypic and phenotypic ratio are 1 : 2 : 1.

Q. 24. (*a*) Provide genetic explanation for the observation in which the flower colour in F_1 generation of snapdragon did not resemble either of the two parents. However, the parental characters reappeared when F_1 progenies were selfed.

(*b*) State the three principles of Mendel's law of inheritance.

Ans. (*a*) This is an exception to Mendel's principle of dominance and can be explained by the phenomenon of 'Incomplete dominance'. It is a phenomenon where none of the two contrasting alleles or factors are dominant. The expression of the character in a hybrid or F1 individual is intermediate or a fine mixture of expression of the two factors (pink flowers in this case from two parents with red and white flowers). This may be considered as an example of quantitative inheritance where only a single gene pair is involved. F2 phenotypic ratio is 1 : 2 : 1, similar to the genotypic ratio, in which the parental characters also reappear.

(*b*) Refer to Basic Concepts Point 4.

Q. 25. (*a*) Differentiate between dominance and co-dominance. **[*CBSE (AI) 2013*]**

(*b*) Explain co-dominance taking an example of human blood groups in the population.

Ans. (*a*) **Dominance:** It is a phenomenon in which when two contrasting alleles are present together, only one expresses itself and is called dominant whereas the other which does not express itself is called recessive.

Co-dominance: It is a phenomenon in which when two contrasting alleles are present together, both of the alleles express themselves.

(*b*) Refer to Basic Concepts Point 6.

Q. 26. Describe the mechanism of inheritance of the ABO system of blood group, highlighting the principle of genetics involved in it. **[*CBSE (AI) 2011, (F) 2010*]**

OR

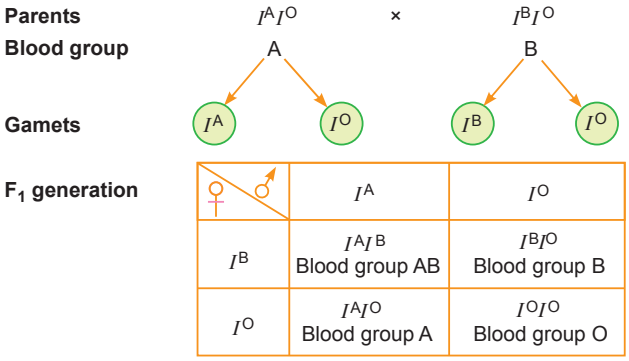
Explain the genetic basis of blood grouping in human population. **[*CBSE Delhi 2015*]**

Ans. Refer to Basic Concepts Point 6.

Q. 27. (*a*) Four children with four different blood groups are born to parents where the mother has blood group 'A' and the father has blood group 'B'. Work out the cross to show the genotypes of the parents and all four children.

(*b*) Explain the contribution of Alfred Sturtevant in 'Chromosome mapping'.

Ans. (*a*)



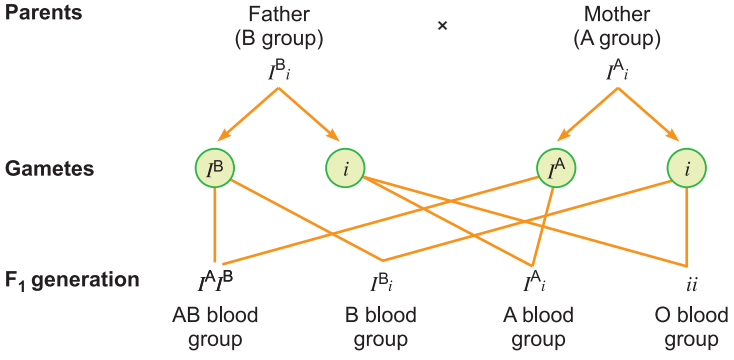
(*b*) Alfred Sturtevant used the frequency of recombination between gene pairs on the same chromosome as a measure of the distance between genes and mapped their position on the chromosome.

Q. 28. (*a*) Write the blood group of people with genotype I^AI^B. Give reasons in support of your answer.

(*b*) In one family, the four children each have a different blood group. Their mother has blood group A and their father has blood group B. Work out a cross to explain how it is possible. **[*CBSE (F) 2012, 2013*]**

Ans. (*a*) Blood group AB. Both the alleles I^A and I^B are co-dominant and express themselves completely.

(*b*) A cross is carried out between heterozygous father (for blood group B) and heterozygous mother (of blood group A) to get four children with different blood groups.



All the four blood groups are controlled by three allelic genes I^A, I^B, i and thus it shows phenomena of multiple allelism. Both I^A and I^B are dominant over i. However, when together, both are dominant and show the phenomena of co-dominance forming the blood group AB. Six genotypes are possible with combination of these three alleles.

Q. 29. (*a*) List the three different allelic forms of gene '*I*' in humans. Explain the different phenotypic expressions, controlled by these three forms.

(*b*) A woman with blood group 'A' marries a man with blood group 'O'. Discuss the possibilities of the inheritance of the blood groups in the following starting with 'yes' or 'no' for each:

(*i*) They produce children with blood group 'A' only.

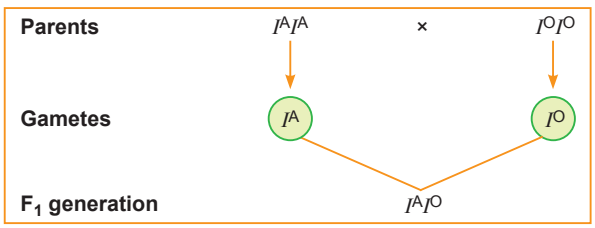
(*ii*) They produce children some with 'O' blood group and some with 'A' blood group.

[*CBSE Delhi 2012*]

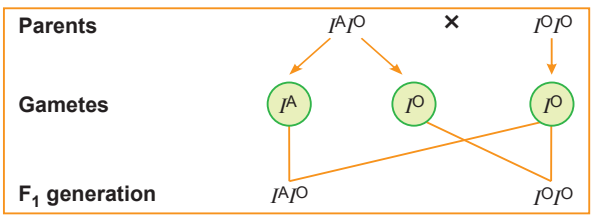
Ans. (*a*) The three different allelic forms are: I^A, I^B, I^O/i.

Refer to Basic Concepts Point 6.

(*b*) (*i*) Yes; when both the parent are homozygous.



(*ii*) Yes; when the woman is heterozygous.



Q. 30. (*a*) How are Mendelian inheritance, polygenic inheritance and pleiotropy different from each other?

(*b*) Explain polygenic inheritance pattern with the help of a suitable example. [*CBSE (AI) 2015*]

Ans (*a*) **Table 5.9: Differences between Mendelian inheritance, polygenic inheritance and pleitropy**

Mendelian Inheritance	Polygenic inheritance	Pleiotropy
One gene controls one trait/character/phenotype	Two or more genes influence the expression of one trait/character/phenotype	One genes controls the expression of more than one traits/characters/phenotypes

(*b*) Human height or skin colour are examples of polygenic inheritance. Height trait is controlled by at least three gene pairs. Additive effect of alleles contributes to the phenotypic expression of the trait. The more is the number of dominant alleles, more pronounced is the phenotypic expression or more is the height. The recessive alleles are less pronounced in the phenotypic expression.

Q. 31. (*a*) What is polygenic inheritance? Explain with the help of a suitable example.

(*b*) How are pleiotropy and Mendelian pattern of inheritance different from polygenic pattern of inheritance? [*CBSE (AI) 2016*]

Ans. (*a*) Refer to Basic Concepts Point 9.

(*b*) Single gene controls multiple phenotypic expression in pleiotropy and one gene controls one phenotypic expression in Mendelian inheritance.

Q. 32. (*a*) Explain Polygenic inheritance and Multiple allelism with the help of suitable examples.

(*b*) "Phenylketonuria is a good example that explains Pleiotropy." Justify. [*CBSE (AI) 2017*]

Ans. (*a*) Refer to Basic Concepts Point 6 and 9.

(*b*) In pleiotropy a single gene can exhibit multiple phenotypic expressions. In phenylketonuria single mutated gene expressrd multiple phenotypic expression like mental retardation and reduction in hair and skin pigmentation.

Q. 33. (*a*) Explain the mechanism of sex-determination in humans.

(*b*) Differentiate between male heterogamety and female heterogamety with the help of an example of each. [*CBSE (AI) 2013*]

Ans. (*a*) Refer to Basic Concepts Point 13

(*b*) Refer to Table 5.6

Q. 34. (*i*) How does a chromosomal disorder differ from a Mendelian disorder?

(*ii*) Name any two chromosomal aberration associated disorders.

(*iii*) List the characteristics of the disorders mentioned above that help in their diagnosis. [*CBSE Delhi 2010*]

Ans. (*i*) **Table 5.10: Differences between Mendelian disorder and chromosomal disorder**

S. No.	Mendelian disorder	Chromosomal disorder
(*i*)	This disorder is mainly due to alteration or mutation in the single gene.	This disorder is caused due to absence or excess or abnormal arrangement of one or more chromosomes.
(*ii*)	This follows Mendel's principles of inheritance.	This does not follow Mendel's principles of inheritance.
(*iii*)	This may be recessive or dominant in nature	This is always dominant in nature.
(*iv*)	For example, haemophilia, sickle-cell anaemia.	For example, Turner's syndrome.

(*ii*) Two chromosomal aberration-associated disorders are Down's syndrome and Klinefelter's syndrome.

(*iii*) (*a*) Down's syndrome: The individuals have overall masculine development but they express feminine development like development of breast, *i.e.*, gynaecomastia. They are sterile.

(*b*) Klinefelter's syndrome: The females are sterile as ovaries are rudimentary. Other secondary sexual characters are also lacking.

Q. 35. (*a*) Why is haemophilia generally observed in human males? Explain the conditions under which a human female can be haemophilic.

(*b*) A pregnant human female was advised to undergo M.T.P. It was diagnosed by her doctor that the foetus she is carrying has developed from a zygote formed by an XX egg fertilised by Y-carrying sperms. Why was she advised to undergo M.T.P.? [*CBSE (AI) 2011*]

Ans. (*a*) Haemophilia is caused due to the recessive gene on X chromosome. Y chromosome has no allele for this. If a male is X^hY, then he is haemophilic. If male inherits X^h from the mother, he will be haemophilic (with the genotype X^hY). If female inherits X^hX^h, one from the carrier mother and one from her haemophilic father, then she can be haemophilic.

(*b*) Embryo has (trisomy of sex chromosomes) XXY karyotype or Klinefelter's syndrome.

She was advised to undergo MTP since the child will have the following problems:

(*i*) male with feminine traits

(*ii*) gynaecomastia

(*iii*) underdeveloped testes

(*iv*) sterile

Q. 36. Thalassemia and haemophilia are both Mendelian disorders related to blood. Write the symptoms of the diseases. Explain with the help of crosses the difference in the inheritance pattern of the two diseases. ***[CBSE (F) 2016]***

OR

(*a*) Why are thalassemia and hemophilia categorised as Mendelian disorders? Write the symptoms of these diseases. Explain their pattern of inheritance in humans.

(*b*) Write the genotypes of the normal parents producing a haemophilic son. ***[CBSE (AI) 2015]***

Ans. Both are caused due to alteration or mutation, in a single gene and follow Mendelian pattern of inheritance.

Symptoms:

Thalassemia: anaemia (caused due to defective/abnormal Hb).

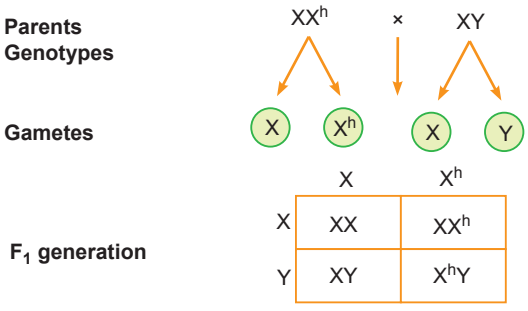
Haemophilia: non-stop bleeding even in minor injury.

Pattern of inheritance:

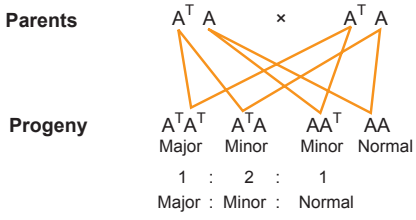
Thalassemia: autosomal recessive inheritance pattern inherited from heterozygous/parent carrier.

Haemophilia: X-linked recessive inheritance inherited from a haemophilic father/carrier mother (females are rarely haemophilic).

Cross for haemophilia:



Cross for thalassemia:



Thalassemia is an autosome-linked recessive blood disease. Its inheritance is like Mendelian inheritance pattern.

Q. 37. Write the symptoms of haemophilia and sickle-cell anaemia in humans. Explain how the inheritance pattern of the two diseases differs from each other. ***[CBSE Delhi 2010]***

Ans. **Symptoms of haemophilia:** Patient continues to bleed through a minor cut as the patient does not possess natural phenomenon of blood clotting.

Symptoms of sickle-cell anaemia: Erythrocytes lose their circular shape and become sickle-shaped. As a result, the cells cannot pass through narrow capillaries. Blood capillaries are clogged and thus affects blood supply to different organs.

Table 5.11: Differences between haemophilia and sickle-cell anaemia

S. No.	Haemophilia	Sickle-cell anaemia
(*i*)	It is a sex-linked recessive disorder.	It is an autosomal linked recessive trait.
(*ii*)	The gene for haemophilia is located on X-chromosome.	The disease is controlled by a single pair of allele Hb^A and Hb^S.
(*iii*)	More males suffer from haemophilia than females because in males single gene for the defect is able to express. Females suffer from this disease only in homozygous condition, *i.e.*, X^cX^c.	Only the homozygous individuals for Hb^S, *i.e.*, Hb^SHb^S show the diseased phenotype.
(*iv*)	The defective alleles produce non-functional protein which later form a non-functional cascade of proteins involved in blood clotting.	Due to point mutation Glutamic acid (Glu) is replaced by Valine (Val) at sixth positions of beta globin chain of haemoglobin molecule.

Q. 38. Why are colour blindness and thalassemia categorised as Mendelian disorders? Write the symptoms of these diseases seen in people suffering from them. ***[CBSE (AI) 2015]***

Ans. Both are caused due to mutation or alteration in a single gene, and follow Mendelian inheritance, therefore, they are called Mendelian disorders.

Symptoms of colour blindness: unable to discriminate between red and green colours.

Symptoms of thalassemia: formation of abnormal haemoglobin resulting in Anaemia.

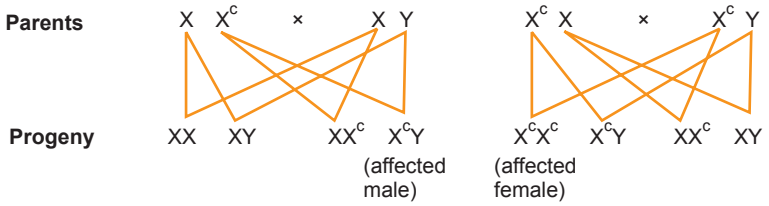
Q. 39. (*a*) State the cause and symptoms of colour-blindness in humans.

(*b*) Statistical data has shown that 8% of the human males are colour-blind whereas only 0.4% of females are colour-blind. Explain giving reasons how is it so. ***[CBSE (AI) 2015; (F) 2016]***

Ans. (*a*) Colour-blindness is a sex-linked recessive disorder.

Its symptoms are failure to discriminate between red and green colour.

(*b*) Since males have only one X chromosomes, hence one gene for colour blindness, so if present in any one parent will always be expressed, whereas in female it will be expressed only if it is present on both the X chromosome or when both parents are carrying gene for colour blindness.



Q. 40. Write the type and location of the gene causing thalassemia in humans. State the cause and symptoms of the disease. How is sickle cell anaemia different from this disease? ***[CBSE (F) 2014]***

Ans. Refer to Basic Concepts Point 16(*iv*) and 16 (*ii*).

Q. 41. Identify *'a'*, *'b'*, *'c'*, *'d'*, *'e'* and *'f'* in the table given below:

S. No.	Syndrome	Cause	Characteristics of affected individuals	Sex Male/Female/Both
1.	Down's	Trisomy of 21	*'a'* (*i*) (*ii*)	*'b'*
2.	*'c'*	XXY	Overall masculine development	*'d'*
3.	Turner's	45 with XO	*'e'* (*i*) (*ii*)	*'f'*

[CBSE (AI) 2014]

Ans. (*a*) Short stature/small round head/furrowed tongue/partially open mouth/ mental development retarded.

(*b*) Both

(*c*) Klinefelter's syndrome

(*d*) Male

(*e*) (*i*) Sterile ovaries; (*ii*) Lack of secondary sexual characters.

(*f*) Female

Q. 42. Describe the dihybrid cross carried on *Drosophila melanogaster* by Morgan and his group. How did they explain linkage, recombination and gene mapping on the basis of their observations? ***[CBSE (F) 2017]***

Ans. Refer to Basic Concepts Point 11.

Q. 43. (*a*) Write the scientific name of the organism Thomas Hunt Morgan and his colleagues worked with for their experiments. Explain the correlation between linkage and recombination with respect to genes as studied by them.

(*b*) How did Sturtevant explain gene mapping while working with Morgan?

[CBSE Examination Paper 2018]

Ans. (*a*) Thomas Hunt Morgan and his colleagues worked on *Drosophila melanogaster.*

They had the following observations.:

(*i*) Two genes which are located closely on a chromosome did not segregate independently of each other.

(*ii*) Tightly linked genes tend to show lesser recombinant frequency of parental traits.

(*iii*) Loosely linked genes show higher percentage of recombinant frequency of parental traits.

(*iv*) Genes present on same chromosome are said to be linked and the recombinant frequency depends on their relative distance on the chromosome.

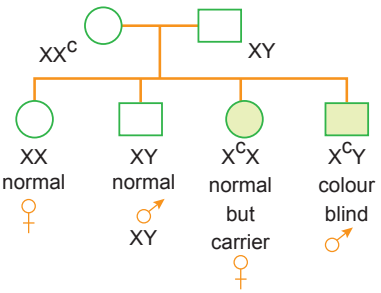
(*b*) Alfred Sturtevant used the frequency of recombination between gene pairs on the same chromosome as a measure of the distance between genes and mapped their position on the chromosome.

Q. 44. A normal visioned woman, whose father is colour blind, marries a normal visioned man. What would be the probability of her (*a*) sons (*b*) daughters to be colour blind? Explain with the help of pedigree chart. ***[NCERT Exemplar]*** ***[HOTS]***

Ans. The genotypes of parents are:

Father ⟶ XX^c as her father is colour blind.

Mother ⟶ XY



All daughters are normal visioned and 50% of sons are likely to be colour blind.

Self-Assessment Test

Time allowed: 1 Hour **Max. marks: 30**

1. Choose and write the correct option in the following questions. **(3×1 = 3)**

(i) Mother and father of a person with 'O' blood group have 'A' and 'B' blood group, respectively. What would be the genotype of both mother and father?

(a) Mother is homozygous for 'A' blood group and father is heterozygous for 'B'

(b) Mother is heterozygous for 'A' blood group and father is homozygous for 'B'

(c) Both mother and father are heterozygous for 'A' and 'B' blood group, respectively

(d) Both mother and father are homozygous for 'A' and 'B' blood group, respectively

(ii) The genotype of a plant showing the dominant phenotype can be determined by

(a) monohybrid cross (b) dihybrid cross

(c) test cross (d) pedigree analysis

(iii) A human female with Turner's syndrome has

(a) karyotype 45+XO (b) an additional X chromosome

(c) trisomy of X chromosome (d) male characteristics

2. In the following questions a statement of assertion followed by a statement of reason is given. Choose the correct answer out of the following choices. **(3×1 = 3)**

(a) Assertion and reason both are correct statements and reason is correct explanation for assertion.

(b) Assertion and reason both are correct statements but reason is not correct explanation for assertion.

(c) Assertion is correct statement but reason is wrong statement.

(d) Assertion is wrong statement but reason is correct statement.

(i) Assertion : Human skin colour show polygenic inheritance.

Reason : Each allele of human skin colour gane shows participation and the phenotype is controlled by many genes.

(ii) Assertion : The genes on a chromosome are physically linked.

Reason : The number of linkage groups in an organism is equal to their haploid number of chromosomes.

(iii) Assertion : Phenylalanine reductase is needed to breakdown the amino acid phenylalanine.

Reason : Phenylketonuria is an inborn error of metabolism.

3. Write the chromosomal defect in individuals affected with Klinefelter's syndrome. **(1)**

4. What is the karyotype of Turner's syndrome? **(1)**

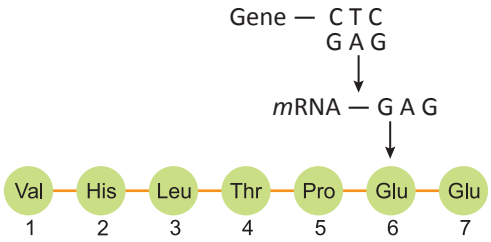
5. A pea plant homozygous for axial flowers and constricted pods is crossed with the pea plant homozygous for terminal flowers having inflated pods. Work out the cross up to F_1 generation. Show the genotypes of the parents and phenotype and genotype of the progeny. **(2)**

6. Colour blindness in humans is a sex-linked trait. Explain with the help of a cross. **(2)**

7. How can you say that the sex of a child is determined by the father and not by the mother? **(2)**

8. Why is haemophilia generally observed in men? Under what condition can women also suffer from this disorder? **(2)**

9. Given below is representation of amino acid composition of the relevant translated portion of β chain of hemoglobin, related to shape of human red cells. **(3×1 = 3)**



HbA peptide

(i) Is this representation indicating normal human or a sufferer from certain related genetic disease. Give reason in support of your answer.

(ii) What difference would be noticed in phenotype of the normal and sufferer related to this gene.

(iii) Who are likely to suffer more from the defect related to the gene represented; the males, the females or both males and females equally likely and why?

10. When tall pea plants were selfed some of the offsprings were dwarf. Explain with the help of a Punnett square. **(3)**

11. What is heterogamety ? Explain the mechanism of sex determination in *Drosophila*. **(3)**

12. (i) Why did T.H. Morgan select *Drosophila melanogaster* as a specimen for his experiments ?

(ii) Morgan, in his dihybrid crosses with *Drosophila* observed deviations in the phenotypic ratio of F_2 progeny in comparison to that of Mendel. With the help of a suitable example, explain how his results deviated from that of Mendel. **(5)**

Answers

1. (*i*)—(*c*), (*ii*)—(*c*), (*iii*)—(*a*) **2.**(*i*)—(*a*), (*ii*)—(*b*), (*iii*)—(*d*)

Chapter–6

Molecular Basis of Inheritance

basic concepts

- Two types of nucleic acids are present in living systems—ribonucleic acid (RNA) and deoxyribonucleic acid (DNA).

1. The Structure of Polynucleotide Chain

- A nucleotide is the basic unit of polynucleotide chain of DNA or RNA.
- Each nucleotide is composed of three components:
  (*i*) a nitrogenous base,
  (*ii*) pentose sugar (ribose in case of RNA and deoxyribose for DNA), and
  (*iii*) a phosphate group.

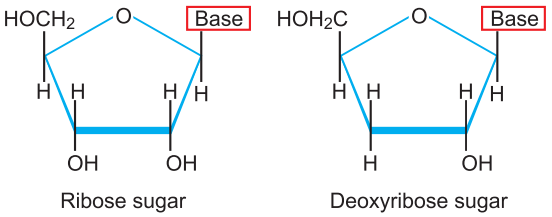


Fig. 6.1 Types of sugar molecules

- **Nitrogenous base:** It is of two types, purine (adenine and guanine) and pyrimidine (cytosine and thymine). Uracil is only present in RNA instead of thymine.
- A nitrogenous base is attached to the pentose sugar by an N-glycosidic linkage to form a nucleoside.
- When a phosphate group is attached to 5′–OH of a nucleoside through phosphodiester linkage, a nucleotide is formed.
- Two nucleotides are joined through 3′–5′ phosphodiester linkage and a dinucleotide is formed. Thus, when numerous nucleotides are joined, a polynucleotide chain is formed.

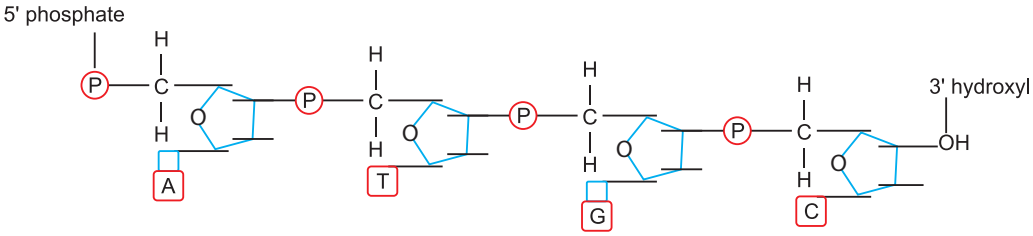


Fig. 6.2 A polynucleotide chain

- One end of polynucleotide chain contains pentose sugar with free OH at 5′ end (it is called 5′–end) and the other end contains sugar with free OH at 3′ end (it is called 3′–end).
- Sugar and phosphate constitute the backbone of polynucleotide chain and nitrogenous bases are linked to sugar moiety which projects from the backbone.

2. Salient Features of Double Helical DNA

- James Watson and Francis Crick in 1953 proposed the double helix model of DNA based on the X-ray diffraction data produced by Maurice Wilkins and Rosalind Franklin and Erwin Chargaff's rules of base pairing.

- **Chargaff's rules:**
  - (*i*) The amount of adenine is always equal to the amount of thymine and the amount of guanine is always equal to the amount of cytosine, *i.e.*, [A] = [T], [G] = [C]
  - (*ii*) Adenine is joined to thymine with two hydrogen bonds and guanine is joined to cytosine by three hydrogen bonds.
  - (*iii*) The ratio of adenine and guanine to that of thymine and cytosine is always equal to one, *i.e.*,

$$\frac{[A + G]}{[T + C]} = 1$$

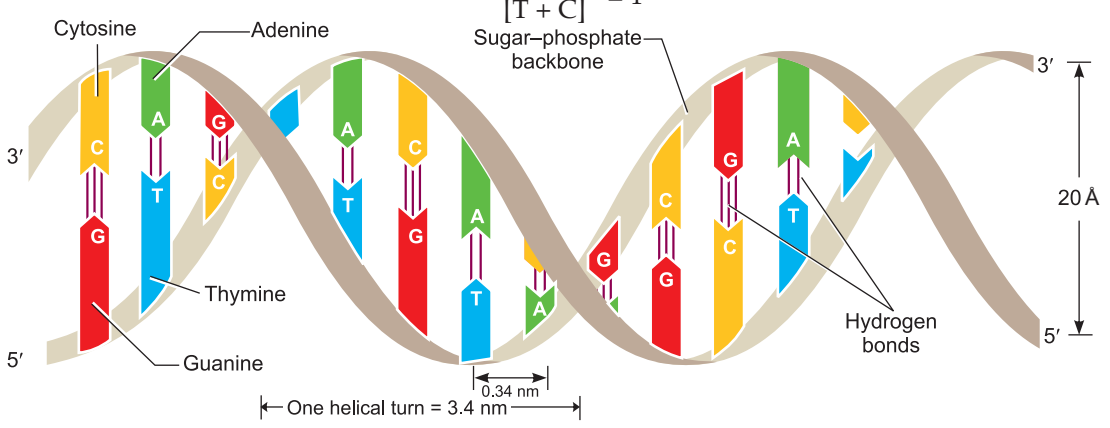


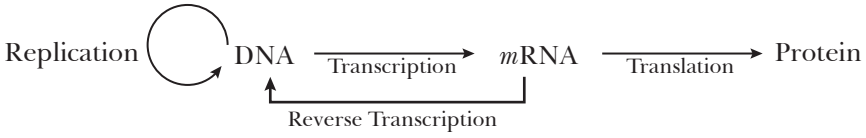
Fig. 6.3 DNA double helix

Following are some features of DNA:

- (*i*) DNA is made up of two polynucleotide chains, where the backbone is made up of sugar and phosphate groups and the nitrogenous bases project towards the centre.
- (*ii*) There is complementary base pairing between the two strands of DNA. 'A' pairs with 'T' with 2 hydrogen bonds and 'C' pairs with 'G' with 3 hydrogen bonds.
- (*iii*) The two strands are coiled in right-handed fashion and are anti-parallel in orientation. One chain has a 5′→3′ polarity while the other has 3′→5′ polarity.
- (*iv*) The diameter of the strand is always constant due to pairing of purine and pyrimidine, *i.e.*, adenine is complementary to thymine while guanine is complementary to cytosine.
- (*v*) The distance between two base pairs in a helix is 0.34 nm and a complete turn contains approximately ten base pairs. The pitch of the helix is 3.4 nm and the two strands are right-handed coiled.
- (*vi*) Plane of one base pair stacks over the other in double helix. This in addition to hydrogen bonds confers stability to the helical structure.
- (*vii*) Linkage between nitrogenous base and pentose sugar is N-glycosidic linkage.

3. Central Dogma of Molecular Biology

- **Francis Crick** proposed the central dogma of molecular biology which states that genetic information flows from DNA to *m*RNA (transcription) and then from *m*RNA to protein (translation) always unidirectionally (except bidirectionally in some viruses and the process is called reverse transcription).



4. Packaging of DNA

- Distance between two base pairs is 0.34 nm. If length of DNA double helix in a typical mammalian cell is calculated, *i.e.*, total number of base pairs × by distance between two consecutive base pairs, *i.e.*, 6.6×10^9 bp $\times$ 0.34×10^{-9} m/bp = 2.2 meters. This length is far greater than the dimension of a typical nucleus (= 10^{-6} m). Therefore, DNA needs to be packaged to fit in the nucleus.

(i) Packaging of DNA in prokaryotes

- In prokaryotes, well-defined nucleus is absent so DNA is present in a region called **nucleoid**. The negatively charged DNA is coiled with some positively charged non-histone basic proteins.
- DNA in nucleoid is organised in large loops held by proteins.

(ii) Packaging of DNA in eukaryotes

- **Roger Kornberg** (1974) reported that chromosome is made up of DNA and protein.
- Later, Beadle and Tatum reported that chromatin fibres look like beads on the string, where beads are repeated units of proteins.
- The proteins associated with DNA are of two types—basic proteins (histones) and acidic non-histone chromosomal (NHC) proteins.
- The negatively charged DNA molecule wraps around the positively charged histone proteins to form a structure called **nucleosome**.
- The nucleosome core is made up of four types of histone proteins—H_2A, H_2B, H_3 and H_4 occurring in pairs.

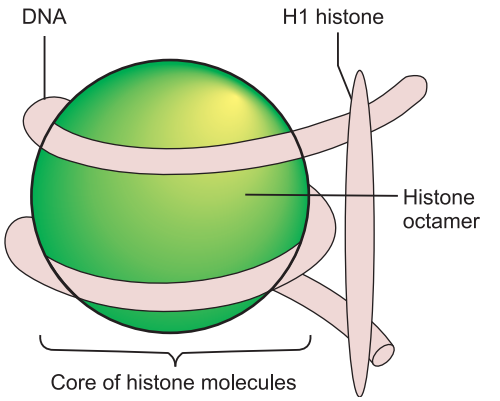


Fig. 6.4 Nucleosome

- 200 bp of DNA helix wrap around the nucleosome by 1¾ turns, plugged by H_1 histone protein.
- Repeating units of nucleosomes form the chromatin in nucleus, which is a thread-like structure.
- The chromatin is packed to form a **solenoid structure** of 30 nm diametre.
- Further supercoiling forms a looped structure called the **chromatin fibre**.
- These chromatin fibres further coil and condense at metaphase stage of cell division to form chromosomes. Packaging of chromatin at higher level requires NHC proteins.

Table 6.1: Differences between euchromatin and heterochromatin

S. No.	Euchromatin	Heterochromatin
(*i*)	Regions of chromatin, which are loosely packed during interphase are called euchromatin.	Regions of chromatin, which are densely packed during cell division are called heterochromatin.
(*ii*)	When chromosomes are stained with Feulgen stain (specific for DNA), these appear as lightly stained chromatin.	When chromosomes are stained with Feulgen stain, these appear as intensely stained chromatin.
(*iii*)	Euchromatin contains active genes.	Heterochromatin contains inactive genes.
(*iv*)	They do not contain repetitive DNA sequences.	They are enriched with highly repetitive tandemly arranged DNA sequences.
(*v*)	It is transcriptionally active.	It is transcriptionally inactive.

5. Transforming Principle

- **Frederick Griffith** (1928) conducted experiments with *Streptococcus pneumoniae* (bacterium causing pneumonia).
- He observed two strains of this bacterium—one forming smooth shiny colonies (S-type) with capsule, while other forming rough colonies (R-type) without capsule.

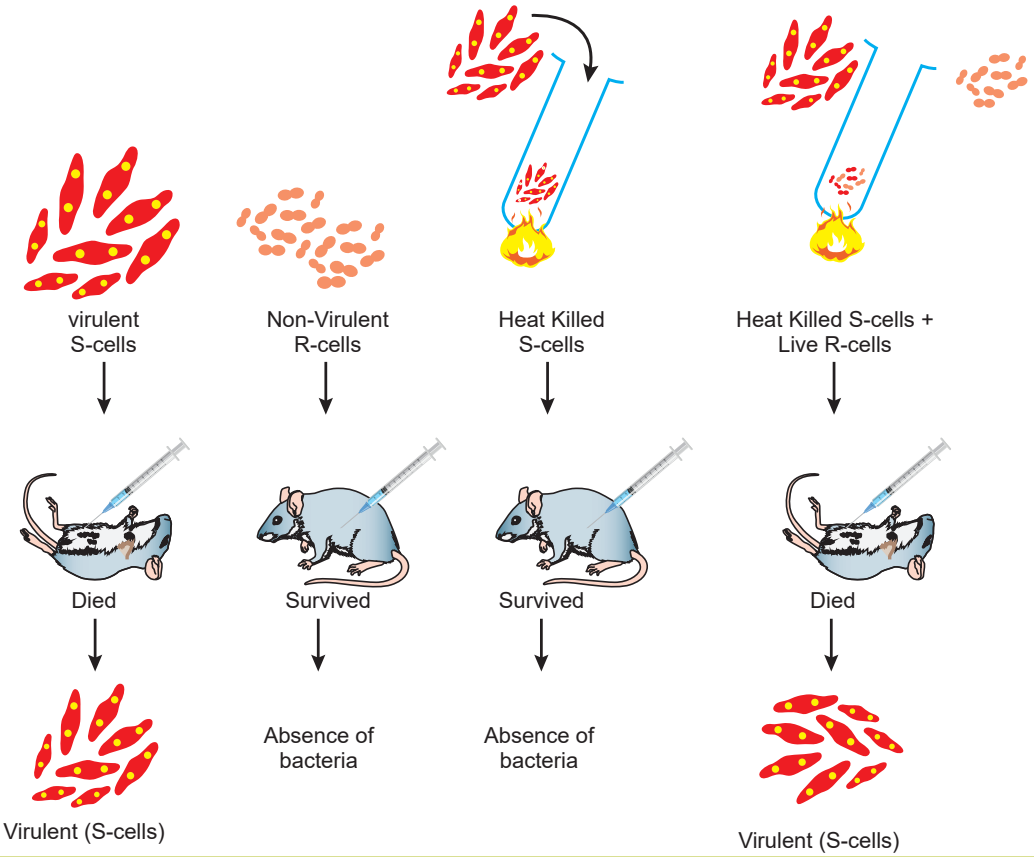


Fig. 6.5 Griffith's experiment on transformation

- When live S-type cells were injected into mice, they died due to pneumonia.
- When live R-type cells were injected into mice, they survived.
- When heat-killed S-type cells were injected into mice, they survived and there were no symptoms of pnuemonia.
- When heat-killed S-type cells were mixed with live R-type cells and injected into mice, they died due to unexpected symptoms of pneumonia and live S-type cells were obtained from mice.
- He concluded that heat-killed S-type bacteria caused a transformation of the R-type bacteria into S-type bacteria but he was not able to understand the cause of this bacterial transformation.
- He further stated that some 'transforming principle' transferred from heat killed S strain, enabled R strain to synthesize a smooth polysaccharide coat and become virulent. But biochemical nature of genetic material was not defined from his experiments.

6. Biochemical Characterisation of Transforming Principle

- **Oswald Avery, Colin MacLeod** and **Maclyn McCarty** repeated Griffith's experiment in an *in vitro* system in order to determine biochemical nature of transforming principle.

- They purified biochemicals (proteins, DNA, RNA) from heat-killed S-type cells, and checked which of these could transform live R-type cells into S-type cell. They observed that DNA alone from S-type cells caused transformation of R-type cells into virulent S-type cells.
- They also discovered that proteases (protein digesting enzymes) and RNases (RNA digesting enzymes) did not affect transformation while DNases inhibited the process.
- They concluded that DNA is the hereditary material.

7. Proof for DNA as the Genetic Material

- **Hershey** and **Chase** (1952) conducted experiments on bacteriophage to prove that DNA is the genetic material.

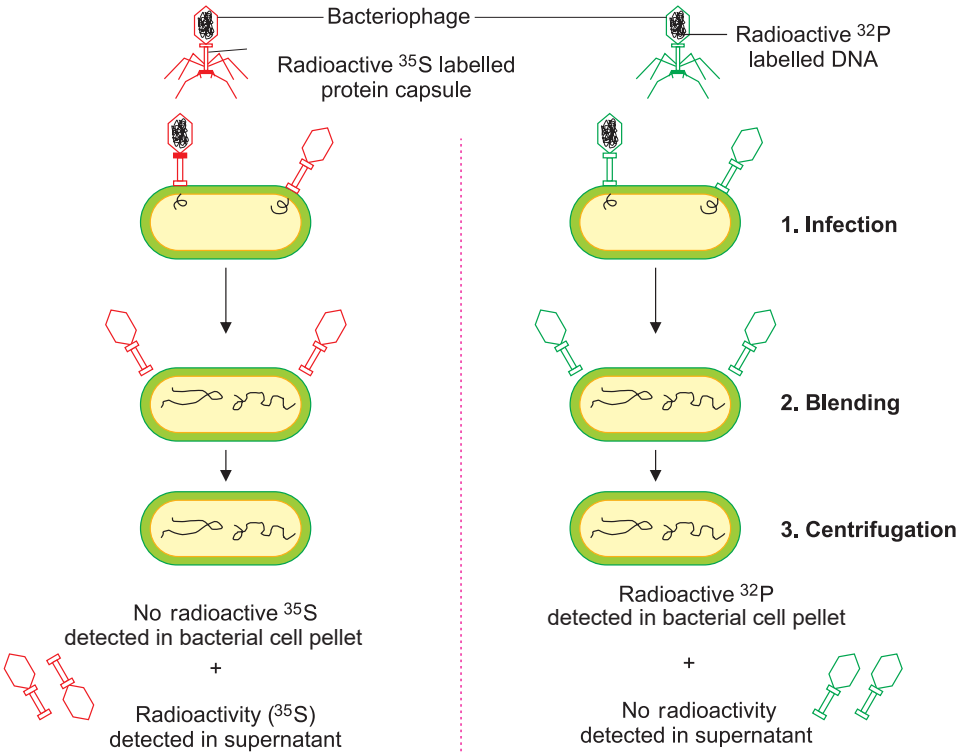


Fig. 6.6 The Hershey–Chase experiment

- **Procedure:**
  - (*i*) Some bacteriophage virus were grown on a medium that contained radioactive phosphorus (^{32}P) and some in another medium with radioactive sulphur (^{35}S).
  - (*ii*) Viruses grown in the presence of radioactive phosphorus (^{32}P) contained radioactive DNA.
  - (*iii*) Similar viruses grown in presence of radioactive sulphur (^{35}S) contained radioactive protein.
  - (*iv*) Both the radioactive virus types were allowed to infect *E. coli* separately.
  - (*v*) Soon after infection, the bacterial cells were gently agitated in blender to remove viral coats from the bacteria.
  - (*vi*) The culture was also centrifuged to separate the viral particle from the bacterial cell.
- **Observations and Conclusions:**
  - (*i*) Only radioactive ^{32}P was found to be associated with the bacterial cell, whereas radioactive ^{35}S was only found in surrounding medium and not in the bacterial cell.
  - (*ii*) This indicates that only DNA and not the protein coat entered the bacterial cell.
  - (*iii*) This proves that DNA is the genetic material which is passed from virus to bacteria and not protein.

8. Characteristics of Genetic Material

- In some viruses, RNA is the genetic material (*e.g.*, Tobacco Mosaic virus). RNA also performs functions of messenger and adapter.
  - (*i*) DNA and RNA have the ability to direct their duplications because of rule of base pairing and complementarity but proteins fail to fulfill first criteria itself.
  - (*ii*) Genetic material should be stable so as not to change with different stages of life cycle, age or change in physiology of organism.
  - (*iii*) RNA being unstable mutates at a faster rate. Thus, viruses having RNA genome and having shorter life span mutate and evolve faster.
  - (*iv*) RNA can code directly for protein synthesis and hence can easily express characters. But DNA is dependent on RNA for protein synthesis. Protein synthesizing machinery has evolved around RNA.

    Conclusion: Both RNA and DNA can function as genetic material, but DNA being chemically less reactive and structurally being more stable is a better genetic material. DNA is more stable than RNA because of:
    - (*a*) being double standard.
    - (*b*) two strands being complementary; even if separated by heating they come together.
    - (*c*) DNA is less reactive than RNA as has 2′–OH group is absent in every nucleotide (RNA has 2′–OH group). RNA being catalytic, is very reactive.
    - (*d*) Presence of thymine in place of uracil provides additional stability to DNA.

9. Ribonucleic Acid (RNA)

- RNA was the first genetic material.
- Essential life processes (such as metabolism, translation, splicing, etc.) evolved around RNA.
- RNA acts as genetic material as well as catalyst.
- RNA being a catalyst was reactive and hence unstable. Therefore, DNA has evolved from RNA with chemical modifications that make it more stable.
- DNA being double stranded and having complementary strand resist changes by evolving a process of repair.

Table 6.2: Differences between DNA and RNA

S. No.	DNA	RNA
(*i*)	The sugar present is deoxyribose.	The sugar present is ribose.
(*ii*)	Nitrogenous bases present are adenine, guanine, thymine and cytosine.	Nitrogenous bases present are adenine, guanine, cytosine and uracil.
(*iii*)	It is always double stranded.	It can be single stranded or double stranded.
(*iv*)	It is the genetic material of almost all living organisms.	It is the genetic material of only some viruses.
(*v*)	It is chemically less reactive and structurally more stable.	It is chemically more reactive and structurally less stable.

10. DNA Replication

- **Watson** and **Crick** in 1953 proposed a scheme that DNA replication was **semi-conservative**.
- According to the scheme, the two parental strands separate and each strand acts as a template for synthesising a complementary strand over it.
- After completion of replication, each DNA had one parental strand and one newly synthesised strand.

(i) Experimental proof for semi-conservative mode of DNA replication

- **Matthew Meselson** and **Franklin Stahl** in 1958 performed experiments on *E. coli* to prove that DNA replication is semi-conservative.
- They grew *E. coli* in a medium containing $^{15}NH_4Cl$ (in which ^{15}N is the heavy isotope of nitrogen) for many generations.
- As a result, ^{15}N got incorporated into newly synthesised DNA.
- This heavy DNA can be differentiated from normal DNA by centrifugation in caesium chloride (CsCl) density gradient.
- Then they transferred the cells into a medium with normal $^{14}NH_4Cl$ and took the samples at various definite time intervals as the cells multiplied.
- The extracted DNAs were centrifuged and measured to get their densities.
- The DNA extracted from the culture after one generation of transfer from the ^{15}N medium to ^{14}N medium (*i.e.*, after 20 minutes; *E. coli* divides every 20 minutes) showed an intermediate hybrid density.
- The DNA extracted from culture after two generations (*i.e.*, after 40 minutes) showed equal amounts of light DNA and hybrid DNA.
- When allowed to grow for 80 minutes, it showed more amounts of light DNA but the hybrid DNA still maintained itself.

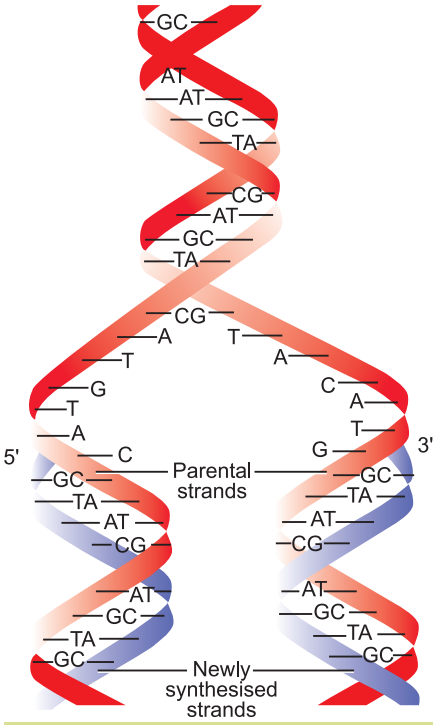


Fig. 6.7 Watson–Crick model for semi-conservative DNA replication

- Similar experiment was performed by Taylor and colleagues in 1958, on *Vicia faba* using radioactive thymidine to detect distribution of newly synthesized DNA in chromosomes to prove that the DNA in chromosome also replicate semi-conservatively.

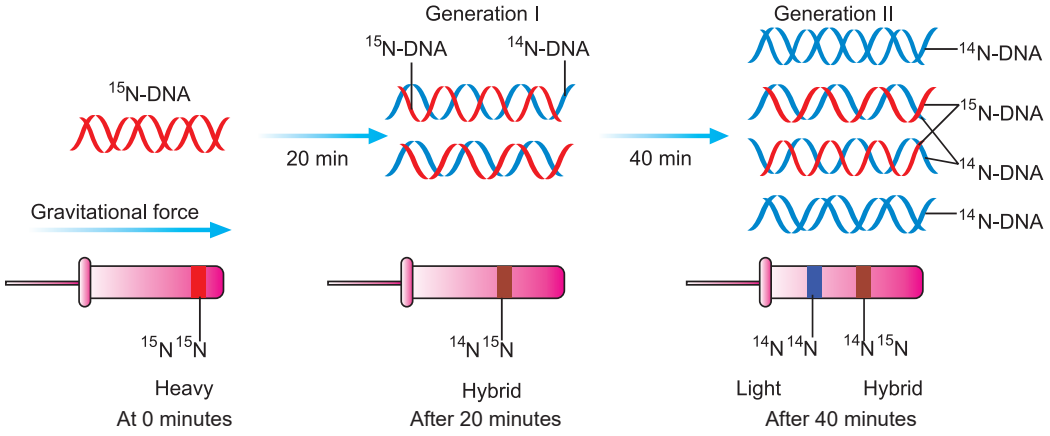


Fig. 6.8 Meselson and Stahl's experiment

(ii) Enzymes for DNA replication

- Various enzymes are required as catalysts during DNA replication in living cells.

(*a*) **DNA-dependent DNA polymerase:** It catalyses the polymerisation of deoxynucleotides on DNA template at a fast rate. Its average rate of polymerisation is 2000 bp per second. [It completes process of replication for *E.coli* within 38 minutes which has only 4.6×10^6

bp whereas for human genome, diploid content is 6.6×10^9 bp]. It also has to catalyse reaction with high degree of accuracy as any mistake during replication would result into mutations.

(*b*) Helicase: It unwinds the DNA strand to form the replication fork.

(*c*) DNA ligase: It joins the Okazaki fragments which are formed on the lagging strand.

- Dual Purpose of Deoxyribonucleoside triphosphates:
  (*i*) Act as substrate because deoxyribonucleotides are joined to form DNA.
  (*ii*) Provide energy for polymerisation reaction as polymeristion is energetically very expensive (The two terminal phosphates in a deoxyribonucleoside triphosphates are high energy phosphates as in ATP).

(iii) Process of DNA Replication

- DNA replication begins at a unique and fixed point called **origin of replication** or **'ori'**.

Initiation

- The complementary strands of DNA double helix are separated by enzyme, DNA helicase. This is called **unwinding** of double-stranded DNA.
- The separated strands tend to rewind, therefore these are stabilised by proteins called **single strand binding proteins (ssBPs)**, which bind to the separated strands.
- Unwinding of double-stranded DNA forms a Y-shaped configuration in the DNA duplex, which is called **replication fork**.

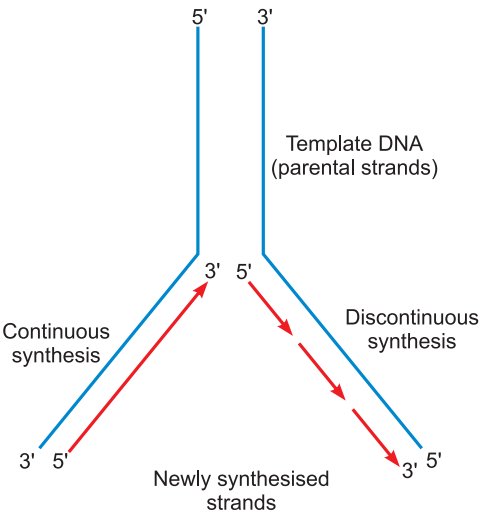


Fig. 6.9 Replication fork

Elongation

- An enzyme called **primase** initiates replication of the strand oriented in the 3′ (towards origin)→5′ (towards fork) direction. This generates 10–60 nucleotides long primer RNA (replicated in 5′→3′ direction).
- The free 3′–OH of this RNA primer provides the initiation point for DNA polymerase for sequential addition of deoxyribonucleotides.
- DNA polymerase progressively adds deoxyribonucleotides to the free 3′-end of the growing polynucleotide chain so that replication of the 3′→5′ strand of the DNA molecule is continuous (growth of the new strand in 5′→3′ direction).
- The replication of 3′→5′ strand is continuous and it is called **leading strand,** while the replication of second strand (5′→3′ strand) of the DNA molecules is discontinuous and it is known as the **lagging strand**.
- The replication of lagging strand generates small polynucleotide fragments called **'Okazaki fragments'** (after R. Okazaki, who first identified them).
- These Okazaki fragments are then joined together by enzyme called DNA **ligase**.

11. Transcription

- The process of copying genetic information from one strand of the DNA into RNA is termed as **transcription**.
- The principle of complementarity governs the process, except that adenosine now base pairs with uracil instead of thymine, as in replication.
- Unlike replication, only a single-stranded fragment of DNA gets copied into RNA.

Transcription unit

- The transcription unit of DNA contains three regions in the DNA:
  (*i*) The **promoter**: It is the binding site for RNA polymerase for initiation of transcription.
  (*ii*) The **structural gene**: It codes for enzyme or protein for structural functions.
  (*iii*) The **terminator**: It is the region where transcription ends.

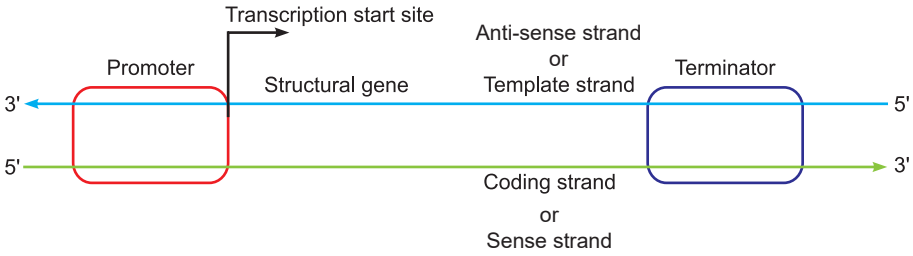


Fig. 6.10 Schematic structure of a transcription unit

- The **DNA-dependent RNA polymerase** helps in DNA replication by catalysing the polymerisation in only one direction, *i.e.*, 5′→3′.
- The DNA strand that has the polarity 3′→5′ acts as a template and is also referred to as **template strand**.
- The strand which does not get transcripted is called **coding strand** and has the polarity 5′→3′. Its sequence is same as RNA formed.
- The promoter is located towards 5′-end (upstream) of the structural gene of coding strands and provides the binding site for RNA polymerase.
- The sequence of DNA located towards the 3′-end (downstream) of the coding strand where the process of transcription would stop is called **terminator**.

12. Transcription Unit and the Gene

- The segment of DNA coding for a polypeptide is called **cistron**.
- In eukaryotes, the transcription unit possess a structural gene specific only for a single polypeptide. Thus it is called **monocistronic**.
- In prokaryotes, the transcription unit possessing the structural genes for many polypeptides which are part of single metabolic pathway are called **polycistronic**.
- The gene in eukaryotes are split into the coding or expressed sequence of DNA called **exon**, and non-expressable sequence of DNA called **intron** or **intervening sequence**.
- *m*RNA contains only exon but no intron.
- Regulatory sequences are loosely defined as regulatory genes, though they do not code for any RNA or protein.

13. Transcription in Prokaryotes

- In prokaryotes, the structural gene is polycistronic and continuous.
- In bacteria, the transcription of all the three types of RNA (*m*RNA, *t*RNA and *r*RNA) is catalysed by single DNA-dependent enzyme, called the **RNA polymerase**.
- All three RNA's are needed to synthesize a protein in cell. *m*RNA provides the template, *t*RNA brings amino acids and reads the genetic code, and *r*RNA plays structural and catalytic role durinng translation.
- The transcription is completed in three steps: initiation, elongation and termination.
- **Initiation:** σ (sigma) factor recognises the start signal and promotor region on DNA which then along with RNA polymerase binds to the promoter to initiate transcription. It uses nucleoside triphosphates as substrate and polymerises in a template-dependent fashion following the rule of complementarity.

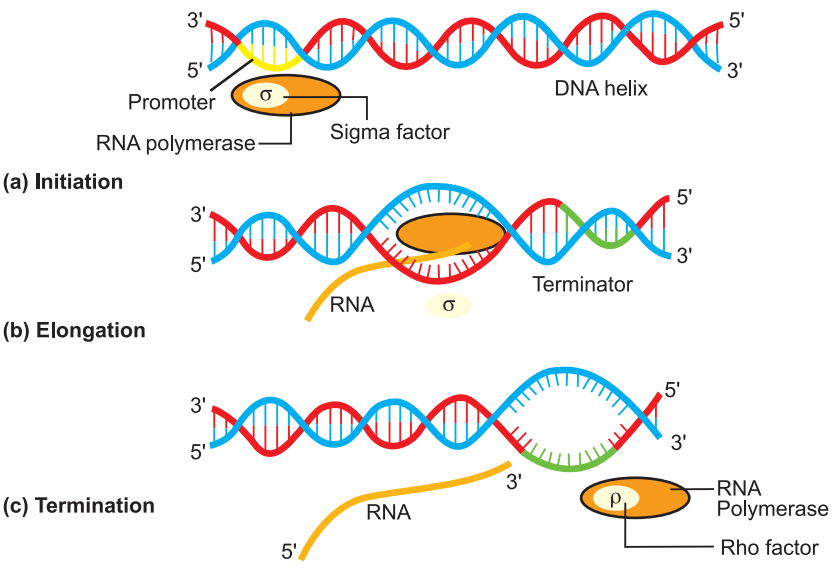


Fig. 6.11 Process of transcription in bacteria

- **Elongation:** The RNA polymerase after initiation of RNA transcription loses the σ factor but continues the polymerisation of ribonucleotides to form RNA. It facilitates opening of helix and continues elongation with only a short stretch of RNA being bound to enzyme at a time.
- **Termination:** Once the RNA polymerase reaches the termination region of DNA, the RNA polymerase is separated from DNA–RNA hybrid, as a result nascent RNA separates. This process is called termination which is facilitated by a termination factor ρ (**rho**).
- In prokaryotes, *m*RNA does not require any processing, so both transcription and translation occur in the cytosol. It can be said that transcription and translation are coupled together as many times translation can begin much before *m*RNA is fully transcribed.

14. Transcription in Eukaryotes

- The structural genes are monocistronic in eukaryotes.
- The process of transcription is similar to that in prokaryotes.
- It takes place in the nucleus.
- Coding gene sequences called exons form the part of *m*RNA and non-coding sequence called introns are removed during RNA splicing and exons are joined in a defined order.
- In eukaryotes, three types of RNA polymerases are found in the nucleus:
  - (*i*) **RNA polymerase I** transcribes *r*RNAs (28S, 18S, and 5.8S).
  - (*ii*) **RNA polymerase II** transcribes the precursor of *m*RNA (called heterogeneous nuclear RNA or *hn*RNA).
  - (*iii*) **RNA polymerase III** transcribes *t*RNA, 5S *r*RNA and *sn*RNAs (small nuclear RNAs).

Post-transcriptional modifications

- The primary transcripts are non-functional, containing both the coding region, exon, and non-coding region, intron, in RNA and are called heterogenous RNA or *hn*RNA.
- The *hn*RNA undergoes splicing and two additional processes called **capping** and **tailing**.
- In capping, an unusual nucleotide, methyl guanosine triphosphate, is added to the 5′-end of *hn*RNA.

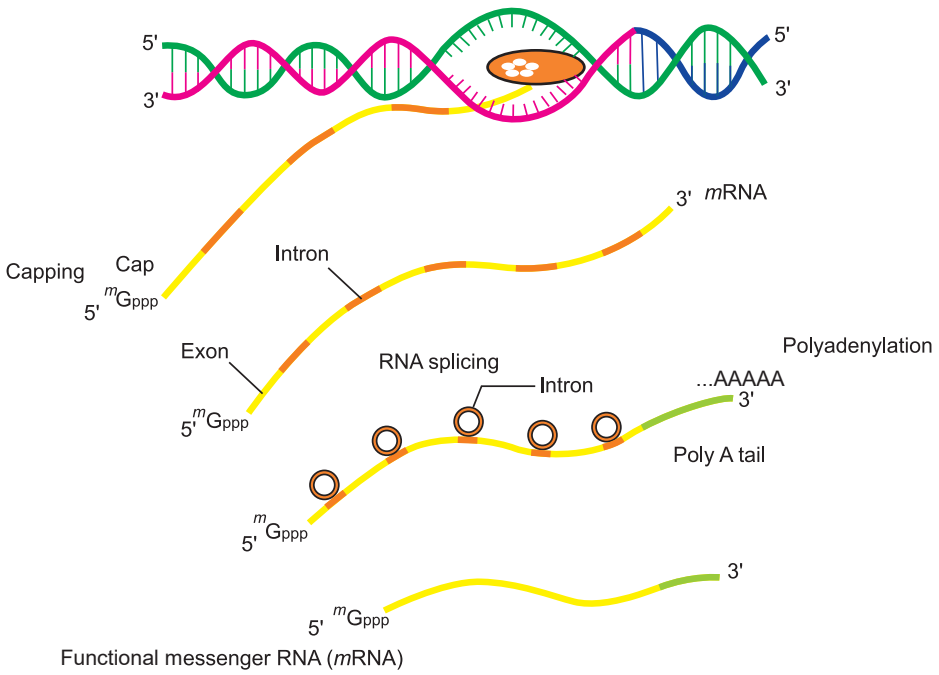


Fig. 6.12 Post-transcriptional modifications in eukaryotes

- In tailing, adenylate residues (about 200–300) are added at 3′-end in a template independent manner.
- Now the *hn*RNA undergoes a process where the introns are removed and exons are joined to form *m*RNA by the process called **splicing**.

15. Genetic Code

- The relationship between the sequence of nucleotides on *m*RNA and sequence of amino acids in the polypeptide is called **genetic code**.
- **George Gamow** suggested that the code must be of 3 bases in order to code for 20 amino acids because there are only 4 bases (*i.e.*, 4^3 or $4 \times 4 \times 4 = 64$) which code for 20 amino acids. So, codon is a triplet.
- **Har Gobind Khorana** developed chemical method for synthesising RNA molecules with defined base combinations (homopolymers and copolymers) to develop the genetic code.
- **Marshall Nirenberg** developed cell-free system for protein synthesis and thus artificially synthesised proteins to understand the nature of codons.
- **Severo Ochoa** demonstrated that polynucleotide phosphorylase also helped in polymerising RNA with defined sequences in a template-independent manner (enzymatic RNA synthesis).

Table 6.3: The Codons for the Various Amino Acids

First position ↓ | Second position | Third position ↓

	U	C	A	G	
U	UUU Phe	UCU Ser	UAU Tyr	UGU Cys	U
	UUC Phe	UCC Ser	UAC Tyr	UGC Cys	C
	UUA Leu	UCA Ser	**UAA Stop**	**UGA Stop**	A
	UUG Leu	UCG Ser	**UAG Stop**	UGG Trp	G

C	CUU Leu CUC Leu CUA Leu CUG Leu	CCU Pro CCC Pro CCA Pro CCG Pro	CAU His CAC His CAA Gln CAG Gln	CGU Arg CGC Arg CGA Arg CGG Arg	U C A G
A	AUU Ile AUC Ile AUA Ile **AUG Met/ Start**	ACU Thr ACC Thr ACA Thr ACG Thr	AAU Asn AAC Asn AAA Lys AAG Lys	AGU Ser AGC Ser AGA Arg AGG Arg	U C A G
G	GUU Val GUC Val GUA Val GUG Val	GCU Ala GCC Ala GCA Ala GCG Ala	GAU Asp GAC Asp GAA Glu GAG Glu	GGU Gly GGC Gly GGA Gly GGG Gly	U C A G

Salient features of genetic code

(*i*) The codons are triplet. Out of 64 codons, 61 code for 20 amino acids and 3 codons (UAA, UGA, UAG) do not code for any amino acid hence, function as **stop** or **terminating codons**.

(*ii*) One codon codes for only one particular amino acid, hence the code is **unambiguous** and **specific**.

(*iii*) Some amino acids are coded by more than one codon, hence the code is **degenerate**.

(*iv*) The codon is read on *m*RNA in a contiguous fashion, *i.e.*, without punctuations and thus the code is **commaless**.

(*v*) The genetic code is nearly **universal**, *i.e.*, a particular codon codes for the same amino acid in all organisms from bacteria to human except in mitochondria and few protozoans.

(*vi*) AUG is a dual function codon, it codes for methionine (met) and it also acts as initiator codon.

16. *t*RNA—the Adapter Molecule

- **Francis Crick** proposed the presence of an adapter molecule which could read the code on one end and on the other end would bind to the specific amino acids.
- However, *t*RNA was known before the genetic code was postulated and was then called *s*RNA (soluble RNA). Its role as an adapter molecule was reported later.

Structure

- The secondary structure of *t*RNA is clover-leaf like but the three-dimensional tertiary structure depicts it as a compact inverted L-shaped molecule.
- *t*RNA has five arms or loops:
  - (*i*) **Anticodon loop,** which has bases complementary to the code.
  - (*ii*) **Amino acid acceptor end** to which amino acids bind.
  - (*iii*) **T loop,** which helps in binding to ribosome.
  - (*iv*) **D loop,** which helps in binding aminoacyl synthetase.
  - (*v*) **Variable arm**.

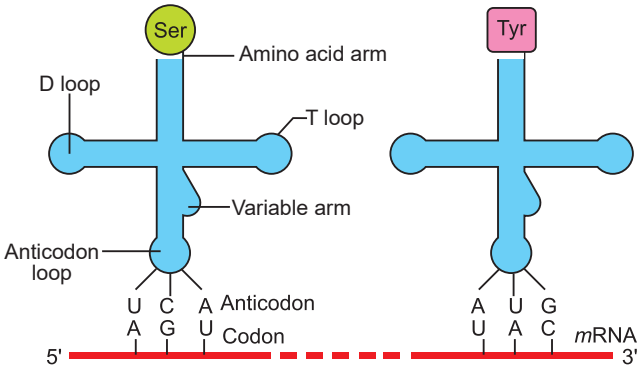


Fig. 6.13 tRNA—the adapter molecule

- Each *t*RNA is specific for a particular amino acid.
- A specific *t*RNA for initiation is called initiator *t*RNA.
- There is no *t*RNA for stop codons.

17. Translation

- Translation is the process of synthesis of protein from amino acids, sequence and order of amino acids being defined by sequence of bases in *m*RNA. Amino acids are joined by peptide bonds.
- A translational unit in *m*RNA from 5' → 3' comprises of a start codon, region coding for a polypeptide, a stop codon and untranslated regions (UTRs). UTRs are additional sequences of *m*RNA that are not translated. They are present at both 5' end (before start codon) and at 3' end (after stop codon) for efficient translation process.

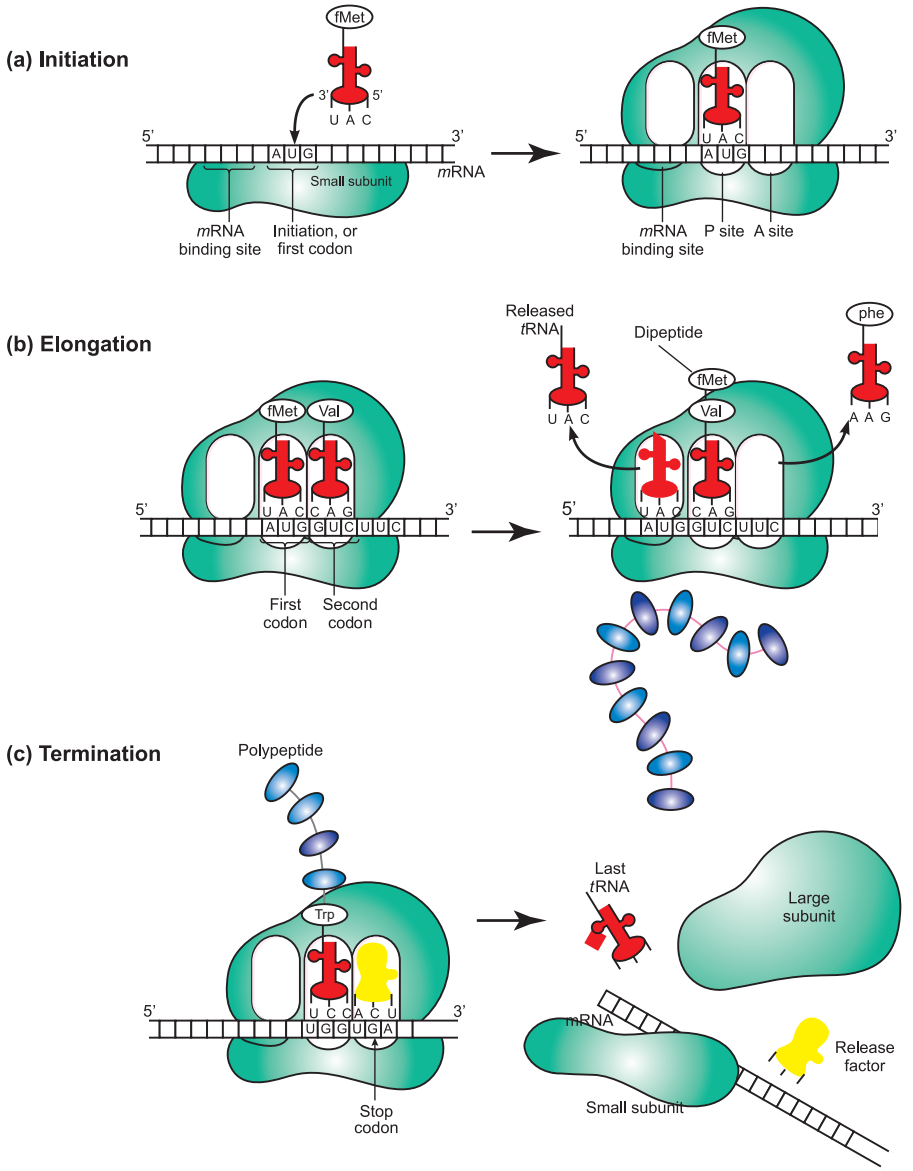


Fig. 6.14 Process of translation

(i) Initiation

- In prokaryotes, initiation requires the large and small ribosome subunits, the *m*RNA, initiation *t*RNA and three initiation factors (IFs).
- **Activation of amino acid:** Amino acids become activated by binding with aminoacyl *t*RNA synthetase enzyme in the presence of ATP.

$$\text{Amino acid (AA)} + \text{ATP} \xrightarrow[\text{synthetases}]{\text{Aminoacyl } t\text{RNA}} \text{AA–AMP–Enzyme complex} + P_i$$

- **Transfer of amino acid to *t*RNA:** The AA–AMP–Enzyme complex formed reacts with specific *t*RNA to form aminoacyl-*t*RNA complex.

$$\text{AA–AMP–Enzyme complex} + t\text{RNA} \longrightarrow \text{AA–}t\text{RNA} + \text{AMP} + \text{Enzyme.}$$

- The cap region of *m*RNA binds to the smaller subunit of ribosome.
- The ribosome has two sites, A-site and P-site.
- The smaller subunit first binds to the initiator *m*RNA and then binds to the larger subunit so that initiation codon (AUG) lies on the P-site.
- The initiation *t*RNA, *i.e.*, methionyl *t*RNA then binds to the P-site.

(ii) Elongation of polypeptide chain

- Another charged aminoacyl *t*RNA complex binds to the A-site of the ribosome at the second codon.
- A peptide bond is formed between carboxyl group (—COOH) of amino acid at P-site and amino group (—NH) of amino acid at A-site by the enzyme **peptidyl transferase**.
- The ribosome slides over *m*RNA from codon to codon in the 5′→3′ direction *i.e.* called **translocation**.
- According to the sequence of codons, amino acids are attached to one another by peptide bonds and a polypeptide chain is formed.

(iii) Termination of polypeptide

- When the A-site of ribosome reaches a termination codon, which does not code for any amino acid, no charged *t*RNA binds to the A-site.
- Dissociation of polypeptide from ribosome takes place, which is catalysed by a **'release factor'**.
- There are three **termination codons** namely UGA, UAG and UAA.

18. Regulation of Gene Expression

- **Regulation of gene expression** means controlling the amount and time of formation of gene products according to the requirements of the cell.
- In eukaryotes, gene regulation can take place at four levels:
  - (*i*) Transcription level (regulation of primary transcript formation),
  - (*ii*) Processing level (regulation of splicing),
  - (*iii*) Transport of *m*RNA from nucleus to the cytoplasm,
  - (*iv*) Translation level.
- In prokaryotes, control of rate of transcriptional initiation is the predominant site for control of gene expression. It can be seen in *lac* operon and *trp* operon.

19. The *lac* Operon

- **Operon:** The concept of operon was first proposed in 1961, by **Jacob and Monod**. An operon is a unit of prokaryotic gene expression which includes coordinately regulated (structural) genes and control elements which are recognised by regulatory gene product.
- **Components of an operon:**
  - **(*i*) Structural gene:** The fragment of DNA which transcribe *m*RNA for polypeptide synthesis.
  - **(*ii*) Promoter:** The sequence of DNA where RNA polymerase binds and initiates transcription of structural genes is called promoter.
  - **(*iii*) Operator:** The sequence of DNA adjacent to promoter where specific repressor protein binds is called operator.
  - **(*iv*) Regulator gene:** The gene that codes for the repressor protein that binds to the operator and suppresses its activity as a result of which transcription will be switched off.
  - **(*v*) Inducer:** The substrate that prevents the repressor from binding to the operator, is called an inducer. As a result transcription is switched on. It is a chemical of diverse nature like metabolite, hormone substrate, etc.
- **The lactose operon:** The *lac z*, *lac y*, *lac a* genes are transcribed from a *lac* transcription unit under the control of a single promoter. They encode enzyme required for the use of lactose as a carbon source. The *lac i* gene product, the *lac* repressor, is expressed from a separate transcription unit upstream from the operator.
- Regulation of lac operon by repressor is referred to as negative regulation.
- *lac* operon consists of **three structural genes** (*z*, *y*, *a*), operator (*o*), promoter (*p*) and a separate regulatory gene (*i*). Lactose is the inducer in *lac* operon.
- The three structural genes (*z*, *y*, *a*) transcribe a polycistronic *m*RNA.

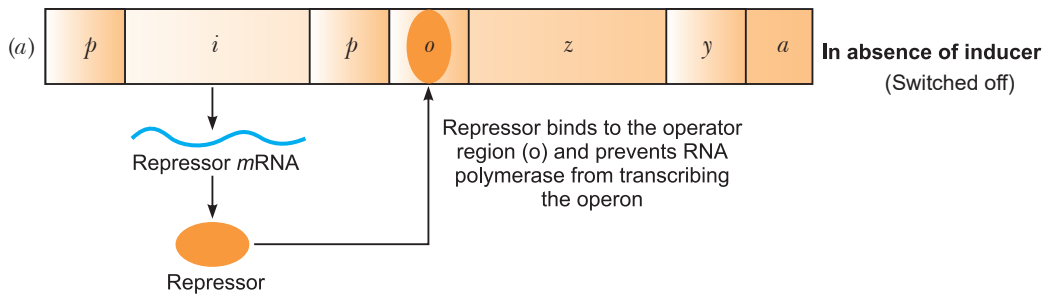


Fig. 6.15 (*a*) The *lac* operon in absence of inducer

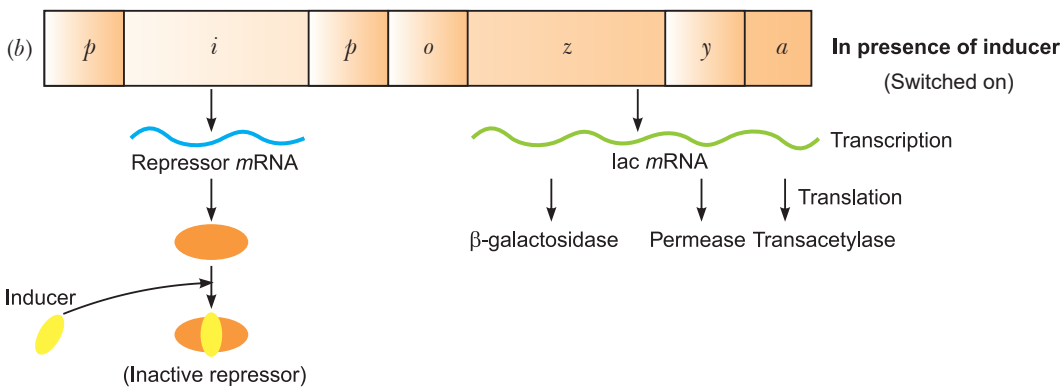


Fig. 6.15 (*b*) The *lac* operon in presence of inducer

- Gene *z* codes for β-galactosidase (β-gal) enzyme which breaks lactose into galactose and glucose.
- Gene *y* codes for permease, which increases the permeability of the cell to lactose (β-galactosides).
- Gene *a* codes for enzyme transacetylase, which catalyses the transacetylation of lactose in its active form.
- **When Lactose is Absent**
  - (*i*) When lactose is absent, *i* gene regulates and produces repressor *m*RNA which translates into repressor protein.
  - (*ii*) The repressor protein binds to the operator region of the operon and as a result prevents RNA polymerase to bind to the operon.
  - (*iii*) The operon is switched off.
- **When Lactose is Present**
  - (*i*) Lactose acts as an inducer which binds to the repressor and forms an inactive repressor.
  - (*ii*) The repressor fails to bind to the operator region.
  - (*iii*) The RNA polymerase binds to the operator and transcribes *lac m*RNA.
  - (*iv*) *lac m*RNA is polycistronic, *i.e.*, produces all three enzymes, β-galactosidase, permease and transacetylase.
  - (*v*) The *lac* operon is switched on.

20. Human Genome Project (HGP)

- Genetic make-up of an organism lies in DNA sequences. If two individuals differ, then their DNA sequences will also vary, at least at some places if not all.
- The human genome project was a 13-year project by the U.S. Department of Energy and the National Institute of Health to gain "complete knowledge of the organization, structure and function of the human genome". It was launched in 1990 and completed in 2003.

Goals of HGP

(*i*) To identify the 20,000–25,000 genes in human DNA and develop a genetic linkage map by identifying the genetic markers.

(*ii*) To determine all the 3 billion chemical base pair sequences that make up human DNA.

(*iii*) To store the data and develop technology for its management.

(*iv*) To obtain a physical map of human genome by cloning genomic DNA using YACs and cosmids.

(*v*) To transfer the technologies to other sectors such as industries.

(*vi*) To address the ethical, legal and social issues (ELSI) that may arise from the project.

- Bacteria, yeast, *Caenorhabditis elegans* (free living non-pathogenic nematode), *Drosophila* (fruit fly), plants (rice and *Arabidopsis*), etc. have also been sequenced as of today.

Advantages of HGP

(*i*) The effect of DNA variation can be studied among individuals which can lead to revolutionary new ways to diagnose and treat many disorders or diseases.

(*ii*) Provides clues to understand human biology.

(*iii*) More information can be obtained about non-human organisms like bacteria, yeast, nematode, fruit fly, plant, rice, etc.

Methodologies of HGP

- The methods involve two major approaches:
  - **(*i*) Expressed sequence tags (ESTs):** This method focusses on identifying all the genes that are expressed as RNA.
  - **(*ii*) Sequence annotation:** It is an approach of simply sequencing the whole set of genome that contains all the coding and non-coding sequences, and later assigning different regions in the sequence with functions.
- For sequencing, the total DNA from cell is first isolated and broken down in relatively small sizes as fragments.
- These DNA fragments are cloned in suitable host using suitable vectors. When bacteria is used as vector, they are called **bacterial artificial chromosomes** (BAC) and when yeast is used as vector, they are called **yeast artificial chromosomes** (YAC).
- Frederick Sanger developed a principle according to which the fragments of DNA are sequenced by automated DNA sequences.
- On the basis of overlapping regions on DNA fragments, these sequences are arranged accordingly.
- For alignment of these sequences, specialised computer-based programmes were developed.
- These sequences were annotated and were assigned to each chromosome. Sequence of chromosome 1 was completed only in May 2006. It was the last chromosome be sequenced).
- Finally, the genetic and physical maps of the genome were constructed by collecting information about certain repetitive DNA sequences and DNA polymorphism, based on endonuclease recognition sites.

21. Salient Features of Human Genome

(*i*) The human genome contains 3164.7 million nucleotide bases.

(*ii*) The average gene consists of 3000 bases; the largest known human gene being dystrophin at 2.4 million bases.

(*iii*) The total number of genes is estimated to be 30,000 and 99.9 per cent nucleotide bases are exactly the same in all people.

(*iv*) The functions are unknown for over 50 per cent of the discovered genes.

(*v*) Less than 2 per cent of the genome codes for proteins.

(*vi*) The human genome contains large repeated sequences, repeated 100 to 1000 times.

(*vii*) The repeated sequence is thought to have no direct coding functions but they throw light on chromosome structures, dynamics and evolution.

(*viii*) Chromosome 1 has most genes (2968) and the Y has the fewest genes (231).

(*ix*) Scientists have identified about 1.4 million locations where single base DNA sequence differences called **SNPs** or **single nucleotide polymorphism** (pronounced as 'snips') occur in humans. This information promises to revolutionise the processes of finding chromosomal locations for disease—associated sequences and tracing human history.

Rice Genome Project

- The International Rice Genome Sequencing Project (IRGSP) began in September 1997, at a workshop held in conjunction with the International Symposium on Plant Molecular Biology in Singapore.
- Rice genome sequencing is being conducted along the same lines as numerous other large-scale

genome sequencing projects. Large insert genomic libraries, used as the primary sequencing templates, are constructed in bacterial artificial chromosomes (BACs).

- One of the initial motivators for sequencing rice, besides the relatively small genome size, was that it could be used as a model for other cereal crops with larger genomes, such as maize and wheat. This was predicated somewhat on rice's small genome size and the realization from molecular mapping, ***e.g.***, RFLPs, of conserved markers and marker order.
- The availability of the rice genome, together with the community annotation and other resources that added functionality, transformed genetics research and rice breeding.

22. DNA Fingerprinting

- **Dr. Alec Jeffreys** developed the technique of DNA fingerprinting in an attempt to identify DNA marker for inherited diseases.
- Human genome has 3×10^9 bp. 99.9% of base sequences among humans are the same, which makes every individual unique in phenotype.
  - **Polymorphism:** The genome consists of small stretches of DNA which are repeated many times. These are called repetitive DNA and comprise of satellite DNA. Satellite DNA does not code for any proteins but form large portion of human genome. These sequences show high degree of polymorphism. As polymorphisms are inheritable from parents to children, DNA fingerprinting is the basis of paternity testing. Polymorphism arises due to mutations. New mutations may arise in somatic cells or in germ cells. If mutation occurs in germ cells; it is passed on to offsprings. If an inheritable mutation is observed in a population at high frequency, it is called as DNA polymorphism. Polymorphism ranges from single nucleotide change to very large scale changes.
- DNA fingerprinting uses short nucleotide repeats called **Variable Number Tandem Repeats** (VNTRs) as markers. VNTRs vary from person to person and are inherited from one generation to the next. Only closely related individuals have similar VNTRs. Satellite DNA that shows very high degree of polymorphism are called **Variable Number of Tandem Repeats** (VNTR) VNTRs are used in DNA fingerprinting as probes. Number of repeat shows very high degree of polymorphism. Thus, size of VNTR varies from 0.1 to 20 kb.

Methodology and Technique

(*i*) DNA is isolated and extracted from the cell or tissue by centrifugation.

(*ii*) By the process of polymerase chain reaction (PCR), many copies are produced. This step is called **amplification**.

(*iii*) DNA is cut into small fragments by treating with **restriction endonucleases**.

(*iv*) DNA fragments are separated by agarose gel electrophoresis.

(*v*) The separated DNA fragments are visualised under ultraviolet radiation after applying suitable dye.

(*vi*) The DNA is transferred from electrophoresis plate to nitrocellulose or nylon membrane sheet. This is called **Southern blotting**.

(*vii*) VNTR probes are now added which bind to specific nucleotide sequences that are complementary to them. This is called **hybridisation**.

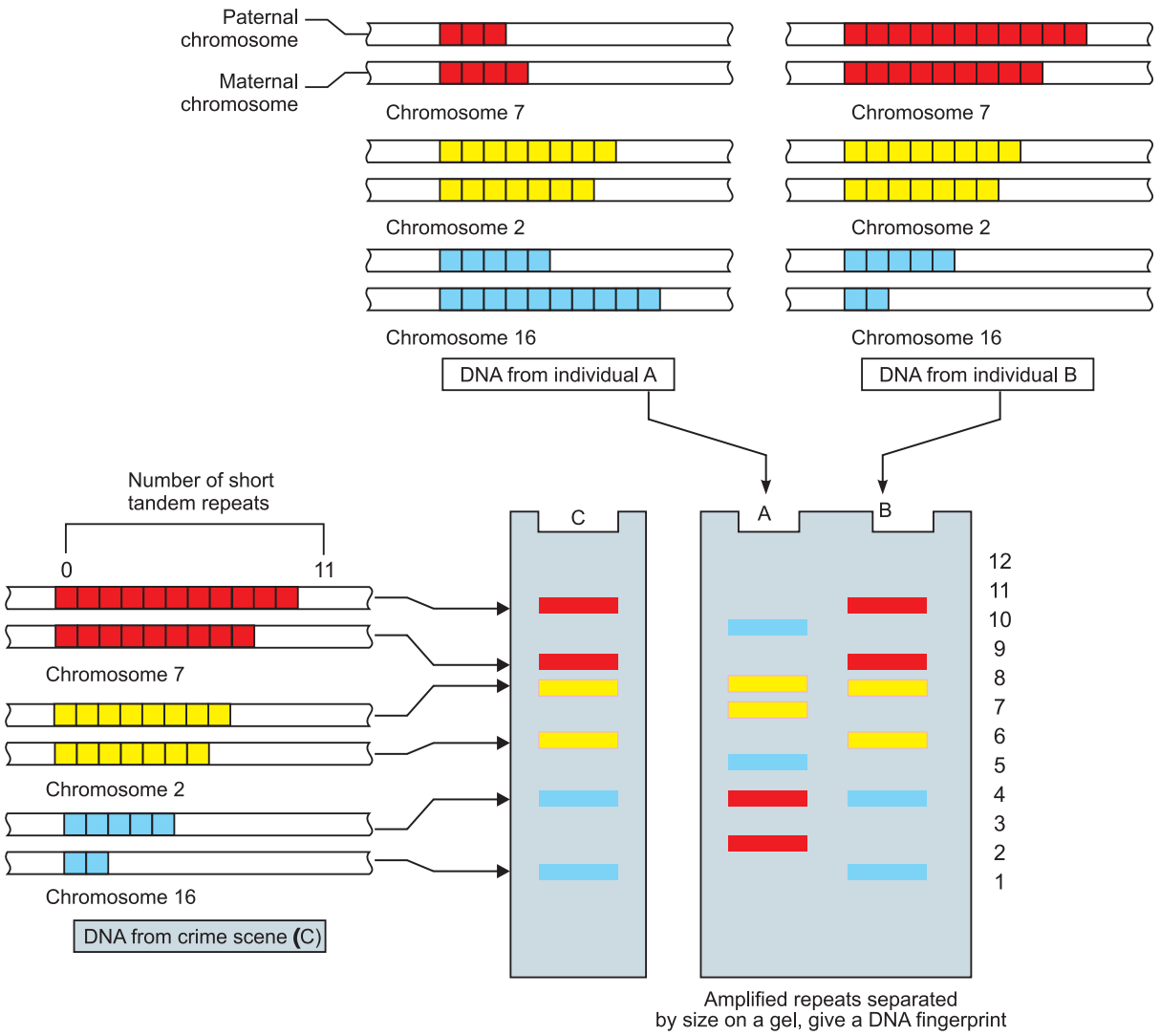


Fig. 6.16 Schematic representation of DNA fingerprinting: Few chromosomes have been shown to contain different copy number of VNTR. The two alleles (paternal and maternal) of a chromosome also contain different copy numbers of VNTR. It is clear that the banding pattern of DNA from crime scene matches with individual B and not with A.

(*viii*) The hybridised DNA fragments are detected by autoradiography. They are observed as dark bands on X-ray film.

(*ix*) These bands being of different sizes, give a characteristic pattern for an individual DNA. It differs from individual to individual except in case of monozygotic (identical) twins.

Applications of DNA Fingerprinting

(*i*) It is used as a tool in forensic tests to identify criminals and criminal investigations.

(*ii*) It is used to settle paternity disputes and maternity disputes.

(*iii*) It is used to determine population and genetic diversities to study evolution.

(*iv*) It is used in the study of evolutionary biology.

NCERT Textbook Questions

Q. 1. Group the following as nitrogenous bases and nucleosides:
Adenine, Cytidine, Thymine, Guanosine, Uracil and Cytosine.

Ans. Nitrogenous bases—Adenine, Thymine, Uracil and Cytosine.
Nucleosides—Cytidine and Guanosine.

Q. 2. If a double stranded DNA has 20 per cent of cytosine, calculate the per cent of adenine in the DNA.

Ans. Cytosine = 20%, therefore Guanine = 20%
According to Chargaff's rule,

$$A + T = 100 - (G + C)$$

$$A + T = 100 - 40.$$ Since both adenine and thymine are in equal amounts,

$$\therefore \quad \text{Thymine} = \text{Adenine} = \frac{60}{2} = 30\%$$

Q. 3. If the sequence of one strand of DNA is written as follows:
5′—ATGCATGCATGCATGCATGCATGCATGC—3′
Write down the sequence of complementary strand in 5′→3′ direction.

Ans. In 3′→5′ direction, 3′—TACGTACGTACGTACGTACGTACGTACG—5′
In 5′→3′ direction, 5′—GCATGCATGCATGCATGCATGCATGCAT—3′

Q. 4. If the sequence of the coding strand in a transcription unit is written as follows:
5′—ATGCATGCATGCATGCATGCATGCATG—3′
Write down the sequence of *m*RNA.

Ans. 5′—AUGCAUGCAUGCAUGCAUGCAUGCAUG—3′

Q. 5. Which property of DNA double helix led Watson and Crick to hypothesise semi-conservative mode of DNA replication? Explain.

Ans. The two strands of DNA show complementary base pairing. This property of DNA led Watson and Crick to suggest semi-conservative mechanism of DNA replication in which one strand of parent is conserved while the other complementary strand formed is new.

Q. 6. Depending upon the chemical nature of the template (DNA or RNA) and the nature of nucleic acids synthesised from it (DNA or RNA), list the types of nucleic acid polymerases.

Ans. **DNA template**
(*i*) DNA polymerase for DNA replication.
(*ii*) RNA polymerase for RNA synthesis or transcription.

RNA template
(*i*) RNA-dependent RNA polymerase for synthesis of RNA in some RNA viruses.
(*ii*) Reverse transcriptase to synthesise *c*DNA (complementary DNA) over RNA template.

Q. 7. How did Hershey and Chase differentiate between DNA and protein in their experiment while proving that DNA is the genetic material?

Ans. Refer to Basic Concepts Point 7.

Q. 8. Differentiate between the following:
(*a*) Repetitive DNA and satellite DNA
(*b*) *m*RNA and *t*RNA
(*c*) Template strand and coding strand

Ans. **(*a*)**

Table 6.4: Differences between repetitive DNA and satellite DNA

S. No.	Repetitive DNA	Satellite DNA
(*i*)	DNA in which certain base sequences are repeated many times are called repetitive DNA.	DNA in which large portion of the gene is tandemly repeated is called satellite DNA.
(*ii*)	Repetitive DNA sequences are transcribed.	Satellite DNA sequences are not transcribed.

(*b*)

Table 6.5: Differences between *m*RNA and *t*RNA

S. No.	*m*RNA	*t*RNA
(*i*)	It is linear.	It is clover-leaf shaped.
(*ii*)	It carries coded information.	It carries information for association with an amino acid and an anticodon for its incorporation in a polypeptide.
(*iii*)	*m*RNA undergoes additional processing, *i.e.*, capping and tailing, splicing.	It does not require any processing
(*iv*)	Nitrogen bases are unmodified.	Nitrogen bases may be modified.

(*c*)

Table 6.6: Differences between template strand and coding strand

S. No.	Template strand	Coding strand
(*i*)	It is the strand of DNA which takes part in transcription.	It is the strand that does not take part in transcription.
(*ii*)	The polarity is 3′→5′.	The polarity is 5′→3′.
(*iii*)	Nucleotide sequence is complementary to the one present in *m*RNA.	The nucleotide sequence is same as the one present in *m*RNA except for presence of thymine instead of uracil.

Q. 9. List two essential roles of ribosome during translation.

Ans. Two essential roles of ribosome during translation are:

(*i*) One of the *r*RNA (23S in prokaryotes) acts as a peptidyl transferase ribozyme for formation of peptide bonds.

(*ii*) Ribosome provides sites for attachment of *m*RNA and charged *t*RNAs for polypeptide synthesis.

Q. 10. In the medium where *E. coli* was growing, lactose was added, which induced the *lac* operon. Then, why does *lac* operon shut down some time after addition of lactose in the medium?

Ans. As *lac* operon is an inducible operon therefore, it shuts down due to decrease in lactose substrate concentration.

Q. 11. Explain (in one or two lines) the function of the following:

(*a*) Promoter (*b*) *t*RNA (*c*) Exons

Ans. **(*a*) Promoter:** It is the segment of DNA which lies adjacent to the operator and functions as the binding site for RNA polymerase to carry transcription if allowed by operator.

(*b*) *t*RNA: It acts as an adaptor molecule that picks up a particular amino acid from cellular pool and takes the same over to A site of *m*RNA for incorporation into polypeptide chain.

(*c*) Exons: These are the coding segments present in primary transcript which after splicing are joined to form functional *m*RNA.

Q. 12. Why is the Human Genome Project called a mega project?

Ans. Human Genome Project is called a mega project because of following reasons:

(*i*) Sequencing of more than 3×10^9 bp.

(*ii*) Identification of all the genes present in human genome.

(*iii*) High expenditure of more than 9 billion dollars.

(*iv*) Identification of all the alleles of genes and their functions.

(*v*) Storage of data for sequencing would require space equal to 3300 books of 1000 pages each if each page contains 1000 letters.

Q. 13. What is DNA fingerprinting? Mention its application.

Ans. DNA fingerprinting is the technique to determine the relationship between two DNA samples by studying the similarity and dissimilarity of VNTRs (variable number of tandem repeats). Its applications are:

(*i*) It is used as a tool in forensic tests to identify criminals.

(*ii*) To settle paternity disputes.

(*iii*) To identify racial groups to study biological evolution.

Q. 14. Briefly describe the following:

(*a*) Transcription **(*b*) Polymorphism**

(*c*) Translation **(*d*) Bioinformatics**

Ans. **(*a*) Transcription:** It is the formation of RNA over the template of DNA. It forms single-stranded RNA which has a coded information similar to the sense or coding strand of DNA with the exception that thymine is replaced by uracil. One strand of DNA is used as template strand for the synthesis of a complementary strand of RNA called *m*RNA.

(*b*) Polymorphism: Genetic polymorphism means occurrence of genetic material in more than one form. It is of three major types, *i.e.*, allelic, SNP and RFLP.

Allelic polymorphism: Allelic polymorphism occurs due to multiple alleles of a gene. Allele possess different mutations which alter the structure and function of a protein formed by them as a result, change in phenotype may occur.

SNP or single nucleotide polymorphism: Over 1.4 million single base DNA differences have been observed in human beings. According to SNP, every human being is unique. SNP is very useful for locating alleles, identifying disease-associated sequence and tracing human history.

(*c*) Translation: It is the process during which the genetic information which is stored in the sequence of nucleotides in an *m*RNA molecule is converted, following dictations of the genetic code, into the sequence of amino acids in the polypeptide. It takes place in cytoplasm in both eukaryotes and prokaryotes.

(*d*) Bioinformatics: The science which deals with handling, storing of huge information of genomics as databases, analysing, modelling and providing various aspects of biological information, especially the molecules connected with genomics and proteomics is called bioinformatics.

Following are some applications of bioinformatics:

(*i*) Phylogeny or evolutionary biology: By comparing gene, nucleotide, protein and amino acid sequence, the organisms are grouped and phylogeny is established.

(*ii*) Chemoinformatics: Information about chemical combination, their effects, side effects, pharmaceutical chemicals, etc., by databases is done.

(*iii*) Faster drug research: Analysis of drug–ligand complexes and assessment of binding interaction help in development of computer-aided drug design.

(*iv*) Proteomics: Protein sequence databases are useful in diagnostics, healthcare and drug research.

Multiple Choice Questions [1mark]

Choose and write the correct option in the following questions.

1. **Amino acid sequence, in protein synthesis is decided by the sequence of**
   (*a*) *r*RNA (*b*) *t*RNA
   (*c*) *m*RNA (*d*) *c*DNA

2. **Antiparallel strands of a DNA molecule means that**
   (*a*) one strand turns clockwise
   (*b*) one strand turns anti-clockwise
   (*c*) the phosphate groups of two DNA strands, at their ends, share the same position
   (*d*) the phosphate groups at the start of two DNA strands are in opposite position (pole).

3. **Polysome is formed by**
   (*a*) a ribosome with several subunits
   (*b*) ribosomes attached to each other in a linear arrangement
   (*c*) several ribosomes attached to a single *m*RNA
   (*d*) many ribosomes attached to a strand of endoplasmic reticulum.

4. **In the DNA molecule**
   (*a*) the proportion of adenine in relation to thymine varies with the organism
   (*b*) there are two strands which run antiparallel—one in $5' \rightarrow 3'$ direction and other in $3' \rightarrow 5'$
   (*c*) the total amount of purine nucleotides and pyrimidine nucleotides is not always equal
   (*d*) there are two strands which run parallel in the $5' \rightarrow 3'$ direction.

5. **What is not true for genetic code?**
   (*a*) It is nearly universal.
   (*b*) It is degenerate.
   (*c*) It is unambiguous
   (*d*) A codon in *m*RNAt is read in a non-contiguous fashion.

6. **Removal of introns and joining the exons in a defined order in a transcription unit is called**
   (*a*) tailing (*b*) transformation
   (*c*) capping (*d*) splicing

7. **The net electric charge on DNA and histones is** *[NCERT Exemplar]*
   (*a*) both positive (*b*) both negative
   (*c*) negative and positive, respectively (*d*) zero

8. **Gene controls**
   (*a*) protein synthesis but not heredity
   (*b*) protein synthesis and heredity
   (*c*) heredity but not protein synthesis
   (*d*) biochemical reaction of some enzymes

9. **The promoter site and the terminator site for transcription are located at** *[NCERT Exemplar]*
   (*a*) 3' (downstream) end and 5' (upstream) end, respectively of the transcription unit
   (*b*) 5' (upstream) end and 3' (downstream) end, respectively of the transcription unit
   (*c*) the 5' (upstream) end
   (*d*) the 3' (downstream) end

10. **Which of the following statements is the most appropriate for sickle cell anaemia?** *[NCERT Exemplar]*
    (*a*) It cannot be treated with iron supplements (*b*) It is a molecular disease
    (*c*) It confers resistance to acquiring malaria (*d*) All of the above

11. With regard to mature *m*RNA in eukaryotes [*NCERT Exemplar*]

(*a*) exons and introns do not appear in the mature RNA

(*b*) exons appear but introns do not appear in the mature RNA

(*c*) introns appear but exons do not appear in the mature RNA

(*d*) both exons and introns appear in the mature RNA

12. The human chromosome with the highest and least number of genes in them are respectively [*NCERT Exemplar*]

(*a*) Chromosome 21 and Y (*b*) Chromosome 1 and X

(*c*) Chromosome 1 and Y (*d*) Chromosome X and Y

13. Who amongst the following scientists had no contribution in the development of the double helix model for the structure of DNA? [*NCERT Exemplar*]

(*a*) Rosalind Franklin (*b*) Maurice Wilkins

(*c*) Erwin Chargaff (*d*) Meselson and Stahl

14. DNA is a polymer of nucleotides which are linked to each other by 3′→ 5′ phosphodiester bond. To prevent polymerisation of nucleotides, which of the following modifications would you choose? [*NCERT Exemplar*]

(*a*) Replace purine with pyrimidines

(*b*) Remove/replace 3' OH group in deoxyribose

(*c*) Remove/replace 2' OH group with some other group in deoxyribose

(*d*) Both '*b*' and '*c*'

15. Discontinuous synthesis of DNA occurs in one strand, because [*NCERT Exemplar*]

(*a*) DNA molecule being synthesised is very long

(*b*) DNA dependent DNA polymerase catalyses polymerisation only in one direction (5′ → 3′)

(*c*) it is a more efficient process

(*d*) DNA ligase joins the short stretches of DNA

16. Which of the following steps in transcription is catalysed by RNA polymerase? [*NCERT Exemplar*]

(*a*) Initiation (*b*) Elongation

(*c*) Termination (*d*) All of the above

17. Control of gene expression in prokaryotes take place at the level of [*NCERT Exemplar*]

(*a*) DNA-replication (*b*) Transcription

(*c*) Translation (*d*) None of the above

18. Which of the following statements is correct about the role of regulatory proteins in transcription in prokaryotes? [*NCERT Exemplar*]

(*a*) They only increase expression

(*b*) They only decrease expression

(*c*) They interact with RNA polymerase but do not affect the expression

(*d*) They can act both as activators and as repressors

19. Which was the last human chromosome to be completely sequenced? [*NCERT Exemplar*]

(*a*) Chromosome 1 (*b*) Chromosome 11

(*c*) Chromosome 21 (*d*) Chromosome X

20. Which of the following are the functions of RNA? [*NCERT Exemplar*]

(*a*) It is a carrier of genetic information from DNA to ribosomes synthesising polypeptides.

(*b*) It carries amino acids to ribosomes.

(*c*) It is a constituent component of ribosomes.

(*d*) All of the above.

21. While analysing the DNA of an organism a total number of 5386 nucleotides were found, out of which the proportion of different bases were: Adenine = 29%, Guanine = 17%, Cytosine = 32%, Thymine = 17%.
Considering the Chargaff's rule it can be concluded that *[NCERT Exemplar]*

(*a*) it is a double stranded circular DNA (*b*) it is single stranded DNA

(*c*) it is a double stranded linear DNA (*d*) no conclusion can be drawn

22. In some viruses, DNA is synthesised by using RNA as template. Such a DNA is called *[NCERT Exemplar]*

(*a*) A-DNA (*b*) B-DNA (*c*) *c*DNA (*d*) *r*DNA

23. If Meselson and Stahl's experiment is continued for four generations in bacteria, the ratio of N^{15}/N^{15}: N^{15}/N^{14}: N^{14}/N^{14} containing DNA in the fourth generation would be *[NCERT Exemplar]*

(*a*) 1:1:0 (*b*) 1:4:0 (*c*) 0:1:3 (*d*) 0:1:7

24. If the sequence of nitrogen bases of the coding strand of DNA in a transcription unit is: 5' - A T G A A T G - 3', the sequence of bases in its RNA transcript would be *[NCERT Exemplar]*

(*a*) 5' - A U G A A U G - 3' (*b*) 5' - U A C U U A C - 3'

(*c*) 5' - C A U U C A U - 3' (*d*) 5' - G U A A G U A - 3'

25. In *E.coli*, the *lac* operon gets switched on when *[NCERT Exemplar]*

(*a*) lactose is present and it binds to the repressor

(*b*) repressor binds to operator

(*c*) RNA polymerase binds to the operator

(*d*) lactose is present and it binds to RNA polymerase

Answers

1. (*c*)	**2.** (*d*)	**3.** (*c*)	**4.** (*b*)	**5.** (*d*)	**6.** (*d*)	**7.** (*c*)	**8.** (*b*)	**9.** (*b*)	**10.** (*d*)
11. (*d*)	**12.** (*c*)	**13.** (*d*)	**14.** (*d*)	**15.** (*b*)	**16.** (*b*)	**17.** (*b*)	**18.** (*d*)	**19.** (*a*)	**20.** (*d*)
21. (*b*)	**22.** (*c*)	**23.** (*d*)	**24.** (*a*)	**25.** (*a*)					

Assertion-Reason Questions

In the following questions a statement of assertion followed by a statement of reason is given. Choose the correct answer out of the following choices.

(a) Assertion and reason both are correct statements and reason is correct explanation for assertion.

(b) Assertion and reason both are correct statements but reason is not correct explanation for assertion.

(c) Assertion is correct statement but reason is wrong statement.

(d) Assertion is wrong statement but reason is correct statement.

1. Assertion : The *t*RNA molecules possess anticodons.
Reason : It needs the message in form of codons.

2. Assertion : Histones are basic proteins of major importance in packaging of eukaryotic DNA, DNA and histones comprise chromatin forming the bulk of eukaryotic chromosome.
Reason : Histones are of five major types: H_1, H_2A, H_2B, H_3 and H_4.

3. **Assertion :** *m*RNA attaches to ribosome through its 5' end.
   Reason : The *m*RNA has bases of lagging sequence.
4. **Assertion :** Replication and transcription occur in the nucleus but translation occurs in the cytoplasm.
   Reason : *m*RNA is transferred from the nucleus into the cytoplasm where ribosomes and amino acids are available for protein synthesis.
5. **Assertion :** In Griffith's experiment, the mixture of heat-killed virulent *R* bacteria and live non-virulent S bacteria, lead to the death of mice.
   Reason : The transforming principle got transferred from *S* strain to heat-killed *R* strain and made it virulent.
6. **Assertion :** DNA is considered to be a better genetic material than RNA for most organisms.
   Reason : 2'–OH group present in DNA makes it less reactive.
7. **Assertion :** DNA replication is semiconservative in nature.
   Reason : In each cycle of replication the complementary strands of parental double helix is conserved.
8. **Assertion :** *Lac* operon is a repressible operon.
   Reason : The product of repressor binds to the operator and prevents expression of the said gene.
9. **Assertion :** The human genome comprise of a large amount of repetitive sequences.
   Reason : The repetitive sequences in the genome do not have direct coding functions.
10. **Assertion :** Eukaryotic *m*RNA requires post-transcriptional modifications to form functional *m*RNA.
    Reason : Eukaryotic transcripts possess extra non-functional gene segments called introns.

Answers

1. (*b*) **2.** (*b*) **3.** (*c*) **4.** (*a*) **5.** (*d*) **6.** (*c*) **7.** (*a*) **8.** (*d*) **9.** (*b*) **10.** (*a*)

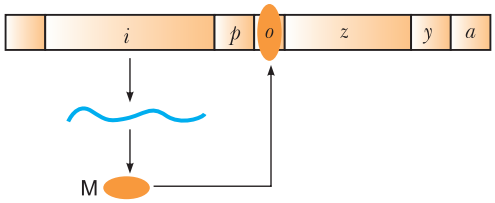
Case-based/Source-based Question

1. Study the schematic representation of the genes involved in the lac operon given below and answer the questions that follow:

p	*i*	*p*	*o*	*z*	*y*	*a*

(*i*) Sometimes cattle or even human beings give birth to their young ones that have extremely different sets of organs like limbs/position of eye(s), etc. Why?

(*ii*) What will prevent the binding of the molecule 'M' with the operator gene? Mention the event that follows.



(*iii*) A region of a coding DNA strand has the following nucleotide sequence:

– A T G C –

What shall be the nucleotide sequence in (*a*) sister DNA segment it replicates, and (*b*) *m*-RNA polynucleotide it transcribes?

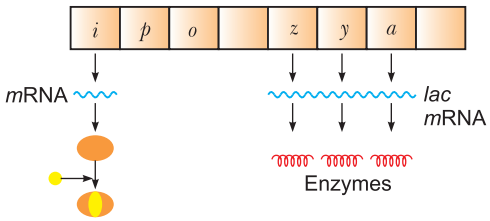
Ans. (*i*) This is due to a disturbance in coordinated regulation of expression of sets of genes associated with organ development or due to mutations.

(*ii*) An inducer prevents the binding of repressor to operator and starts transcription i.e., lactose here.

(*iii*) (*a*) – TACG –

(*b*) – UACG –

2. Study the figure given below and answer the questions:



(*i*) How does the repressor molecule get inactivated?

(*ii*) When does the transcription of *lac* *m*RNA stop?

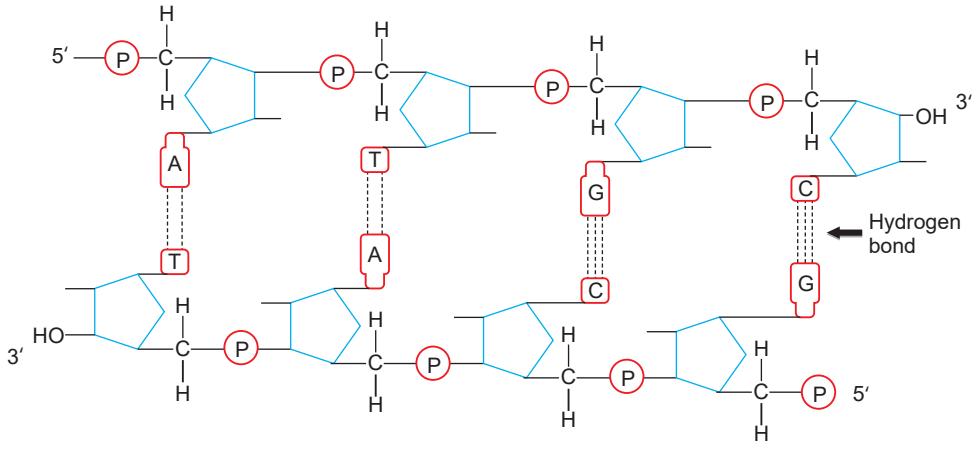
(*iii*) Name the enzyme transcribed by the gene 'z'.

Ans. (*i*) When the inducer comes in contact with repressor, it is inactivated.

(*ii*) When lactose is lacking or absent, the transcription of *lac* *m*RNA stops.

(*iii*) β-galactosidase.

3. Observe the diagram of the polynucleotide chain and answer the questions.



(*i*) The fact that a purine base always pairs through hydrogen bonds with a pyrimidine base in the DNA double helix leads to

(*a*) the antiparallel nature

(*b*) the semiconservative nature

(*c*) uniform width throughout DNA

(*d*) uniform length in all DNA

(*ii*) How does the flow of genetic information in HIV deviate from the 'Central dogma' proposed by Francis Crick?

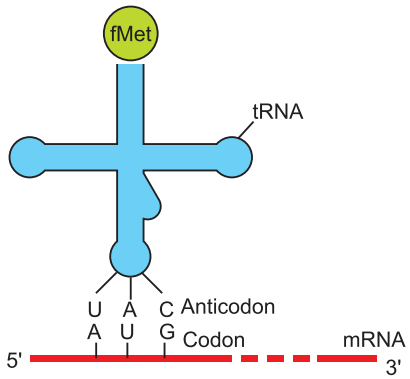
(*iii*) Write the role of histone protein in packaging of DNA in eukaryotes.

Ans. (*i*) (*c*) uniform width throughout DNA.

(*ii*) In HIV single stranded RNA is converted to double stranded DNA.

(*iii*) Histones are positively charged basic proteins. The negatively charged DNA is wrapped around the positively charged histone octamer to form nucleosome

3. Given below is the diagram of a tRNA molecule.



Answer the questions based on the above diagram:

(*i*) Why is charging of tRNA essential in translation?

(*ii*) Where does peptide bond formation occur in a bacterial ribosome?

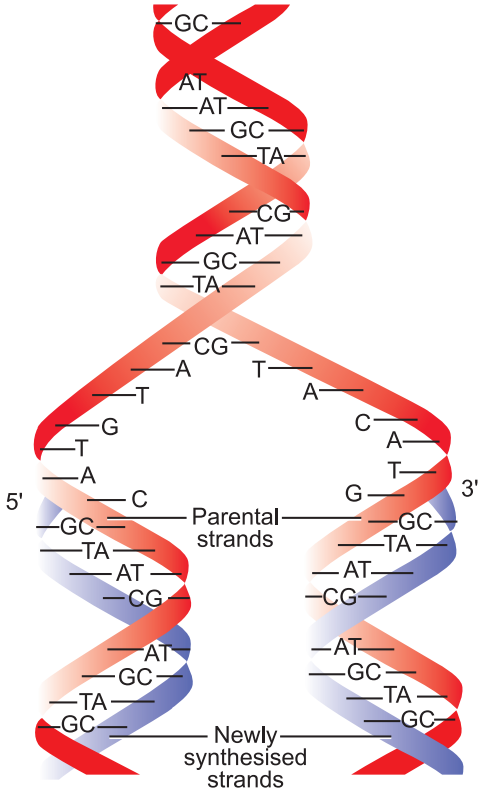
(*iii*) Name the scientist who called tRNA an adaptor molecule.

Ans. (*i*) Charging of *t*RNA is essential for ribosome to recognise it and convert the genetic code into protein.

(*ii*) Peptide bond formation takes place in the ribosome.

(*iii*) Francis Crick

4. Watson-Crick gave the semi-conservative mode of DNA replication.



Answer the questions based on the given diagram:

(*i*) In a nucleus, the number of RNA nucleoside triphosphates is 10 times more than the number of DNA nucleoside triphosphates, still only DNA nucleotides are added during the DNA replication, and not the RNA nucleotides. Why?

(*ii*) Name the enzyme and state its property that is responsible for continuous and discontinuous replication of the two strands of a DNA molecule.

(*iii*) Name the enzyme involved in the continuous replication of DNA strand. Mention the polarity of the template strand.

Ans. (*i*) DNA polymerase is highly specific to recognise only deoxyribonucleoside triphosphates. Therefore it cannot hold RNA nucleotides.

(*ii*) DNA dependent DNA polymerase. It catalyses polymerisation in 5′ → 3′ direction only.

(*iii*) DNA polymerase is involved in continuous replication of DNA strand. The polarity of template strand is 3′ → 5′.

Very Short Answer Questions [1 mark]

Q. 1. How many base pairs would a DNA segment of length 1.36 nm have? ***[CBSE (F) 2017]***

Ans. Distance between two base pairs = 0.34 nm or 0.34×10^{-6} nm

Number of base pairs in 1.36 nm DNA segment

$$= \frac{1}{0.34 \times 10^{-6}} \times 1.36$$

$$= \mathbf{4 \times 10^6\ bp}$$

Q. 2. In an experiment, DNA is treated with a compound which tends to place itself amongst the stacks of nitrogenous base pairs. As a result of which the distance between two consecutive base increases, from 0.34 nm to 0.44 nm. Calculate the length of DNA double helix (which has 2×10^9 bp) in the presence of saturating amount of this compound. ***[HOTS]***

Ans. $2 \times 10^9 \times 0.44$ nm.

Q. 3. Calculate the length of the DNA of bacteriophage lambda that has 48502 base pairs. ***[CBSE Sample Paper]*** ***[HOTS]***

Ans. Distance between two consecutive base pairs = 0.34×10^{-9} m

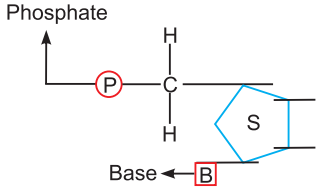
The length of DNA in bacteriophage lambda = $48502 \times 0.34 \times 10^{-9}$ m

$$= \mathbf{16.49 \times 10^{-6}\ m}$$

Q. 4. Why are proteins either positively or negatively charged? ***[HOTS]***

Ans. If the proteins are rich in basic amino acids, they are positively charged, and if the proteins are rich in acidic amino acids, they are negatively charged.

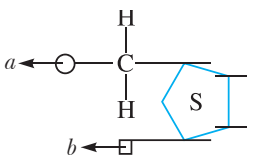
Q. 5. Mention the carbon positions to which the nitrogenous base and the phosphate molecule are respectively linked in the nucleotide given below: ***[HOTS]***



Ans. Nitrogenous base is linked to first carbon.

Phosphate is linked to fifth carbon.

Q. 6. What are *'a'* and *'b'* in the nucleotide with purine represented below?



Ans. *'a'* is phosphate group and *'b'* is purine (adenine/guanine).

Q. 7. Name the negatively charged and positively charged components of a nucleosome. *[CBSE Delhi 2015]* *[HOTS]*

Ans. In a nucleosome, the negatively charged component is DNA and positively charged component is histone octamer.

Q. 8. In a nucleus, the number of RNA nucleoside triphosphates is 10 times more than the number of DNA nucleoside triphosphates, still only DNA nucleotides are added during the DNA replication, and not the RNA nucleotides. Why? *[NCERT Exemplar]* *[HOTS]*

Ans. DNA polymerase is highly specific to recognise only deoxyribonucleoside triphosphates. Therefore it cannot hold RNA nucleotides.

Q. 9. Name the transcriptionally active region of chromatin in a nucleus. *[CBSE Delhi 2015]*

Ans. Euchromatin or exon.

Q. 10. Mention the two additional processing which *hn*RNA needs to undergo after splicing so as to become functional.

Ans. Capping and tailing.

Q. 11. When and at what end does the 'tailing' of *hn*RNA take place?

Ans. 'Tailing' of *hn*RNA takes place during conversion of *hn*RNA into functional *m*RNA after transcription. It takes place at the 3′-end.

Q. 12. At which ends do 'capping' and 'tailing' of *hn*RNA occur, respectively?

Ans. Capping occurs at 5′-end and tailing occurs at 3′-end.

Q. 13. What is cistron? *[CBSE (AI) 2015]*

Ans. A cistron is a segment of DNA coding for a polypeptide.

Q. 14. How does a degenerate code differ from an unambiguous one? *[CBSE (F) 2015]*

Ans. Degenerate code means that one amino acid can be coded by more than one codon. Unambiguous code means that one codon codes for only one amino acid.

Q. 15. Mention two functions of the codon AUG. *[CBSE Delhi 2010]*

Ans. Two functions of the codon AUG are:

(*i*) It acts as a start codon during protein synthesis.

(*ii*) It codes for the amino acid methionine.

Q. 16. Write the function of RNA polymerase II. *[CBSE (F) 2015]*

Ans. RNA polymerase II transcribes precursor of *m*RNA or *hn*RNA.

Q, 17. Give an example of a codon having dual function. *[CBSE Delhi 2016]*

Ans. AUG acts as an initiation codon and also codes for methionine.

Q. 18. Mention how does DNA polymorphism arise in a population. *[CBSE Delhi 2014]*

Ans. DNA polymorphism in a population arise due to presence of inheritable mutations at high frequency.

Q. 19. Suggest a technique to a researcher who needs to separate fragments of DNA. *[CBSE Delhi 2016]*

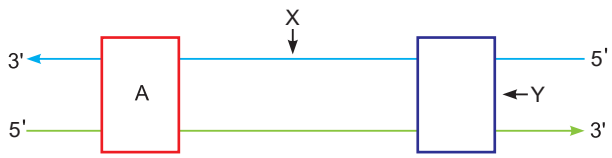
Ans. Gel electrophoresis is used to separate DNA fragments.

Q. 20. Mention one difference to distinguish an exon from an intron. *[CBSE (F) 2016]*

Ans. Exon is the coded or expressed sequence of nucleotides in *m*RNA.

Intron is the intervening sequence of nucleotides not appearing in processed *m*RNA.

Q. 21. What do 'X' and 'Y' represent in the transcription unit of the DNA molecule shown? *[CBSE 2019 (57/5/1)]*

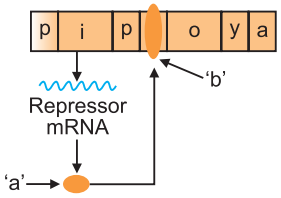


Ans. X—Template Strand Y—Terminator

Q. 22. Why *hn*RNA is required to undergo splicing? **[*HOTS*]**

Ans. *hn*RNA undergoes splicing in order to remove introns which are intervening or non-coding sequences and exons are joined to form functional *m*RNA.

Q. 23. Given below is a schematic representation of a *lac* operon in the absence of an inducer. Identify '*a*' and '*b*' in it.



Ans. *a*–Repressor

b–Repressor bound to the operator and prevents transcription of structural genes.

Q. 24. Why is lactose considered an inducer in lac operon? **[*HOTS*]**

Ans. Lactose binds to repressor and prevents it from binding with the operator, as a result RNA polymerase binds to promoter–operator region to transcribe the structural genes.

Q. 25. State which human chromosome has

(*i*) the maximum number of genes and

(*ii*) the one which has the least number of genes? **[*CBSE (F) 2011*] [*HOTS*]**

Ans. (*i*) Chromosome-1

(*ii*) Y-Chromosome

Q. 26. How is repetitive/satellite DNA separated from bulk genomic DNA for various genetic experiments? **[*CBSE Delhi 2014*] [*HOTS*]**

Ans. By density gradient centrifugation.

Q. 27. Mention the contribution of genetic maps in human genome project. **[*CBSE (AI) 2011*]**

Ans. Genetic maps have played an important role in sequencing of genes, DNA fingerprinting, tracing human history, chromosomal location for disease associated sequences (*Any one*).

Short Answer Questions [2 marks]

Q. 1. Draw a schematic representation of dinucleotide. Label the following:

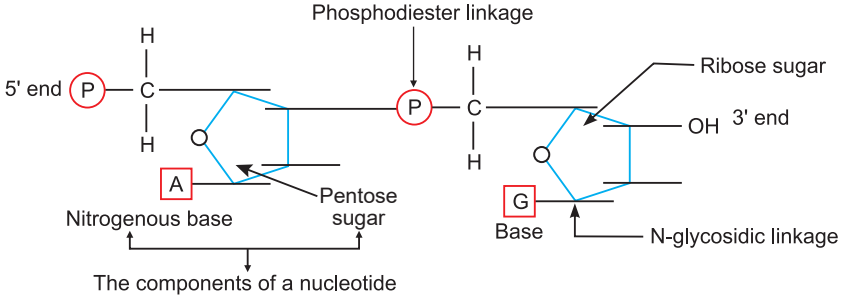
(*i*) The components of a nucleotide

(*ii*) 5′ end

(*iii*) N-glycosidic linkage

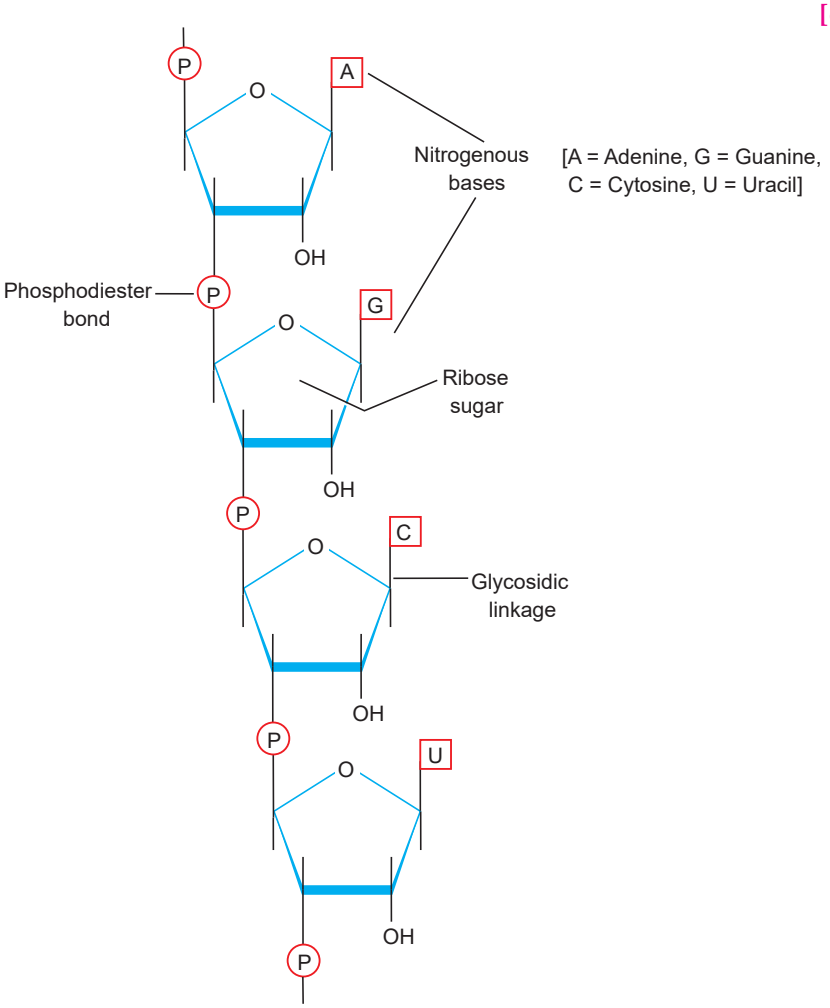
(*iv*) Phosphodiester linkage. **[*CBSE (F) 2010*]**

Ans. Nucleotide = Ribose sugar + Base + phosphate group.



Q. 2. Describe the structure of a RNA polynucleotide chain having four different types of nucleotides.
[*CBSE Delhi 2013*]

Ans.



Q. 3. A DNA segment has a total of 1500 nucleotides, out of which 410 are Guanine containing nucleotides. How many pyrimidine bases this DNA segment possesses?
[*CBSE Delhi 2015*] [*HOTS*]

Ans. According to Chargaff's rule

$$\frac{A}{G} = \frac{T}{G} = 1$$

G = C, G = 410, hence C = 410

$$G + C = 410 + 410$$
$$= 820$$

So, $$A + T = 1500 - 820$$
$$= 680$$

A = T, so $$T = \frac{680}{2} = 340$$

So, $$\text{Pyrimidines} = C + T$$
$$= 410 + 340$$
$$= \mathbf{750}$$

Q. 4. A DNA segment has a total of 2,000 nucleotides, out of which 520 are adenine containing nucleotides. How many purine bases this DNA segment possesses? [*CBSE Delhi 2015*] [*HOTS*]

Ans. $[A] = [T]$

$A + T = 520 + 520$

$= 1040$

Total number of nucleotides = 2000

$\therefore \quad G + C = 2000 - 1040$

$= 960$

$G = \frac{960}{2} = 480$

$\therefore$ Total number of purines (A + G) = 520 + 480

= **1000**.

Q. 5. Describe the structure of a nucleosome. **[*CBSE Delhi 2017*]**

Ans. Refer to Basic Concepts Point 4(*ii*) and Fig. 6.4.

Q. 6. Draw a schematic diagram of a part of double stranded dinucleotide DNA chain having all the four nitrogenous bases and showing the correct polarity. **[*CBSE Delhi 2012*]**

Ans. Refer to Fig. 6.3.

Q. 7. Although a prokaryotic cell has no defined nucleus, yet DNA is not scattered throughout the cell. Explain. **[*CBSE 2018*]**

Ans. DNA is negatively charged and has positively charged histone proteins. These help DNA to be held in a place in large loops called nucleoid.

Q. 8. Explain the role of ^{35}S and ^{32}P in the experiments conducted by Hershey and Chase.

Ans. Viruses grown in the medium containing ^{32}P contained radioactive DNA but not radioactive protein because DNA contains phosphorus but proteins do not contain phosphorus. Similarly, viruses grown on radioactive sulphur contained radioactive protein but not radioactive DNA because DNA does not contain sulphur.

Q. 9. Recall the experiment done by Frederick Griffith, Avery, Macleod annd McCarty, where DNA was speculated to be the genetic material. If RNA, instead of DNA was the genetic material, would the heat killed strain of *Streptococcus* have transformed the R-strain into virulent strain? Explain your answer. **[*HOTS*]**

Ans. RNA is more labile and prone to degradation (owing to the presence of 2′–OH group in its ribose). Hence heat-killed S-strain may not have retained its ability to transform the R-strain.

Q. 10. How do histones acquire positive charge? **[*CBSE Delhi 2011*]**

Ans. Histones are rich in the basic amino acid residues lysines and arginines, which carry positive charges in their side chains. Therefore, histones are positively charged.

Q. 11. A single base mutation in a gene may not 'always' result in loss or gain of function. Do you think the statement is correct? Defend your answer. **[*NCERT Exemplar*] [*HOTS*]**

Ans. The statement is correct because of degeneracy of codons, mutations at third base of codon, usually doe not result into any change in phenotype. This is called silent mutations but at other times it can lead to loss or formation of malformed protein changing the phenotype.

Q. 12. Protein synthesis machinery revolves around RNA but in the course of evolution it was replaced by DNA. Justify. **[*CBSE Sample Paper 2016*]**

Ans. Since RNA was unstable and prone to mutations, DNA evolved from RNA with chemical modifications that makes it more stable.

DNA has double stranded nature and has complementary strands. These further resist changes by evolving a process of repair.

Q. 13. Explain the two factors responsible for conferring stability to double helix structure of DNA. *[CBSE (AI) 2014]*

Ans. Factors responsible for conferring stability to double helix structure are presence of hydrogen-bonds, the plane of one base pair stacks over the other, complementary presence of thymine in place of uracil.

Q. 14. *(a)* **(A) — DNA $\xrightarrow{(B)}$ *m*RNA $\xrightarrow{(C)}$ Protein**

Look at the above sequence and mention the events (A), (B) and (C).

***(b)* What does Central Dogma state in Molecular Biology? How does it differ in some viruses?**

Ans. (*a*) A—DNA replication, B—Transcription, C—Translation

(*b*) Central Dogma in Molecular Biology states that information flows in the order

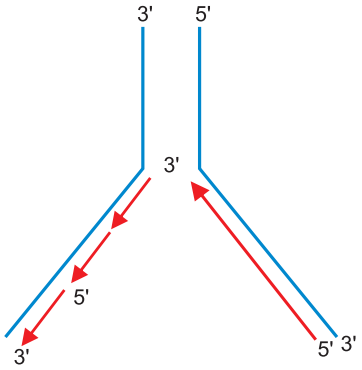
DNA ⟶ RNA ⟶ Proteins

It differs in some viruses as the flow of information is in reverse direction, that is, from DNA to RNA.

Q. 15. Retrovirus do not follow central dogma. Comment. *[HOTS]*

Ans. Genetic material of retrovirus is RNA. At the time of synthesis of protein, RNA is reverse transcribed to its complementary DNA first, then transcriped to RNA and proteins. Hence, retrovirus are not known to follow central dogma.

Q. 16.



Why do you see two different types of replicating strands in the given DNA replication fork? Explain. Name these strands. *[CBSE Delhi 2011]*

Ans. The DNA-dependent DNA polymerase catalyses polymerisation only in one direction *i.e.*, 5′→3′. Therefore, in one strand with polarity 3′→5′ continuous replication takes place whereas the other strand with polarity 5′→3′ carries out discontinuous replication.

The strand with polarity 3′→5′ is called leading strand and the strand with polarity 5′→3′ is called lagging strand.

Q. 17. Name indicating their functions, a few additional enzymes, other than DNA polymerase and ligase, that are involved in the replication of DNA with high degree of processivity and accuracy. *[NCERT Exemplar]* *[HOTS]*

Ans. **(*i*) Helicase:** opens the helix

(*ii*) Topoisomerases: removes the supercoiling of DNA relieves the tension due to unwinding

(*iii*) Primase: synthesises RNA primer

(*iv*) Telomerase: to synthesises the DNA of telomeric end of chromosomes.

Q. 18. During *in vitro* synthesis of DNA, a researcher used 2′, 3′-dideoxycytidine triphosphate as raw nucleotide in place of 2′-deoxy cytidine triphosphate, other conditions remaining as standard. Will further polymerisation of DNA continue up to the end or not? Explain. *[NCERT Exemplar]* *[HOTS]*

Ans. Further polymerisation up to the end would not occur as the 3′–OH on sugar molecule is not for forming ester bond, which is required to add another nucleotide.

Q. 19. State the dual role of deoxyribonucleoside triphosphates during DNA replication. *[CBSE Delhi 2011]*

OR

Write the dual purpose served by Deoxyribonucleoside triphosphates in polymerisation. *[CBSE 2018]*

Ans. (*i*) Deoxyribonucleoside triphosphates act as substrates for polymerisation.

(*ii*) These provide energy from its two terminal phosphates for polymerisation reaction.

Q. 20. Discuss the role of enzyme DNA ligase plays during DNA replication. *[CBSE Delhi 2016]*

Ans. DNA ligase joins or seals the discontinuous DNA fragments.

Q. 21. A template strand is given below. Write down the corresponding coding strand and the *m*RNA strand that can be formed, along with their polarity.

3′ ATGCATGCATGCATGCATGCATGC 5′ *[CBSE (F) 2014]* *[HOTS]*

Ans. **Coding strand:** 5′ TACGTACGTACGTACGTACGTACG 3′

***m*RNA strand:** 5′ UACGUACGUACGUACGUACGUACG 3′

Q. 22. The base sequence of one strand of DNA is TACTAGGAT.

(*i*) Write the base sequence of the RNA got after transcription of the given sequence.

(*ii*) What is the distance maintained between the two consecutive pairs of bases in the DNA molecule?

(*iii*) Who contributed the base complementary rule? *[HOTS]*

Ans. (*i*) AUGAUCCUA.

(*ii*) 3.4 Å or 0.34 nm.

(*iii*) Chargaff contributed the base complementary rule.

Q. 23. Draw a labelled schematic diagram of a transcription unit. *[CBSE (F) 2012]*

Ans. Refer to Fig. 6.10.

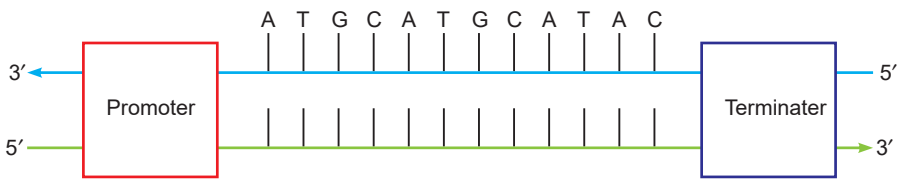
Q. 24. Explain the process of transcription in a bacterium. *[CBSE (F) 2012]*

Ans. Refer to Basic Concepts Point 13.

Q. 25. (*a*) Construct a complete transcription unit with promoter and terminator on the basis of the hypothetical template strand given below:

(*b*) Write the RNA strand transcribed from the above transcription unit along with its polarity. *[CBSE Delhi 2012]*

Ans. (*a*)



(*b*) Transcribed RNA

Q. 26. (*i*) Name the enzyme that catalyses the transcription of *hn*RNA.

(*ii*) Why does the *hn*RNA need to undergo changes? List the changes that *hn*RNA undergoes and where in the cell such changes take place. **[*CBSE (AI) 2011*]**

Ans. (*i*) RNA polymerase II.

(*ii*) *hn*RNA has non-functional introns in between the functional exons. To remove these, it undergoes changes. The changes that *hn*RNA undergoes include capping, *i.e.*, methyl guanosine triphosphate is added to 5′ end; tailing in which poly A tail is added at 3′ end; and splicing by which introns are removed and exons are joined.

Q. 27. State the difference between the structural genes in a transcription unit of prokaryotes and eukaryotes. **[*CBSE (AI) 2014*]**

Ans. **Table 6.7: Differences between structural genes of prokaryotes and eukaryotes**

S.No.	Prokaryotes	Eukaryotes
(*i*)	Polycistronic	Monocistronic
(*ii*)	No split genes present. The coding sequence is not interrupted.	Split genes present. The coding sequence is interrupted to form exon and intron.

Q. 28. (*i*) Name the scientist who suggested that the genetic code should be made of a combination of three nucleotides.

(*ii*) Explain the basis on which he arrived at this conclusion. **[*CBSE Delhi 2014*]**

Ans. (*i*) George Gamow.

(*ii*) He proposed that there are four bases and 20 amino acids So, there should be atleast 20 different genetic codes for these 20 amino acids.

The only possible combinations that would meet the requirement is combinations of 3 bases that will give 64 codons.

Q. 29. Explain the dual function of AUG codon. Give the sequence of bases it is transcribed from and its anticodon.

Ans. The dual function of AUG codon:

(*a*) It codes for amino acid methionine.

(*b*) It is an initiation codon.

The sequence of bases from which it is transcribed is TAC. Its anticodon is UAC.

Q. 30. Name the category of codons UGA belongs to. Mention another codon of the same category. Explain their role in protein synthesis.

Ans. UGA is a stop or termination codon.

UAA, UAG are the other stop codons of the category.

They prevent the elongation of the polypeptide chain by terminating translation.

Q. 31. Following are the features of genetic codes. What does each one indicate?
Stop codon; Unambiguous codon; Degenerate codon; Universal codon. **[*CBSE (AI) 2016*]**

Ans. Stop codon does not code for any amino acid and terminates the synthesis of polypeptide chain.

Unambiguous codon: one codon codes for one amino acid only.

Degenerate codon: some amino acid are coded by more than one codon.

Universal codon: Genetic code is same for all organisms (bacteria to humans).

Q. 32. Mention the role of ribosomes in peptide bond formation. How does ATP facilitate it? **[*CBSE (AI) 2010*]**

Ans. There are two sites in the large subunit of the ribosome, for subsequent amino acids to bind to and thus, be close enough to each other for the formation of a peptide bond. The ribosome also acts as a catalyst for the formation of peptide bond 23S *r*RNA in bacteria is a ribozyme. Amino acids become activated by binding with its *t*RNA in the presence of aminoacyl *t*RNA synthetase and ATP.

Q. 33. State the functions of the following in a prokaryote:

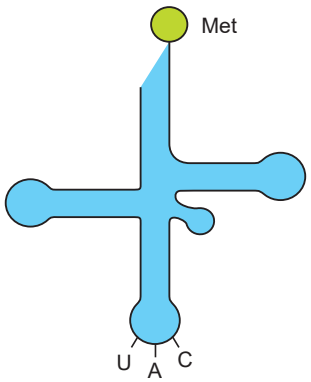
(*i*) *t*RNA (*ii*) *r*RNA ***CBSE (AI) 2012***

Ans. (*i*) *t*RNA reads the genetic codes, carries amino acids to the site of protein synthesis and act as an adaptor molecule.

(*ii*) *r*RNA plays structural and catalytic role during translation.

Q. 34. Draw the structure of a *t*RNA charged with methionine. ***[CBSE (F) 2012]***

Ans.



Q. 35. What is aminoacylation? State its significance. ***[CBSE (AI) 2016]***

Ans. Aminoacylation of *t*RNA or charging of *t*RNA is the activation of amino acids in the presence of ATP and their linkage to their cognate *t*RNA.

If two such charged *t*RNAs are brought close enough, the formation of peptide bond between them would be favoured energetically.

Q. 36. Differentiate between codon and an anticodon.

Ans.

Table 6.8: Differences between codon and anticodon

Codon	Anticodon
The sequence of 3 nitrogen bases on *m*RNA that codes for a particular amino acid during translation is called codon.	The sequence of 3 nitrogenous bases on *t*RNA that are complementary to the codon on *m*RNA for a particular amino acid during translation is called anticodon.

Q. 37. What would happen if histones were to be mutated and made rich in amino acids aspartic acid and glutamic acid in place of basic amino acids such as lysine and arginine?

[NCERT Exemplar] ***[HOTS]***

Ans. If histone proteins were rich in acidic amino acids instead of basic amino acids then they may not have any role in DNA packaging in eukaryotes as DNA is also negatively charged molecule. The packaging of DNA around the nucleosome would not happen. Consequently, the chromatin fibre would not be formed.

Q. 38. Differentiate between the genetic codes given below:

(*a*) Unambiguous and Universal.

(*b*) Degenerate and Initiator ***[CBSE (AI) 2017]***

Ans.

(*a*) **Unambiguous:** One codon codes for only one amino acid.	**Universal:** Codons are (nearly) same for all organisms (from bacteria to humans)
(*b*) **Degenerate:** More than one codon can code for the same amino acid.	**Initiator:** Start codon *i.e.*, AUG is the initiation codon.

Q. 39. (*a*) Name the enzyme responsible for the transcription of *t*RNA and the amino acid the initiator *t*RNA gets linked with.

(*b*) Explain the role of initiator *t*RNA in initiation of protein synthesis. [*CBSE Delhi 2012*]

Ans. (*a*) RNA polymerase III is responsible for transcription of *t*RNA and the initiator *t*RNA gets linked with the amino acid methionine.

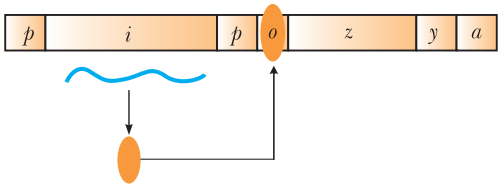
(*b*) The initiator *t*RNA, which is charged with amino acid methionine, reaches the smaller subunit of ribosome. Its anticodon UAC recognises the codon AUG on *m*RNA and binds by forming complementary base pairs. The large subunit of ribosome joins the smaller subunit and initiates translation.

Q. 40. One of the salient features of the genetic code is that it is nearly universal from bacteria to humans. Mention two exceptions to this rule. Why are some codes said to be degenerate? [*CBSE (F) 2014*] [*HOTS*]

Ans. The genetic code is universal except in mitochondria and few protozoans.

Some codes are said to be degenerate because some amino acids are coded by more than one code.

Q. 41. Given below is a schematic representation of *lac* operon:



(*a*) Identify *i* and *p*.

(*b*) Name the 'inducer' for this operon and explain its role. [*CBSE (F) 2011*]

Ans. (*a*) *i* is the regulatory gene and *p* is the promoter gene.

(*b*) Lactose is the inducer. It is the substrate for the enzyme beta-galactosidase and it regulates switching on and off of the operon.

Q. 42. How are the structural genes inactivated in *lac* operon in *E. coli*? Explain. [*CBSE Delhi 2012*]

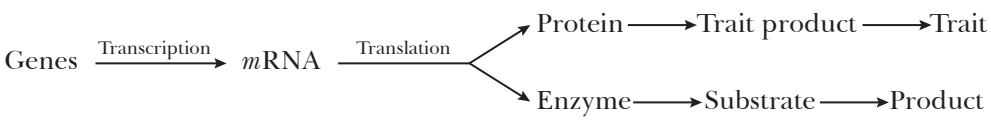
Ans. The regulator gene produces repressor which when free, binds to the operator region of the operon and prevents RNA polymerase from transcribing the structural genes.

Q. 43. How are the structural genes activated in the *lac* operon in *E. coli*? [*CBSE (AI) 2012*]

Ans. Lactose acts as the inducer that binds with repressor protein that cannot bind to operator and hence frees the operator gene. RNA polymerase freely moves over the structural genes, transcribing lac *m*RNA, which in turn produces the enzymes responsible for the digestion of lactose.

Q. 44. "Genes contain the information that is required to express a particular trait." Explain. [*NCERT Exemplar*] [*HOTS*]

Ans. The genes present in an organism show a particular trait by way of forming certain product. This is facilitated by the process of transcription and translation (according to central dogma of Biology)



Q. 45. A low level of expression of *lac* operon occurs at all the time. Can you explain the logic behind this phenomena? [*NCERT Exemplar*] [*HOTS*]

Ans. In the complete absence of expression of *lac* operon, permease will not be synthesised which is essential for transport of lactose from medium into the cells. And if lactose cannot be transported into the cell, then it cannot act as inducer. Hence, cannot relieve the *lac* operon from its repressed state. Therefore, *lac* operon is always expressed.

Q. 46. Where is an 'operator' located in a prokaryote DNA? How does an operator regulate gene expression at transcriptional level in a prokaryote? Explain. ***[CBSE (F) 2016]***

Ans. The operator region is located adjacent to promoter elements or prior to structural gene.

The operator regulates switching on and off the operon when the repressor binds to the operator region it is switched off and prevents transcription.

In the presence of inducer the repressor is inactivated and operator allows RNA polymerase to access the promoter. The operon is switched on and transcription proceeds.

Q. 47. (*a*) List the two methodologies which were involved in human genome project. Mention how they were used.

(*b*) Expand 'YAC' and mention what was it used for. ***[CBSE (AI) 2017]***

Ans. The two methodologies involved in human genome project are:

(*a*) (*i*) Expressed Sequence Tags: Identifying all the genes that are expressed as RNA

(*ii*) Sequence Annotation: Sequencing the whole set of genome coding or non coding sequences and later assigning different region with functions.

(*b*) 'YAC' stands for Yeast Artificial Chromosome. It is used as a cloning vectors.

Q. 48. Would it be appropriate to use DNA probes such as VNTR in DNA fingerprinting of a bacteriophage? ***[HOTS]***

Ans. Bacteriophage does not have repetitive sequence such as VNTR in its genome as its genome is very small and have all the codon sequenced. Therefore, DNA fingerprinting is not done for bacteriophages.

Q. 49. Comment on the utility of variability in number of tandem repeats during DNA fingerprinting. ***[HOTS]***

Ans. Tandemness in repeats provides many copies of the sequence for fingerprinting and variability in nitrogen base sequence in them. Being individual-specific, this proves to be useful in the process of DNA fingerprinting.

Q. 50. Write the full form of VNTR. How is VNTR different from a probe?

Ans. Full form of VNTR is Variable Number of Tandem Repeats

VNTR	Probe
The segment of DNA which shows very high no. of repetitive nucleotide sequences which vary from person to person are called variable number tandem repeats.	The small fragments of DNA strands which are highly selective and specific to be complementary to VNTR sequences are called probe.

Q. 51. Mention two applications of DNA polymorphism. ***[CBSE (F) 2016]***

Ans. DNA polymorphism is applicable in genetic mapping and DNA finger printing.

Q. 52. What are satellite DNA in a genome? Explain their role in DNA fingerprinting. ***[CBSE Sample Paper 2014]***

OR

Explain the significance of satellite DNA in DNA fingerprinting technique. ***[CBSE (AI) 2015]***

Ans. A small stretch of DNA sequence that repeats many a time, shows a high degree of polymorphism and forms a bulk of DNA in a genome called satellite DNA.

(*i*) They do not code for any proteins.

(*ii*) They form large part of the human genome.

(*iii*) They show high degree of polymorphism and are specific to each individual.

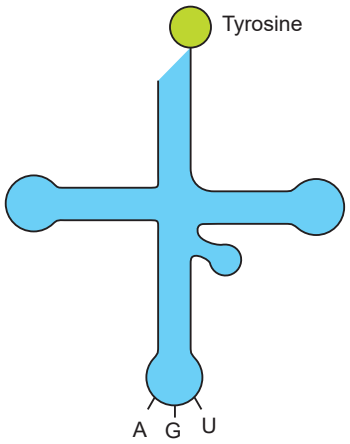
Q. 53. (*a*) Draw a clover leaf structure of *t*RNA showing the following:

(*i*) Tyrosine attached to its amino acid site.

(*ii*) Anticodon for this amino acid in its correct site (codon for tyrosine is UCA).

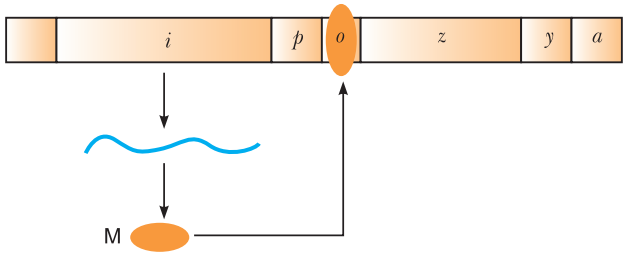
(*b*) What does the actual structure of *t*RNA look like? ***[CBSE (AI) 2011]***

Ans. (*a*)



(*b*) The actual structure of *t*RNA looks like inverted L.

Q. 54. (*a*) Name the molecule 'M' that binds with the operator.
(*b*) Mention the consequences of such binding.



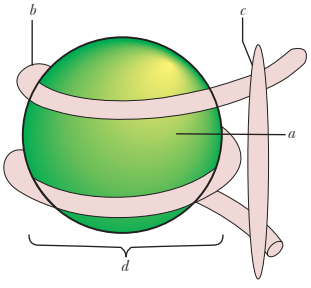
Ans. (*a*) M is the repressor.
(*b*) When repressor binds with the operator, transcription stops.

Long Answer Questions–I [3 marks]

Q. 1. Draw a labelled diagram of a nucleosome. Where is it found in a cell? **[*CBSE (F) 2014*]**

Ans. Refer to Fig. 6.4.
Nucleosome is found in the nucleus of the cell.

Q. 2. (*a*) What is this diagram representing?
(*b*) Name the parts *a*, *b* and *c*.
(*c*) In the eukaryotes, the DNA molecules are organised within the nucleus. How is the DNA molecule organised in a bacterial cell in absence of a nucleus? **[*HOTS*]**



Ans. (*a*) Nucleosome
(*b*) *a*—Histone octamer, *b*—DNA, *c*—H_1 histone
(*c*) In bacterial cell, DNA in nucleoid is organised in large loops held together by proteins.

Q. 3. (*a*) Draw a neat labelled diagram of a nucleosome.
(*b*) Mention what enables histones to acquire a positive charge. **[*CBSE (AI) 2012*]**

Ans. (*a*) Refer to Fig. 6.4.
(*b*) Basic amino acid residues of lysines and arginines.

Q. 4. List the salient features of double helix structure of DNA. **[*CBSE (AI) 2012*]**

Ans. Refer to Basic Concepts Point 2 (*Any six*).

Q. 5. It is established that RNA is the first genetic material. Explain giving three reasons.
[*CBSE Delhi 2012*]

Ans. The reasons in support are:
(*i*) Processes like metabolism, translation and splicing evolve around RNA.
(*ii*) RNA is reactive and catalyses reactions.
(*iii*) In some viruses, RNA is the hereditary material.
(*iv*) RNA is unstable and can be easily mutated leading to evolution. (*Any three*)

Q. 6. A typical mammalian cell has 22 metres long DNA molecule whereas the nucleus in which it is packed measures about 10^{-6} m. Explain how such a long DNA molecule is packed within a tiny nucleus in the cell. **[*HOTS*]**

Ans. Refer to Basic Concepts Point 4 (*ii*) (Packaging of DNA in Eukaryotes).

Q. 7. (*a*) A DNA segment has a total of 1000 nucleotides, out of which 240 of them are adenine containing nucleotides. How many pyrimidine bases this DNA segment possesses?
(*b*) Draw a diagrammatic sketch of a portion of DNA segment to support your answer.
[*CBSE Delhi 2015*] [*HOTS*]

Ans. (*a*) A = T, A = 240, hence T = 240

$$A + T = 240 + 240 = 480$$

So, $$G + C = 1000 - 480 = 520$$

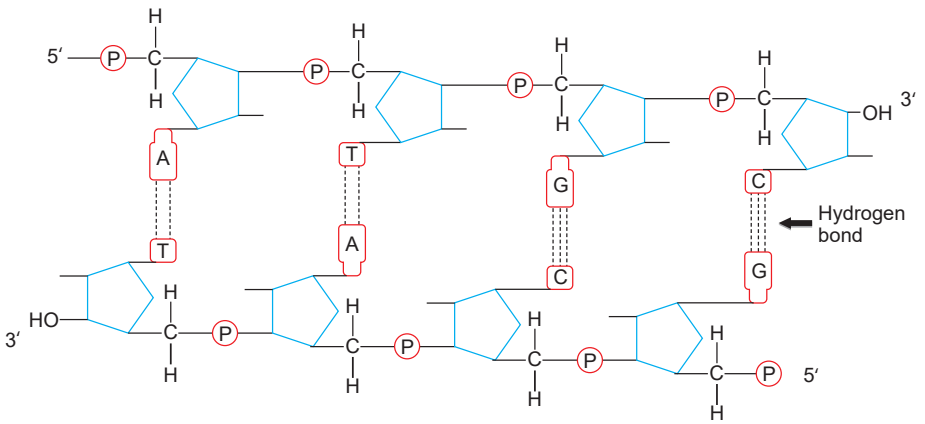
$$G = C, \text{ so } C = \frac{520}{2} = 260$$

So, $$\text{pyrimidines} = C + T$$

$$= 260 + 240$$

$$= \mathbf{500}$$

(*b*)



Q. 8. (*a*) Why did Hershey and Chase use radioactive sulphur and radioactive phosphorus in their experiment?
(*b*) Write the conclusion they arrived at and how. **[*CBSE (F) 2016*]**

Ans. Refer to Basic Concepts Point 7.

Q. 9. Answer the following questions based on Meselson and Stahl's experiment:
(*a*) Write the name of the chemical substance used as a source of nitrogen in the experiment by them.
(*b*) Why did the scientists synthesise the light and the heavy DNA molecules in the organism used in the experiment?
(*c*) How did the scientists make it possible to distinguish the heavy DNA molecule from the light DNA molecule? Explain.
(*d*) Write the conclusion the scientists arrived at after completing the experiment.
[*CBSE (AI) 2011*]

Ans. (*a*) Ammonium chloride (NH_4Cl).

(*b*) To check if DNA replication was semi-conservative.

(*c*) The heavy and light DNA molecules were distinguished by centrifugation in a caesium chloride density gradient.

(*d*) The scientists concluded that DNA replicates semi-conservatively.

Q. 10. The base sequence in one of the strands of DNA is TAGCATGAT.

(*i*) Give the base sequence of its complementary strand.

(*ii*) How are these base pairs held together in a DNA molecule?

(*iii*) Explain the base complementarity rules. Name the scientist who framed this rule.

[*CBSE Delhi 2011*]

Ans. (*i*) The complementary strand is ATCGTACTA.

(*ii*) The base pairs are held together by hydrogen bonds in a DNA molecule. A and T are held by two hydrogen bonds while G and C are held by three hydrogen bonds.

(*iii*) Watson and Crick framed the base complementarity rule. The rule states that the ratios between adenine and thymine, and guanine and cytosine are constant and equals one.

Q. 11. Describe Frederick Griffith's experiment on *Streptococcus pneumoniae*. Discuss the conclusion he arrived at. **[*CBSE (AI) 2012*]**

OR

Describe the experiment with *Streptococcus pneumoniae* that demonstrated the existence of some "transforming principle". **[*CBSE (F) 2013*]**

Ans. Refer to Basic Concepts Point 5.

Q. 12. Describe the experiments that established the identity of 'transforming principles' of Griffith. **[*CBSE (F) 2017*]**

Ans. Oswald Avery, Colin MacLeod and Maclyn McCarty purified biochemicals (proteins, DNA, RNA, etc.) from the heat-killed S cells to see which ones could transfrom live R cells into S cells. They discovered that DNA alone from S bacteria caused R bacteria to become transformed.

They also discovered that protein-digesting enzymes (proteases) and RNA-digesting enzymes (RNases) did not affect transformation, so the transforming substance was not a protein or RNA. Digestion with DNase did inhibit transformation, suggesting that the DNA caused the transformation. They concluded that DNA is the hereditary material.

Q. 13. Describe the experiment that proved that DNA is the genetic material. **[*CBSE (F) 2013*]**

Ans. Refer to Basic Concepts Point 7.

Q. 14. In a series of experiments with *Streptococcus* and mice, F. Griffith concluded that R-strain bacteria had been transformed. Explain. **[*CBSE (AI) 2010*]**

Ans. Refer to Basic Concepts Point 5.

Q. 15. How was a heavy isotope of nitrogen used to provide experimental evidence to semi-conservative mode of DNA replication? **[*CBSE (F) 2015*]**

OR

Describe the experiment that helped to demonstrate the semi-conservative mode of DNA replication. **[*CBSE Delhi 2016; (F) 2013*]**

Ans. Refer to Basic Concepts Point 10(*i*) or Fig. 6.8.

Q. 16. With respect to Messelson and Stahl's Experiment, answer the following questions:

(*a*) Identify the method used to distinguish between heavy and light isotopes of nitrogen.

(*b*) With the help of diagrams, compare the results for the DNA isolated after 20 minutes of experiment with the DNA which was isolated after 40 minutes. **[*CBSE Sample Paper 2016*]**

Ans. (*a*) Centrifugation in a CsCl density gradient.

(*b*) Refer to Fig. 6.8.

Q. 17. DNA separated from one cell, when introduced into another cell is able to bestow some of the properties of former to the latter. What is this change called in technical terms? Describe the experimental evidences which led to the discovery of the above phenomenon.

[*CBSE Sample Paper 2016*]

Ans. This change is called transformation.

For experimental evidences refer to Basic Concepts Points 6 and 7.

Q. 18. What are the three types of RNA? Mention their relation to protein synthesis.

Ans. **Types of RNA**

S. No.	Types of RNA	Functions
(*i*)	Messenger RNA (*m*RNA)	(*i*) It stores the genetic information from DNA. (*ii*) It decides the sequence of amino acid in a polypeptide.
(*ii*)	Transfer RNA (*t*RNA)	(*i*) It acts as an adaptor molecule that at one end reads the code on *m*RNA and accordingly bind to amino acid on the other end. (*ii*) It recognises the codon on *m*RNA by its anticodon and leaves amino acid at the protein synthesis site.
(*iii*)	Ribosomal RNA (*r*RNA)	(*i*) It constitutes the ribosomal structure. (*ii*) It helps to form peptide bond.

Q. 19. (*a*) Differentiate between a template strand and coding strand of DNA.

(*b*) Name the source of energy for the replication of DNA.

Ans. (*a*) Refer to Table 6.6.

(*b*) Deoxynucleoside triphosphates provide the energy for DNA replication.

Q. 20. State any two structural differences and one functional difference between DNA and *r*RNA.

Ans.

S. No.	DNA	*r*RNA
Structural differences		
(*i*)	It is a double-stranded structure.	It is a single-stranded structure.
(*ii*)	It contains nitrogen bases, A, T, G, C.	It contains nitrogen base, A, U, G, C.
(*iii*)	It has deoxyribose sugar.	It has ribose sugar.
Functional difference		
	It determines sequence of amino acid in a polypeptide by transcription and passes information from one generation to another.	It is the site of translation.

Q. 21. DNA polymerase and RNA polymerase differ in their requirement while functioning. Explain.

Ans.

S. No.	RNA polymerase	DNA polymerase
(*i*)	It cannot carry out proofreading.	It carries out proofreading for DNA repair mechanism.
(*ii*)	RNA polymerase does not require RNA primer for synthesis of RNA.	DNA polymerase requires RNA primer for synthesis of DNA.
(*iii*)	It uses ribonucleotides for RNA synthesis.	It uses deoxyribonucleotides for DNA synthesis.

Q. 22. Draw a labelled schematic sketch of replication fork of DNA. Explain the role of the enzymes involved in DNA replication.

Ans. For diagram, refer to Fig. 6.9.

Enzymes involved in DNA replication are:

(*i*) DNA-dependent DNA polymerase, which catalyses the polymerisation of polynucleotides in a very short time only in 5′→3′ direction with accuracy.

(*ii*) DNA ligase, which joins the discontinuously synthesised short segments called Okazaki fragments formed on one of the template strands.

Q. 23. (*a*) Draw a labelled schematic diagram of a replication fork showing continuous and discontinuous replication of DNA strands.

(*b*) State a reason why is the replication continuous and discontinuous in the diagram drawn. **[*CBSE (F) 2017*]**

Ans. (*a*) Refer to Fig. 6.9.

(*b*) The two strands of DNA are anti parallel, *i.e.*, one strand runs in the direction 5′ to 3′ and the other runs in the direction 3′ to 5′. DNA polymerase adds deoxyribonucleotides only in one direction, *i.e.*, 5′ to 3′. Thus, producing Okazaki fragments in the other strands.

Q. 24. (*a*) Draw a schematic representation of the structure of a transcription unit and show the following in it:

(*i*) Direction in which the transcription occurs

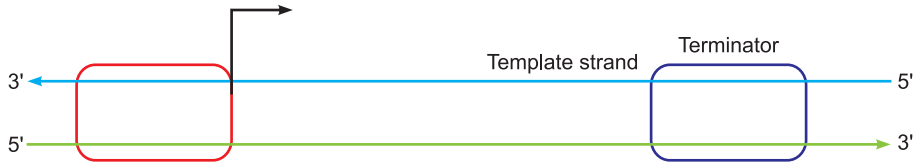
(*ii*) Polarity of the two strands involved

(*iii*) Template strand

(*iv*) Terminator gene

(*b*) Mention the function of promoter gene in transcription.

Ans. (*a*) (*i*) Transcription occurs in 5′→3′.



(*b*) Promotor gene has DNA sequence that provide binding site for RNA polymerase.

Q. 25. Describe the initiation process of transcription in bacteria. **[*CBSE Delhi 2010*]**

Ans. In bacteria, the transcription of all the three types of RNA (*m*RNA, *t*RNA, *r*RNA) is catalysed by single DNA-dependent enzyme called the RNA polymerase. The RNA polymerase has co-factors that catalyse the process. During initiation, σ (sigma) factor recognises the start signal and promotor region on DNA which then along with RNA polymerase binds to the promoter to initiate transcription.

For diagram, refer to Fig. 6.11(*a*).

Q. 26. Describe the elongation process of transcription in bacteria. **[*CBSE Delhi 2010*]**

Ans. After initiation, RNA polymerase loses the σ factor but continues the polymerisation of ribonucleotides to form RNA. It uses nucleoside triphosphates as substrate and polymerises in a template-dependent fashion, following the rule of complementarity.

For diagram, refer to Fig. 6.11(*b*).

Q. 27. Describe the termination process of transcription in bacteria. **[*CBSE Delhi 2010*]**

Ans. Once the RNA polymerase reaches the termination region of DNA, the RNA polymerase is separated from DNA–RNA hybrid, as a result nascent RNA separates. This process is facilitated

by a termination factor ρ (rho). In prokaryotes, *m*RNA does not require any processing, so transcription and translation both occur in the cytosol.

For diagram, refer to Fig. 6.11(*c*).

Q. 28. How is *hn*RNA processed to form *m*RNA? **[*CBSE (F) 2012; 2019 (57/3/1)*]**

Ans. The *hn*RNA undergoes the following processes to form *m*RNA:

(*i*) Capping: Addition of methyl guanosine triphosphate at 5′-end.

(*ii*) Tailing: Addition of 200-300 adenylate residues at 3′-end.

(*iii*) Splicing: Removal of introns and rejoining of exons.

Q. 29. What is *hn*RNA? Explain the changes *hn*RNA undergoes during its processing to form *m*RNA.

Ans. *hn*RNA is the precursor of *m*RNA that is transcribed by RNA ploymerase II and is called heterogenous nuclear RNA.

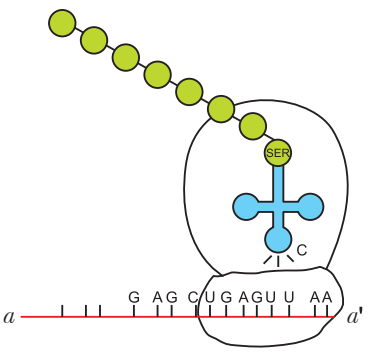
Changes:

- The *hn*RNA undergoes two additional processes called capping and tailing.
- In capping, an unusual nucleotide, methyl guanosine triphosphate, is added to the 5'-end of *hn*RNA.
- In tailing, adenylate residues (about 200–300) are added at 3'-end in a template independent manner.
- Now the *hn*RNA undergoes a process where the introns are removed and exons are joined to form *m*RNA by the process called splicing.
- Fragments on one of the template strands.

Q. 30. (*a*) Identify the polarity from *a* to *a′* in the given diagram and mention how many more amino acids are expected to be added to this polypeptide chain.

(*b*) Mention the DNA sequence coding for serine and the anticodon of *t*RNA for the same amino acid.

(*c*) Why are some untranslated sequence of bases seen in *m*RNA coding for a polypeptide? Where exactly are they present on *m*RNA? **[*HOTS*]**



Ans. (*a*) Polarity from *a* to *a′* is 5′→ 3′.

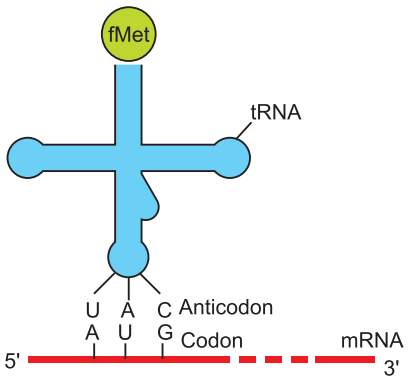
No more amino acid will be added to this polypeptide chain.

(*b*) TCA; anticodon is UCA.

(*c*) The untranslated sequence of bases are required for efficient translation process. They are present before the start codon at the 5′-end and after the stop codon at 3′-end.

Q. 31. One of the codons on *m*RNA is AUG. Draw the structure of *t*RNA adapter molecule for this codon. Explain the uniqueness of this *t*RNA.

Ans. This *t*RNA is specific for amino acid Methionine and it also acts as initiator codon (initiator *t*RNA)



Q. 32. Explain the process of translation in a bacterium. **[*CBSE (F) 2012*]**

Ans. Refer to Basic Concepts Point 17.

Q. 33. How is the translation of *m*RNA terminated? Explain.

Ans. Refer to Basic Concepts Point 17(*iii*).

Q. 34. Unambiguous, universal and degenerate are some of the terms used for the genetic code. Explain the salient features of each one of them. **[*CBSE (AI) 2011*]**

Ans. Unambiguous code means that one codon codes for only one amino acid, *e.g.*, AUG codes for only methionine.

Universal code means that codon and its corresponding amino acid are the same in all organisms, *e.g.*, from bacteria to human, UUU codes for phenylalanine.

Degenerate code means that same amino acids are coded by more than one codon, *e.g.*, UUU and UUC code for phenylalanine.

Q. 35. State the conditions when 'genetic code' is said to be

(*i*) degenerate,

(*ii*) unambiguous and specific,

(*iii*) universal. **[*CBSE (F) 2012*]**

Ans. (*i*) Degenerate—When some amino acids are coded by more than one amino acids.

(*ii*) Unambiguous and specific—When one codon codes for only one specific amino acid.

(*iii*) A particular codon codes for same amino acid in all organisms except in mitochondria and few protozoa.

Q. 36. (*a*) Draw the structure of the initiator *t*RNA adaptor molecule.

(*b*) Why is *t*RNA called an adaptor molecule?

Ans. (*a*) Refer to Fig. 6.13.

(*b*) *t*RNA is called an adaptor molecule because on one end it reads the code on *m*RNA and on other end it would bind to the amino acid corresponding to the anticodon.

Q. 37.

Study the *m*RNA segment given above which is complete to be translated into a polypeptide chain.

(*i*) Write the codons '*a*' and '*b*'.

(*ii*) What do they code for?

(*iii*) How is peptide bond formed between two amino acids in the ribosome? **[*HOTS*]**

Ans. (*i*) *a* is AUG and *b* is UAA/UAG/UGA

(*ii*) AUG codes for methionine (initiation codon).

UAA/UAG/UGA do not code for any amino acid, *i.e.*, stop or terminating codons.

(*iii*) There are two sites (P-site and A-site) in the large subunit of ribosome, where subsequent amino acids bind to and thus are close enough to form peptide bond by peptidyl transferase enzyme. The ribosome also acts as a catalyst for the formation of peptide bond.

Q. 38. "The codon is a triplet and is read in a contiguous manner without punctuations." Provide the genetic basis for the statement. ***[CBSE Sample Paper 2014]***

Ans. Since there are only four bases which code for twenty amino acids, the code should be made up of three bases, *i.e.*, (4 × 4 × 4) = 64 codons; a number more than the required.

If the codon consists of four letters, only (4 × 4), only sixteen codons are possible, which is less than the required. Hence the codon is a triplet.

As the ribosome moves on *m*RNA, continuously without break, the codons are read in a contiguous manner.

Q. 39. Identify giving reasons, the salient features of genetic code by studying the following nucleotide sequence of *m*RNA strand and the polypeptide translated from it.

AUG UUU UCU UUU UUU UCU UAG

Met – Phe – Ser – Phe – Phe – Ser

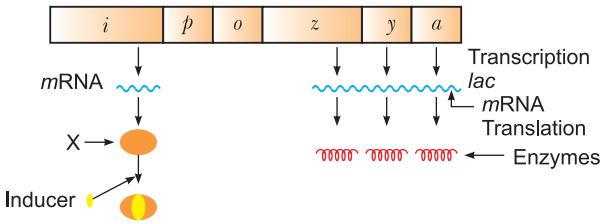
Ans.

S. No.	Salient features of genetic code	Reason
(*i*)	The codon is a triplet.	*e.g.*, AUG, UUU, etc, are triplets
(*ii*)	One codon codes for only one amino acid, hence it is unambiguous and specific.	*e.g.*, UUU codes for serine, AUG for methionine, etc.
(*iii*)	AUG has dual function as it codes for methionine and it also acts as initiator codon.	AUG is seen at the beginning of the polypeptide chain.
(*iv*)	UAG does not code for any amino acid hence is called stop codon and leads to end of translation.	No amino acid is coded by UAG in the polypeptide chain given.

Q. 40. (*a*) Name the molecule 'X' synthesised by '*i*' gene. How does this molecule get inactivated?

(*b*) Which one of the structural genes codes for β-galactosidase?

(*c*) When will the transcription of this gene stop?



Ans. (*a*) The molecule 'X' is repressor. It gets inactivated when lactose (inducer) binds with the repressor molecule.

(*b*) *z* gene codes for β-galactosidase.

(*c*) Transcription of the gene stops when lactose is absent and thus repressor is free to bind with the operator.

Q. 41. Draw a schematic diagram of *lac* operon in its 'switched off' position. Label the following:

(*i*) The structural genes **(*ii*) Repressor bound to its correct position**

(*iii*) Promoter gene **(*iv*) Regulatory gene.** ***[CBSE (F) 2012]***

Ans. Refer to Fig. 6.15 (*a*).

(*i*) *z*, *y* and *a* are structural genes.

(*iii*) *p* is the promoter sequence.

(*iv*) *i* is the regulatory gene.

Q. 42. (*a*) What do 'Y'and 'B' stand for in 'YAC' and 'BAC' used in Human Genome Project (HGP). Mention their role in the project.

(*b*) Write the percentage of the total human genome that codes for proteins and the percentage of discovered genes whose functions are known as observed during HGP.

(*c*) Expand 'SNPs' identified by scientists in HGP. ***[CBSE (AI) 2016]***

Ans. (*a*) 'Y' stands for Yeast and 'B' stands for Bacterial.
'YAC' and 'BAC' are used as vectors for cloning foreign DNA.

(*b*) The total human genome percentage is (<) 2% and percentage of discovered genes is (<) 50%.

(*c*) Single Nucleotide Polymorphism.

Q. 43. (*a*) Explain DNA polymorphism as the basis of genetic mapping of human genome.

(*b*) State the role of VNTR in DNA fingerprinting. ***[CBSE (AI) 2013]***

Ans. (*a*) Genetic polymorphism means occurrence of genetic material in more than one form. It is of three major types, *i.e.*, allelic, SNP and RFLP.

Allelic polymorphism: Allelic polymorphism occurs due to multiple alleles of a gene. Allele possess different mutations which alter the structure and function of a protein formed by them as a result, change in phenotype may occur.

SNP or single nucleotide polymorphism: SNP is very useful for locating alleles, identifying disease-associated sequence and tracing human history.

(*b*) Variable Number Tandem Repeats (VNTRs) are used in DNA fingerprinting as markers. VNTRs vary from person to person and are inherited from one generation to the next. Therefore, only closely related individuals have similar VNTRs.

Q. 44. How are the DNA fragments separated and isolated for DNA fingerprinting? Explain. ***[CBSE (F) 2012]***

Ans. Separation and Isolation of DNA Fragments (Gel Electrophoresis)

- **Gel electrophoresis** is a technique for separating DNA fragments based on their size.
- Firstly, the sample DNA is cut into fragments by restriction endonucleases.
- The DNA fragments being negatively charged can be separated by forcing them to move towards the anode under an electric field through a medium/matrix.
- Commonly used matrix is **agarose,** which is a natural linear polymer of D-galactose and 3, 6-anhydro-L-galactose which is extracted from sea weeds.
- The DNA fragments separate-out (resolve) according to their size because of the sieving property of agarose gel. Hence, the smaller the fragment size, the farther it will move.
- The separated DNA fragments are visualised after staining the DNA with **ethidium bromide** followed by exposure to **UV radiation**.
- The DNA fragments are seen as orange coloured bands.
- The separated bands of DNA are cut out and extracted from the gel piece. This step is called **elution**.
- The purified DNA fragments are used to form recombinant DNA which can be joined with cloning vectors.

Q. 45. Forensic department was given three blood samples. Write the steps of the procedure carried to get the DNA fingerprinting done for the above samples. ***[CBSE (F) 2012]***

Ans. Refer to Basic Concepts Point 22 (Methodology and Technique).

Q. 46. In a maternity clinic, for some reasons the authorities are not able to hand over the two newborns to their respective real parents. Name and describe the technique that you would suggest to sort out the matter. ***[CBSE (AI) 2013]***

Ans. The technique is DNA fingerprinting. It includes the following steps:
Refer to Basic Concepts Point 22 (Methodology and Technique).

Q. 47. Write any six salient features of the human genome as drawn from the human genome project. ***[CBSE 2019 (57/3/1)]***

Ans. Refer to Basic Concepts Point 21.

Q. 48. A criminal blew himself up in a local market when was chased by cops. His face was beyond recognition. Suggest and describe a modern technique that can help establish his identity. ***[CBSE Delhi 2017]***

Ans. The identity can be established by the technique of DNA fingerprinting.

For method: Refer to Basic Concepts Point 22.

Q. 49. Following the collision of two trains a large number of passengers are killed. A majority of them are beyond recognition. Authorities want to hand over the dead to their relatives. Name a modern scientific method and write the procedure that would help in the identification of kinship. ***[CBSE Delhi 2015]*** ***[HOTS]***

OR

A number of passengers were severely burnt beyond recognition during a train accident. Name and describe a modern technique that can help to hand over the dead to their relatives. ***[CBSE Delhi 2017]***

Ans. DNA fingerprinting can help in identification of kinship.

For procedure, refer to Basic Concepts Point 22.

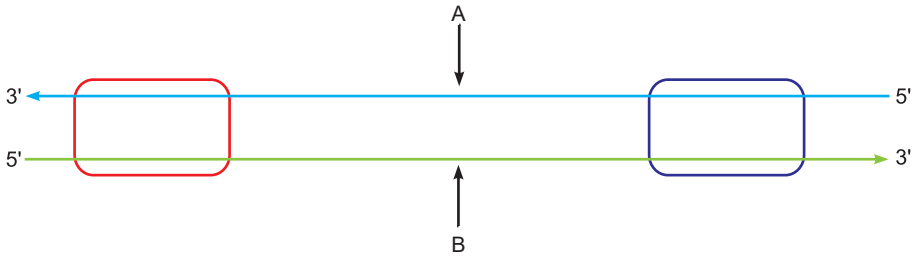
Q. 50. "A very small sample of tissue or even a drop of blood can help determine paternity". Provide a scientific explanation to substantiate the statement. ***[CBSE (AI) 2015]***

Ans. (*i*) DNA from all cells of an individual shows the same degree of polymorphism and therefore becomes a useful identification tool.

(*ii*) Polymorphs are heritable and the child inherits 50% of the chromosome from each parent.

(*iii*) With the help of PCR the small amount of DNA from blood can be amplified and be used in DNA finger printing to identify the paternity.

Q. 51.



(*a*) Identify strands 'A' and 'B' in the diagram of transcription unit given above and write the basis on which you identified them.

(*b*) Write the functions of RNA polymerase-I and RNA polymerase-III in eukaryotes. ***[CBSE (F) 2016]***

Ans. (*a*) A—Template strand

B—Coding strand

The templates are identified on the basis of polarity with respect to promoter. Template strand has polarity 3′ → 5′ and coding strand has polarity 5′ → 3′.

(*b*) RNA polymerase-I transcribes *r*RNAs.

RNA polymerase-III transcribes *t*RNA, 5*sr*RNA and *sn*RNA.

Long Answer Questions–II [5 marks]

Q. 1. The average length of a DNA double helix in a typical mammalian cell is approximately 2.2 metres and the dimension of the nucleus is about 10^{-6} m.

(*a*) How is it possible that long DNA polymers are packed within a very small nucleus?

(*b*) Differentiate between euchromatin and heterochromatin.

(*c*) Mention the role of non-histone chromosomal protein. **[*CBSE (F) 2011*] [*HOTS*]**

Ans. (*a*) Refer to Basic Concepts Point 4(*ii*).

(*b*) Refer to Table 6.1.

(*c*) The packaging of chromatin at higher level requires the presence of non-histone chromosomal protein.

Q. 2. List the criteria a molecule that can act as genetic material must fulfill. Which one of the criteria are best fulfilled by DNA or by RNA thus making one of them a better genetic material than the other? Explain. **[*CBSE Delhi 2016*]**

Ans. A molecule that can act as a genetic material must fulfill the following criteria:

(*i*) It should be able to generate its replica (Replication).

(*ii*) It should chemically and structurally be stable.

(*iii*) It should provide the scope for slow changes (mutation) that are required for evolution.

(*iv*) It should be able to express itself in the form of 'Mendelian Characters'.

In DNA the two strands being complementary if separated by heating come together, when appropriate conditions are provided. Further, 2'-OH group present at every nucleotide in RNA is also now known to be catalytic, hence reactive. Therefore DNA chemically is less reactive and structurally more stable when compared to RNA. Therefore, among the two nucleic acids, the DNA is a better genetic material. The presence of thymine at the place of uracil also confers additional stability to DNA.

Both DNA and RNA are able to mutate. In fact, RNA being unstable, mutate at a faster rate. RNA can directly code for the synthesis of proteins, hence can easily express the characters. DNA, however, is dependent on RNA for synthesis of proteins. The protein synthesising machinery has evolved around RNA.

Q. 3. (*a*) How are the following formed and involved in DNA packaging in a nucleus of a cell?

(*i*) Histone octomer

(*ii*) Nucleosome

(*iii*) Chromatin

(*b*) Differentiate between Euchromatin and Heterochromatin. **[*CBSE Delhi 2016*]**

Ans. (*a*) (*i*) Eight molecules of positively charged basic proteins called histones are organised to form histone octomer.

(*ii*) Negatively charged DNA is wrapped around positively charged histone octamer to give rise to nucleosome.

(*iii*) Nucleosome constitute the repeating unit of a structure called chromatin.

(*b*) Refer to Table 6.1.

Q. 4. What background information did Watson and Crick had available with them for developing a model of DNA? What was their own contribution? **[*NCERT Exemplar*]**

Ans. Watson and Crick had the following informations which helped them to develop a model of DNA:

(*i*) Chargaff's Law suggesting A=T and C≡G.

(*ii*) Wilkins and Franklin's X-ray diffraction studies on DNA's physical structure.

Based on these information, Watson and crick proposed

(*i*) complementary base-pairing of nitrogenous bases

(*ii*) semi-conservative mode of replication

(*iii*) occurrence of mutation through tautomerism.

Q. 5. Describe the packaging of DNA helix in a prokaryotic cell and an eukaryotic nucleus. **[*CBSE (F) 2016*]**

Ans. Refer to Basic Concepts Point 4.

Q. 6. (*a*) How did Griffith explain the transformation of R-strain (non-virulent) bacteria into S-strain (virulent)?

(*b*) Explain how MacLeod, McCarty and Avery determined the biochemical nature of the molecule responsible for transforming R-strain bacteria into S-strain bacteria. **[*CBSE (AI) 2013, 2016*]**

OR

(*a*) Describe the various steps of Griffith's experiment that led to the conclusion of the 'Transforming Principle'.

(*b*) How did the chemical nature of the 'Transforming Principle' get established? **[*CBSE (AI) 2014; (F) 2015*]**

Ans. (*a*) Refer to Basic Concepts Point 5.

(*b*) Refer to Basic Concepts Point 6.

Q. 7. (*a*) Write the scientific name of the bacterium used by Frederick Griffith in his experiment.

(*b*) How did he prove that some 'transforming principle' is responsible for transformation of the non-virulent strains of bacteria into the virulent form?

(*c*) State the biochemical nature of 'transforming principle'.

(*d*) Name the scientists who proved it. **[*CBSE (F) 2011*]**

Ans. (*a*) *Streptococcus pneumoniae*

(*b*) Refer to Basic Concepts Point 6.

(*c*) 'The transforming principle' was nucleic acid, *i.e.*, DNA.

(*d*) It was proved by O. Avery, C. MacLeod and M. McCarty.

Q. 8. (*a*) Explain the experiment performed by Griffith on *Streptococcus pneumoniae*. What did he conclude from this experiment? **[*CBSE (AI) 2012*]**

(*b*) Name the three scientists who followed up Griffith's experiments.

(*c*) What did they conclude and how?

Ans. (*a*) Refer to Basic Concepts Point 5.

(*b*) Oswald Avery, Colin MacLeod and Maclyn McCarty.

(*c*) Refer to Basic Concepts Point 6.

Q. 9. Answer the following questions based on Meselson and Stahl's experiment:

(*a*) Why did the scientists use $^{15}NH_4Cl$ and $^{14}NH_4Cl$ as sources of nitrogen in the culture medium for growing *E. coli*?

(*b*) Name the molecule(s) that ^{15}N got incorporated into.

(*c*) How did they distinguish between ^{15}N labelled molecules from ^{14}N ones?

(*d*) Mention the significance of taking the *E. coli* samples at definite time intervals for observations.

(*e*) Write the observations made by them from the samples taken at the end of 20 minutes and 40 minutes respectively.

(*f*) Write the conclusion drawn by them at the end of their experiment. **[*CBSE (F) 2012*]**

Ans. (*a*) ^{15}N is the heavy isotope of nitrogen and it can be separated from ^{14}N based on the difference in their densities.

(*b*) ^{15}N was incorporated into newly synthesised DNA.

(*c*) The two molecules were distinguished by caesium chloride centrifugation in which these two separated into two different bands at different positions based on their densities.

(*d*) *E. coli* culture is taken at equal intervals to know the progress of the experiment as generation time of *E. coli* is 20 minutes.

(*e*) After 20 minutes the culture had an intermediate density showing a band in the middle tube and after 40 minutes, the culture had equal amounts of hybrid DNA and the light DNA showing two bands, one in the centre and one at the bottom.

(*f*) They concluded that DNA replicates semi-conservatively.

Q. 10. (*a*) What did Meselson and Stahl observe when

(*i*) they cultured *E. coli* in a medium containing $^{15}NH_4Cl$ for a few generations and centrifuged the content?

(*ii*) they transferred one such bacterium to the normal medium of NH_4Cl and cultured for 2 generations?

(*b*) What did Meselson and Stahl conclude from this experiment? Explain with the help of diagrams.

(*c*) Which is the first genetic material? Give reasons in support of your answer.

Ans. (*a*) (*i*) Meselson and Stahl observed that in the *E. coli* bacterium the DNA becomes completely labelled with ^{15}N medium after few generations.

(*ii*) After two generations, they observed that density changed and showed equal amount of light DNA (^{14}N) and dark hybrid DNA (^{15}N–^{14}N).

(*b*) They concluded that DNA replicates semi-conservatively.

For diagram, refer to Fig. 6.8.

(*c*) RNA is the first genetic material.

Reasons:

(*i*) RNA is highly reactive and acts as a catalyst as well as a genetic material.

(*ii*) Essential life processes such as metabolism, translation and splicing evolved around RNA.

(*iii*) It expresses itself through proteins.

Q. 11. Describe the Hershey–Chase experiment. Write the conclusion they arrived at after the experiment. **[*CBSE (AI) 2010, 2014; (F) 2012*]**

OR

How did Hershey and Chase established that DNA is transferred from virus to bacteria? **[*CBSE Delhi 2015*]**

Ans. Refer to Basic Concepts Point 8.

Q. 12. You are repeating the Hershey–Chase experiment and are provided with two isotopes: ^{32}P and ^{15}N (in place of ^{35}S in the original experiment). How do you expect your results to be different? **[*NCERT Exemplar*] [*HOTS*]**

Ans. Use of ^{15}N will be inappropriate because method of detection of ^{35}P and ^{15}N is different (^{32}P being a radioactive isotope while ^{15}N is not radioactive but is the heavier isotope of nitrogen). Even if ^{15}N was radioactive then its presence would have been detected both inside the cell (^{15}N incorporated as nitrogenous base in DNA) as well as in the supernatant because ^{15}N would also

get incorporated in amino group of amino acids in proteins). Hence, the use of ^{15}N would not give any conclusive results.

Q. 13. Answer the following questions based on Hershey and Chases's experiments:

(*a*) Name the kind of virus they worked with and why.

(*b*) Why did they use two types of culture media to grow viruses in? Explain.

(*c*) What was the need for using a blender and later a centrifuge during their experiments?

(*d*) State the conclusion drawn by them after the experiments. ***[CBSE Delhi 2016]***

Ans. (*a*) They worked with bacteriophage because when it attacks a bacteria it only inserts its genetic material in its body.

(*b*) They grew some viruses on a medium that contained radioactive phosphorus and some others on medium that contained radioactive sulphur. Viruses grown in the presence of radioactive phosphorus contained radioactive DNA but not radioactive protein because DNA contains phosphorus but protein does not. Similarly, viruses grown on radioactive sulphur contained radioactive protein but not radioactive DNA because DNA does not contain sulphur.

(*c*) Blender was used to agitate the bacteria to remove the viral coats from them. Centrifuge was used to separate virus particle from the bacteria.

(*d*) Bacteria which was infected with viruses that had radioactive DNA were radioactive, indicating that DNA was the material that passed from the virus to the bacteria. Bacteria that were infected with viruses that had radioactive proteins were not radioactive. This indicates that proteins did not enter the bacteria from the viruses. DNA is therefore the genetic material that is passed from virus to bacteria.

Q. 14. (*a*) Write the conclusion drawn by Griffith at the end of his experiment with *Streptococcus pneumoniae*.

(*b*) How did O. Avery, C MacLeod and M. McCarty prove that DNA was the genetic material? Explain. ***[CBSE (AI) 2013]***

Ans. (*a*) At the end of his experiments Griffith concluded that transformation of R strain by the heat-killed S strain indicated the presence of a transforming principle or genetic material. This transforming principle made the R strain virulent.

(*b*) They purified biochemicals (proteins, DNA, RNA, etc.) from the heat-killed S cells. They discovered that DNA alone from S bacteria caused R bacteria to become transformed. They also discovered that protein-digesting enzymes (proteases) and RNA-digesting enzymes (RNases) did not affect transformation, so the transforming substance was not a protein or RNA. Digestion with DNase did inhibit transformation, suggesting that the DNA caused the transformation. They concluded that DNA is the hereditary material.

Q. 15. How did Alfred Hershey and Martha Chase conclusively establish that DNA is the genetic material? Explain. ***[CBSE (AI) 2014; (F) 2015]***

Ans. Refer to Basic Concepts Point 7.

Q. 16. Who proposed that DNA replication is semi-conservative? How was it experimentally proved by Meselson and Stahl?

Ans. Watson and Crick had proposed the semi-conservative scheme for replication of DNA.

For experimental proof, refer to Basic Concepts Point 10(*i*).

Q. 17. (*a*) Explain what DNA replication refers to.

(*b*) State the properties of DNA replication model.

(*c*) List any three enzymes involved in the process along with their functions.

[CBSE Sample Paper 2014]

Ans. (*a*) DNA replication refers to DNA synthesis: Refer to Basic Concepts 10(*iii*).

(*b*) DNA replication is :

(*i*) Semi-conservative,

(*ii*) Semi-discontinuous,

(*iii*) Unidirectional

(*c*) Refer to Basic Concepts Point 10(*ii*).

Q. 18. Describe Meselson and Stahl's experiment that was carried in 1958 on *E.coli*. Write the conclusion they arrived at after the experiment. ***[CBSE Delhi 2012; (AI) 2016; (F) 2014]***

Ans. Refer to Basic Concepts Point 10(*i*) and Fig. 6.8.

Q. 19. (*a*) Explain the observations of Meselson and Stahl when

(*i*) they cultured *E. coli* in a medium containing $^{15}NH_4Cl$ for a few generations and centrifuged the content.

(*ii*) they transferred one such bacterium to the normal medium of NH_4Cl and cultured for 2 generations?

(*b*) What does the above experiment prove?

(*c*) Which is the first genetic material identified?

Ans. (*a*) (*i*) Meselson and Stahl observed that in the *E. coli* bacterium the DNA becomes completely labelled with ^{15}N medium by centrifugation for few generations.

(*ii*) After two generations, density changed and showed equal amount of light DNA (^{14}N) and dark hybrid DNA (^{15}N–^{14}N).

(*b*) They concluded that DNA replicates semi-conservatively.

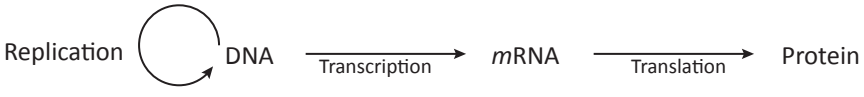
Refer to Fig. 6.8.

(*c*) Ribonucleic acid (RNA) was the first genetic material.

Q. 20. (*a*) State the 'Central dogma' as proposed by Francis Crick. Are there any exceptions to it? Support your answer with a reason and an example.

(*b*) Explain how the biochemical characterisation (nature) of 'Transforming Principle' was determined, which was not defined from Griffith's experiments. ***[CBSE Delhi 2018]***

Ans. (*a*) **Francis Crick** proposed the central dogma of molecular biology which states that genetic information flows from DNA to *m*RNA (transcription) and then from *m*RNA to protein (translation) always unidirectionally (except bidirectionally in some viruses and the process is called reverse transcription).



Yes, there are some exceptions to it. In some viruses flow of information is in reverse direction (reverse transcription).

(*b*) Refer to Basic Concepts Point 6.

Q. 21. (*a*) Explain the process of DNA replication that occurs in a replication fork in *E. coli*.

(*b*) How are translational unit and untranslated regions in *m*RNA different from each other? ***[CBSE (AI) 2013]***

Ans. (*a*) Refer to Basic Concepts Point 10(*iii*).

(*b*) A translational unit in *m*RNA from 5' → 3' comprises of a start codon, region coding for a polypeptide, a stop codon and untranslated regions (UTRs). UTRs are present at both 5'-end and 3'-end of *m*RNA.

Q. 22. (*a*) Name the stage in the cell cycle where DNA replication occurs.
(*b*) Explain the mechanism of DNA replication. Highlight the role of enzymes in the process.
(*c*) Why is DNA replication said to be semiconservative? **[*CBSE (AI) 2016*]**

Ans. (*a*) S-phase/synthetic phase (of interphase).
(*b*) Refer to Basic Concepts Point 10(*ii*) and (*iii*).
(*c*) During DNA replication in the two newly synthesised daughter DNA, one strand is parental (conserved) on the other is newly synthesised. That is why it is called semiconservative.

Q. 23. (*a*) Explain the process of DNA replication with the help of a schematic diagram.
(*b*) In which phase of the cell cycle does replication occur in Eukaryotes? What would happen if cell division is not followed after DNA replication? **[*CBSE Delhi 2014*]**

Ans. (*a*) Replication of DNA begins at *ori*, to form a replication fork. DNA dependent DNA polymerase forms a new strand in 5′ ⟶ 3′ direction. The replication is continuous on the 3′ ⟶ 5′ strand whereas it is discontinuous on the 5′ ⟶ 3′ strand.

The discontinuously synthesised fragments are later joined by the enzyme DNA ligase.

For diagram refer to Fig. 6.9.

(*b*) Replication occurs in S phase

If cell division is not followed after DNA replication, the cell will undergo polyploidy.

Q. 24. (*a*) Draw a labelled diagram of a "replicating fork" showing the polarity. Why does DNA replication occur within such 'forks'?
(*b*) Name two enzymes involved in the process of DNA replication, along with their properties. **[*CBSE (AI) 2015*]**

Ans. (*a*) For Figure, refer to Fig. 6.9.

The two strands of DNA cannot be separated in its entire length due to very high energy requirement. High amount of energy is required to break the hydrogen bonds holding the two strands. Therefore, the replication occurs in small opening of DNA strands called the replication fork.

(*b*) **(*i*) DNA dependent DNA polymerase:** adds nucleotides only in 5 to 3 directions.

(*ii*) DNA ligase: joins the discontinuously synthesised DNA fragments during replication.

Q. 25. (*a*) Write the specific features of the genetic code AUG. **[*CBSE (AI) 2013*]**
(*b*) Genetic codes can be universal and degenerate. Write about them, giving one example of each.
(*c*) Explain aminoacylation of the *t*RNA.

Ans. (*a*) AUG is the starting codon and codes for methionine.

(*b*) The genetic code is universal, *i.e.*, a particular codon codes for the same amino acid in all organisms. For example, UUU codes for phenylalanine in all organisms.

Some amino acids are coded by more than one codon, hence the code is degenerate. For example, UUU and UUC both code for phenylalanine.

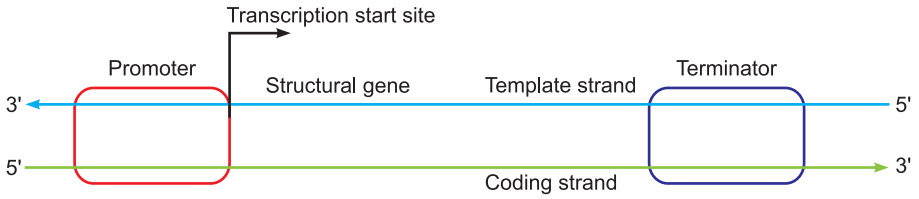
(*c*) Amino acids become activated by binding with aminoacyl *t*RNA synthetase enzyme in the presence of ATP.

$$\text{Amino acid (AA)} + \text{ATP} \xrightarrow{\text{Aminoacyl } t\text{RNA synthetase}} \text{AA–AMP–Enzyme complex} + \text{Pi}$$

These activated amino acids are then linked to their cognate *t*RNA to form aminoacylated *t*RNA.

Q. 26. Draw a labelled schematic structure of a transcription unit. Explain the function of each component in the unit in the process of transcription.

Ans. Schematic structure of a transcription unit:



(*i*) Promoter: It is the binding site for RNA polymerase for initiation of transcription.

(*ii*) Structural gene: It codes for enzyme or protein for structural functions.

(*iii*) Terminator: It is the region where transcription ends.

Q. 27. Explain the process of transcription in prokaryotes. How is the process different in eukaryotes? [*CBSE (AI) 2015*]

Ans. Refer to Basic Concepts Point 13 and 14.

Q. 28. Explain the process of transcription in eukaryotes. [*CBSE (F) 2015*]

Ans. Refer to Basic Concepts Point 14.

Q. 29. (*a*) Describe the process of transcription in bacteria.

(*b*) Explain the processing the *hn*RNA needs to undergo before becoming functional *m*RNA in eukaryotes. [*CBSE (AI) 2016*]

Ans. (*a*) Refer to Basic Concepts Point 13 and Fig. 6.11.

(*b*) Refer to Basic Concepts Point 14 (Post-transcriptional modification) and Fig. 6.12.

Q. 30. (*a*) Explain the role of DNA dependent RNA polymerase in initiation, elongation and termination during transcription in bacterial cell.

(*b*) How is transcription a more complex process in eukaryotic cells? Explain. [*CBSE (F) 2011*]

Ans. (*a*) The DNA dependent RNA polymerase helps in DNA replication by catalysing the polymerisation in only one direction, *i.e.*, 5′→3′. In bacteria, the RNA polymerase has co-factors β, β′, α, α′, ω and σ which catalyse the process. *Refer to the above question*.

(*b*) Refer to Basic Concepts Point 14.

Q. 31. Transcription in eukaryotes is more complex process than in prokaryotes. Justify and compare the initiation, elongation and termination in bacterial cells with eukaryotes. [*CBSE Sample Paper 2016*]

Ans. Transcription is more complex in eukaryotes due to following reasons:

- In prokaryotes only one type of RNA polymerase is involved whereas in eukaryotes three types of RNA polymerases are involved.
- For Description of processing of *hn*RNA involving-introns/exons/splicing in eukaryotes and for Description of capping and tailing, Refer to Basic Concepts Point 14.

Refer to Fig. 6.11 and Fig. 6.12.

Q. 32. Explain the role of RNA polymerase in transcription in bacteria. [*CBSE (F) 2013*]

Ans. Refer to Basic Concepts Point 13.

Q. 33. How do RNA, *t*RNA and ribosomes help in the process of translation? [*CBSE (AI) 2015*]

Ans. *m*RNA provides a template with codons for specific amino acids to be linked to form a polypeptide/protein.

*t*RNA brings amino acid to the ribosomes reads the genetic code with the help of its anti-codons, initiator *t*RNA is responsible for starting polypeptide formation in the ribosomes *t*RNAs are specific for each amino acid.

Ribosomes-(Cellular factories for proteins synthesis) its smaller sub unit binds with *m*RNA to initiate protein synthesis at the start codon AUG, in its larger sub unit there are two sites present which brings two amino acids close to each other helping them to form peptide bond. Ribosomes moves from codon to codon along *m*RNA, amino acids are added one by one to form polypeptide/protein.

Q. 34. (*a*) Describe the process of synthesis of fully functional *m*RNA in an eukaryotic cell.
(*b*) How is this process of *m*RNA synthesis different from that in prokaryotes?
[*CBSE (AI) 2012*]

Ans. (*a*) Refer to Basic Concepts Point 16 (Post-transcriptional modifications) and Fig. 6.12.

(*b*) In prokaryotes, there is a single DNA-dependent RNA polymerase that catalyses transcription of all types of RNA in bacteria. In bacteria, *m*RNA does not require any processing as it does not have any introns.

Q. 35. Name the major types of RNAs and explain their role in the process of protein synthesis in a prokaryote. **[*CBSE (F) 2014*]**

Ans. The three major types of RNAs are—*m*RNA, *t*RNA and *r*RNA.

***m*RNA:** It provides the template for protein synthesis. It also provides site to initiate and terminate the process of protein synthesis

***t*RNA:** Its anticodon loop reads the genetic code on *m*RNA and brings the corresponding amino acid bound to its amino acid binding end on to the *m*RNA.

***r*RNA:** It forms a structural component of ribosome (23S RNA) and acts as a catalyst for the formation of peptide bond.

Q. 36. Illustration below is a DNA segment, which constitutes a gene:

(*i*) Name the shaded and unshaded regions of gene.
(*ii*) Explain how these genes are expressed.
(*iii*) How is this gene different from prokaryotic gene in its expression? **[*HOTS*]**

Ans. (*i*) The shaded portions are introns and unshaded portions are exons.

(*ii*) The primary RNA contains both introns and exons. By the mechanism of splicing, introns are removed and exons are joined to form functional *m*RNA after capping and tailing. Refer to Basic Concepts Point 17 (Post-transcriptional modifications).

(*iii*) In prokaryotes, the structural gene is continuous and is not differentiated into exons and introns unlike eukaryotes. In prokaryotes, transcription is followed by translation without RNA splicing mechanism.

Q. 37. There is only one possible sequence of amino acids when deduced from a given nucleotide. But multiple nucleotide sequences can be deduced from a single amino acid sequence. Explain this phenomena. **[*HOTS*]**

Ans. Some amino acids are coded by more than one codon (known as degeneracy of codon), hence on deducing a nucleotide sequence from an amino acid sequence, multiple nucleotide sequences will be obtained.

For example, isoleucine has three codons AUU, AUC and AUA. Hence a dipeptide Met–Ile can have any of the following nucleotide sequences:

(*i*) AUG–AUU
(*ii*) AUG–AUC
(*iii*) AUG–AUA

If we deduce amino acid sequences of the above nucleotide sequences, all the three will code for Met–Ile.

Q. 38. Where do transcription and translation occur in bacteria and eukaryotes respectively? Explain the complexities in transcription and translation in eukaryotes that are not seen in bacteria. ***[CBSE (F) 2010]***

Ans. Transcription and translation in bacteria occur in the cytoplasm of the cell, whereas in eukaryotes, transcription occurs in the nucleus and translation occurs in the cytoplasm.

Complexities in transcription in eukaryotes

(*i*) The structural genes are monocistronic and split in eukaryotes.

(*ii*) The genes of eukaryotic organisms have coding or expressed sequences called exons that form the part of *m*RNA and non-coding sequences called introns, that do not form part of the *m*RNA and are removed during RNA splicing.

(*iii*) In eukaryotes, apart from the RNA polymerase found in the organelles, three types of RNA polymerases are found in the nucleus.

(*iv*) RNA polymerase I transcribes *r*RNAs (28S, 18S, and 58S).

(*v*) RNA polymerase II transcribes the precursor of *m*RNA (called as heterogeneous nuclear RNA (*hn*RNA).

(*vi*) RNA polymerase III helps in transcription of *t*RNA, 5S *r*RNA, and *sn*RNAs (small nuclear RNAs).

(*vii*) The primary transcripts contain both the coding regions called exons and non-coding regions called intron in RNA and are non-functional called *hn*RNA.

(*viii*) The *hn*RNA undergoes two additional processes called capping and tailing.

(*ix*) In capping, an unusual nucleotide is added to the 5′-end of *hn*RNA *i.e.* methyl guanosine triphosphate.

(*x*) In tailing, about 200-300 adenylate residues are added at 3′-end in a template independent manner.

(*xi*) Now the *hn*RNA undergoes a process where the introns are removed and exons are joined to form *m*RNA called splicing.

Translation in both eukaryotes and prokaryotes is similar.

Q. 39. (*a*) Explain the process of aminoacylation of *t*RNA. Mention its role in translation.

(*b*) How do ribosomes in the cells act as factories for protein synthesis?

(*c*) Describe 'initiation' and 'termination' phases of protein synthesis. ***[CBSE (F) 2011]***

Ans. (*a*) Aminoacylation is the process by which amino acids become activated by binding with its aminoacyl *t*RNA synthetase in the presence of ATP.

If two charged *t*RNAs come close during translation process, the formation of peptide bond between them in energetically favourable.

(*b*) The cellular factory responsible for synthesising proteins is the ribosome. The ribosome consists of structural RNAs and about 80 different proteins. In its inactive state, it exists as two subunits: a large subunit and a small subunit. When the small subunit encounters an *m*RNA, the process of translation of the *m*RNA to protein begins. There are two sites in the large subunit, for subsequent amino acids to bind to and thus, be close enough to each other for the formation of a peptide bond. The ribosome also acts as a catalyst (23S *r*RNA in bacteria is the enzyme ribozyme) for the formation of peptide bond.

(*c*) Refer to Basic Concepts Point 17.

Q. 40. (*a*) Name the scientist who postulated the presence of an adapter molecule that can assist in protein synthesis.

(*b*) Describe its structure with the help of a diagram. Mention its role in protein synthesis.

[*CBSE (F) 2014*]

Ans. (*a*) Francis Crick

(*b*) Refer to Basic Concepts Point 16 (Structure) and Fig. 6.13 for the structure.

The adapter molecule reads code with the help of anticodon loop and on the other end binds specific amino acids by peptide bond.

Q. 41. (*a*) What is an operon?

(*b*) Explain how a polycistronic structural gene is regulated by a common promoter and a combination of regulatory genes in a *lac* operon. **[*CBSE (AI) 2017*]**

Ans. (*a*) An operon is a polycistronic structural gene which is regulated by a common promoter and regulator gene.

(*b*) Refer to Basic Concepts Point 19.

Q. 42. Study the schematic representation of the genes involved in the *lac* operon given below and answer the questions that follow:

p	*i*	*p*	*o*	*z*	*y*	*a*

(*i*) Identify and name the regulatory gene in this operon. Explain its role in 'switching off' the operon.

(*ii*) Why is *lac* operon's regulation referred to as negative regulation?

(*iii*) Name the inducer molecule and the products of the genes '*z*' and '*y*' of the operon. Write the functions of these gene products. **[*CBSE (F) 2010*] [*HOTS*]**

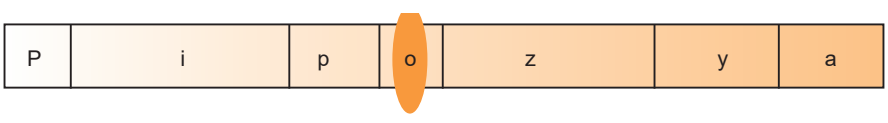
Ans. (*i*) *i* gene is the regulatory gene and codes of repressor which acts as inhibitor as inhibits the transcription of structural genes.

The repressor of the operon is synthesised from the *i* gene. The repressor protein in the absence of an inducer (lactose or allolactose) binds to the operator region of the operon and prevents RNA polymerase from transcribing the structural genes. Thus 'switching off' the operon.

(*ii*) Regulation by *lac* operon is referred to as negative regulation because the repressor binds to the operator for 'switching off' the operon.

(*iii*) Lactose or allolactose acts as an inducer. Gene *z* codes for β-galactosidase (*gal*) enzyme which breaks lactose into galactose and glucose. Gene *y* codes for permease, which increases the permeability of the cell to lactose.

Q. 43. Observe the representation of genes involved in the *lac* operon given below:



(*a*) Identify the region where the repressor protein will attach normally.

(*b*) Under certain conditions repressor is unable to attach at this site. Explain.

(*c*) If repressor fails to attach to the said site what products will be formed by *z*, *y* and *a*?

(*d*) Analyse why this kind of regulation is called negative regulation.

[*CBSE Sample Paper 2016*] [*HOTS*]

Ans. (*a*) The repressor protein will attach to operator region, *o*.

(*b*) In presence of an inducer, lactose, repressor is unable to attach.

(*c*) *z*—β galactosidase.

y—Permease

a—Transacetylase

(*d*) It is called negative regulation as it involves constitutive (all the time) repressor. The operon is always in off position due to presence of repressor and is switched on only in presence of an inducer. Inducer Lactose or allolactose interacts with repressor making it inactive.

Q. 44. (*a*) Absence of lactose in the culture medium affects the expression of a *lac* operon in *E. coli*. Why and how? Explain.

(*b*) Write any two ways in which the gene expression is regulated in eukaryotes.

Ans. (*a*) (*i*) When lactose is absent, *i* gene regulates and produces repressor *m*RNA which translate repression.

(*ii*) The repressor protein binds to the operator region of the operon and as a result prevents RNA polymerase to bind to the operon.

(*iii*) The operon is switched off.

(*b*) Gene expression in eukaryotes is regulated at following levels:

Transcriptional level (formation of primary transcripts)

Processing level (regulation of splicing)

Transport of messenger RNA from nucleus to the cytoplasm

Translational level. (*Any two*)

Q. 45. (*a*) State the arrangement of different genes that in bacteria is referred to as 'operon'.

(*b*) Draw a schematic labelled illustration of *lac* operon in a 'switched on' state.

(*c*) Describe the role of lactose in *lac* operon. **[*CBSE (AI) 2011*]**

Ans. (*a*) The operon has polycistronic structural genes, *i.e.*, three structural genes adjacent to an operator, a promoter and a regulator.

(*b*) Refer to Fig. 6.15(*b*).

(*c*) Lactose is the inducer that inactivates repressor. This allows RNA polymerase to access promoter and initiate transcription of the structural genes or switch on the operon.

Q. 46. Describe how the *lac* operon operates, both in the presence and absence of an inducer in *E.coli*. **[*CBSE (AI) 2014*]**

Ans. Refer to Fog. 6.15 (*a*) and (*b*).

The repressor is synthesised from the *i* gene. The repressor protein binds to the operator region and prevents RNA polymerase from transcribing the structural genes *zya*. In the presence of an inducer, the repressor is inactivated by interaction with inducer. This allows RNA polymerase access to promotor and transcription proceeds.

Q. 47. Explain the role of lactose as an inducer in a *lac* operon. **[*CBSE Delhi 2016*]**

Ans. Refer to Basic Concepts Point 19 or Fig. 6.15.

Q. 48. Explain the steps of DNA fingerprinting that will help in processing of the two blood samples A and B picked up from the crime scene.

Ans. **Methodology and Technique:**

(*i*) DNA is isolated and extracted from the cell or tissue by centrifugation.

(*ii*) By the process of polymerase chain reaction (PCR), many copies are produced. This step is called **amplification**.

(*iii*) DNA is cut into small fragments by treating with **restriction endonucleases**.

(*iv*) DNA fragments are separated by agarose gel electrophoresis.

(*v*) The separated DNA fragments are visualised under ultraviolet radiation after applying suitable dye.

(*vi*) The DNA is transferred from electrophoresis plate to nitrocellulose or nylon membrane sheet. This is called **Southern blotting**.

(*vii*) VNTR probes are now added which bind to specific nucleotide sequences that are complementary to them. This is called **hybridisation**.

(*viii*) The hybridised DNA fragments are detected by autoradiography. They are observed as dark bands on X-ray film.

(*ix*) These bands being of different sizes, give a characteristic pattern for an individual DNA. It differs from individual to individual except in case of monozygotic (identical) twins.

Q. 49. (*i*) DNA polymorphism is the basis of DNA fingerprinting technique. Explain.
(*ii*) Mention the causes of DNA polymorphism. ***[CBSE (F) 2010]***

Ans. (*i*) Allelic sequence variation has traditionally been described as a DNA polymorphism if its frequency is greater than 0.01. Simply, if an inheritable mutation is observed in a population at high frequency, it is referred to as DNA polymorphism. DNA fingerprinting is a technique of determining nucleotide sequences of certain areas of DNA which are unique to each individual.

Although the DNA from different individuals is more alike than different, there are many regions of the human chromosomes that exhibit a great deal of diversity. Such variable sequences are termed "polymorphic" (meaning many forms)

A special type of polymorphism, called VNTR (variable number of tandem repeats), is composed of repeated copies of a DNA sequence that lie adjacent to one another on the chromosome. Since polymorphism is the basis of genetic mapping of human genome, therefore it forms the basis of DNA fingerprinting too.

(*ii*) The probability of such variations to be observed in non-coding DNA sequences would be higher as mutations in these sequences may not have any immediate effect in an individual's reproductive ability. These mutations keep on accumulating generation after generation and form one of the basis of variability. There is a variety of different types of polymorphisms ranging from single nucleotide change to very large scale changes. For evolution and speciation, such polymorphisms play very important role.

The single nucleotide polymorphisms are used in locating diseases and tracing of human history.

DNA polymorphisms are due to mutations.

Q. 50. Two blood samples A and B picked up from the crime scene were handed over to the forensic department for genetic fingerprinting. Describe how the technique of genetic fingerprinting is carried out. How will it be confirmed whether the samples belonged to the same individual or to two different individuals?

Ans. Refer to Basic Concepts Point 22 (Methodology and technique).

On comparing the DNA prints of blood samples A and B, it can be confirmed that the blood sample picked up from the crime scene belongs to the same individual or to two different individuals by matching the position and thickness of the bands.

Q. 51. Which methodology is used while sequencing the total DNA from a cell? Explain it in detail. ***[CBSE Sample Paper 2015, 2017, 2018]***

Ans. Methodologies of HGP:

- For sequencing, the total DNA from cell is first isolated and broken down in relatively small sizes as fragments.

- These DNA fragments are cloned in suitable host using suitable vectors. When bacteria is used as vector, they are called **bacterial artificial chromosomes** (BAC) and when yeast is used as vector, they are called **yeast artificial chromosomes** (YAC).
- Frederick Sanger developed a principle according to which the fragments of DNA are sequenced by automated DNA sequences.
- On the basis of overlapping regions on DNA fragments, these sequences are arranged accordingly.
- For alignment of these sequences, specialised computer-based programmes were developed.
- These sequences were annotated and were assigned to each chromosome. Sequence of chromosome 1 was completed only in May 2006. It was the last chromosome be sequenced).
- Finally, the genetic and physical maps of the genome were constructed by collecting information about certain repetitive DNA sequences and DNA polymorphism, based on endonuclease recognition sites.
-

Self-Assessment Test

Time allowed: 1 Hour **Max. marks: 30**

1. Choose and write the correct option in the following questions. **(3×1 = 3)**

(i) If the base sequence of a codon in *m*RNA is 5′-AUG-3′, the sequence of *t*RNA pairing with it must be

(a) 5′-UAC-3′ (b) 5′-CAU-3′

(c) 5′-AUG-3′ (d) 5′-GUA-3′

(ii) The usual method of DNA replication is

(a) Conservative

(b) Dispersive

(c) Non-conservative

(d) Semi-conservative

(iii) A bacterium containing 100% N^{15} nitrogen bases is allowed to replicate in a medium containing N^{14} bases. After one round of duplication, the result would be

(a) All individuals would be identical to parents

(b) All individuals would be radioactive but the percentage of radioactivity in DNA would be 50%

(c) Only 50% individuals would be radioactive

(d) All individuals would be similar to parents but different among themselves

2. In the following questions a statement of assertion followed by a statement of reason is given. Choose the correct answer out of the following choices. **(3×1 = 3)**

(a) Assertion and reason both are correct statements and reason is correct explanation for assertion.

(b) Assertion and reason both are correct statements but reason is not correct explanation for assertion.

(c) Assertion is correct statement but reason is wrong statement.

(d) Assertion is wrong statement but reason is correct statement.

(i) **Assertion :** RNA does not have the ability to mutate.

Reason : RNA is unstable because of the presence of 2′–OH group.

(ii) **Assertion :** Replication of DNA in 3′ → 5′ strand is continuous.

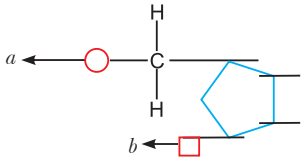
Reason : DNA-dependent DNA polymerase catalyse polymerisation only in one direction.

(iii) **Assertion :** Lactose is known to be the inducer and the substrate for the enzyme β-galactosidase.

Reason : Lactose binds to the operator region of the operon and prevents binding of RNA polymerase.

3. What is Chargaff's rule? **(1)**

4. Name the components 'a' and 'b' in the nucelotide with a purine, given below.



(1)

5. Given below is a part of the template strand of a structural gene:

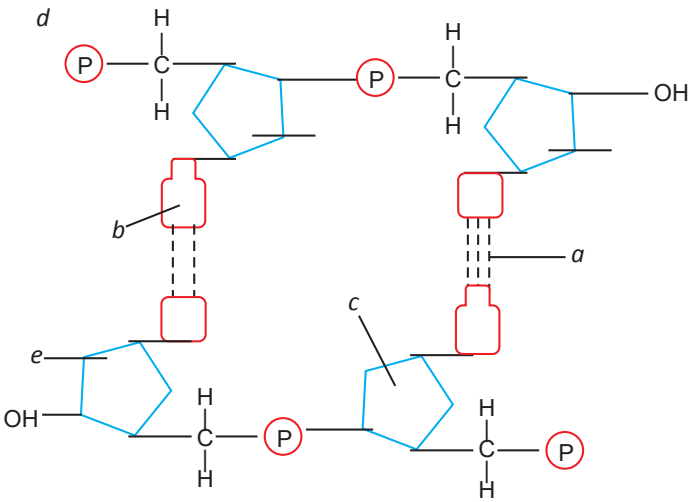
TAC CAT TAG GAT

(i) Write its transcribed *m*RNA strand with its polarity.

(ii) Explain the mechanism involved in initiation of transcription of this strand. **(2)**

6. Draw a neat labelled sketch of a replicating fork of DNA. **(2)**

7. Study the given portion of double stranded polynucleotide chain carefully. Identify a, b, c and the 5′-end of the chain. **(2)**



8. What is Central dogma? Who proposed it? **(2)**

9. Why is DNA considered a better hereditary material than RNA? [CBSE (F) 2012] **(3)**

10. (i) Differentiate between exons and introns.

(ii) State the contribution of Macleod, Mc Carty and Avery. **(3)**

11. The illustration below is of a DNA segment which constitute a gene. **(3×1 = 3)**

(i) Will the whole gene be transcribed in RNA primarily?

(ii) Name the shaded and unshaded part of the gene.

(iii) Explain how is gene expressed.

12. Name the scientists who proved experimentally that DNA is the genetic material. Describe their experiment. [CBSE Delhi 2012] **(5)**

Answers

1. (*i*)—(*b*), (*ii*)—(*d*), (*iii*)—(*b*) **2.** (*i*)—(*d*), (*ii*)—(*a*), (*iii*)—(*b*)

Evolution

basic concepts

- The study of life forms on earth is known as **evolutionary biology**.

1. Origin of the Universe

- Universe is around 20 billion years old and comprise of huge clusters of galaxies.
- **Galaxies** contain stars and clouds of gas and dust.
- The origin of universe is explained by the **Big Bang theory**.
- According to it, a huge explosion occurred, the universe expanded, temperature came down and hydrogen and helium were formed later. The galaxies were then formed due to condensation of gases under gravitation.
- Earth belongs to milky way galaxy.

2. Origin of Earth

- Earth was formed 4.5 billion years back.
- Initially, the surface was covered with water vapour, methane, CO_2 and NH_3 released from molten mass.
- The UV rays of the sun broke water into hydrogen and oxygen.
- Hydrogen, being lighter escaped and oxygen combined with NH_3 and CH_4 to form water, CO_2 and other gases, also forming the ozone layer.
- Cooling of water vapour led to rain which filled the depressions on earth's surface, forming water bodies.

3. Theories of Origin of Life

- Life appeared 500 million years after formation of earth.
- Different theories were given to explain the origin of life.
  - (*i*) **Theory of special creation:** According to this theory, God created life by his divine act of creation.
  - (*ii*) **Theory of panspermia/cosmozoic theory:** According to early Greek thinkers, units of life called spores or **panspermia** came from outer space and developed into living forms. This theory was rejected as spores cannot survive extreme cold, dryness or UV rays from Sun, which are required to be crossed to reach earth.

(*iii*) **Theory of spontaneous generation:** According to this theory, life originated from decaying and rotting matter like straw, mud, etc.

- **Louis Pasteur** dismissed the theory of spontaneous generation and demonstrated that life came from pre-existing life.
- He placed killed yeast in a pre-sterilised flask and in a flask open to air. He showed that life did not originate in the former but new living organisms arose in the latter.

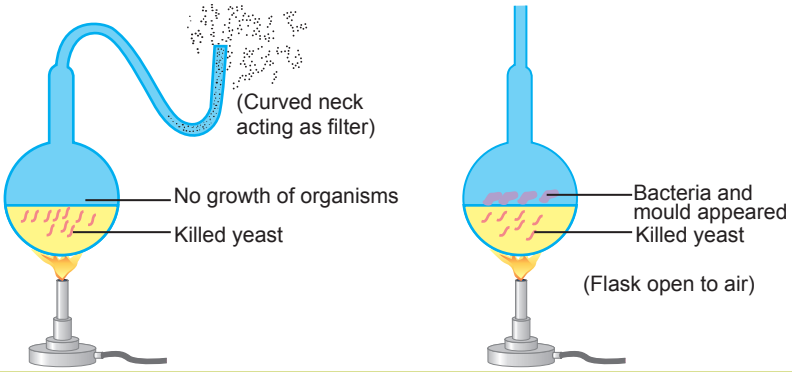


Fig. 7.1 Louis Pasteur's Experiment

(*iv*) **Theory of chemical evolution or Oparin–Haldane theory:** This theory was given by **Oparin and Haldane** and stated that life originated from pre-existing non-living organic molecules (*e.g.*, RNA, protein, etc.) and that formation of life was preceded by chemical evolution, *i.e.* formation of diverse organic molecules from inorganic constituents.

- The conditions on earth favouring chemical evolution were high temperature, volcanic storms, reducing atmosphere containing CH_4, NH_3, etc.

Experimental evidence of chemical evolution/Miller's experiment

- Experiment was performed by S.L. Miller and H.C. Urey in 1953.
- **Experimental set-up:** In a closed flask containing CH_4, H_2, NH_3 and water vapour at 800°C, electric discharge was created. The conditions were similar to those in primitive atmosphere.
- **Observations:** After a week, they observed presence of amino acids and complex molecules like sugars, nitrogen bases, pigments and fats in the flask.

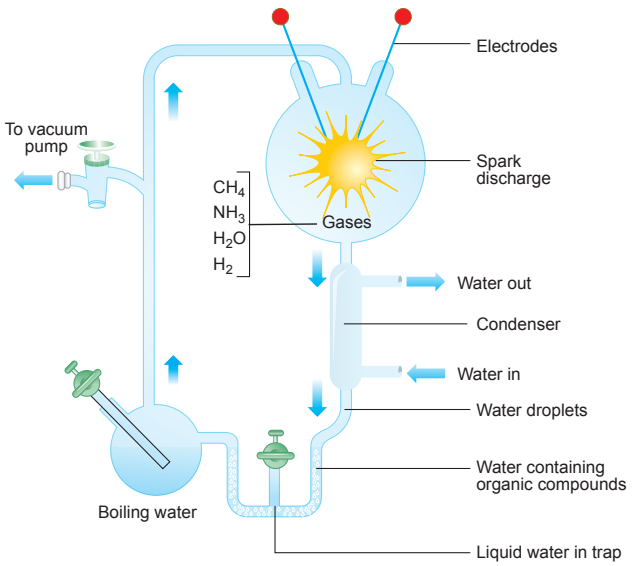


Fig. 7.2 Diagrammatic representation of Miller's experiment

- **Conclusions:**
  (*i*) It provides experimental evidence for the theory of chemical origin.
  (*ii*) It showed that the first non-cellular form of life was created about 3 billion years ago.
  (*iii*) It showed that non-cellular biomolecules exist in the form of DNA, RNA, polysaccharides and protein.

4. Formation of First Cell

- First non-cellular life-forms originated 3 millions years ago.
- These could be giant molecules like RNA, protein and polysaccharides, which might have reproduced themselves.
- First cellular form of life originated about 2000 million year ago.
- These might have been single-cells formed in aquatic environment.
- **Theory of Biogenesis,** *i.e.,* first form of life arose slowly through evolutionary forces from non-living molecules. However once formed, the first cellular forms evolved into complex biodiversity of today.

5. Evidences for Evolution

(i) Paleontological evidences

- The study of fossil is called **paleontology**.
- **Fossils** are the remains or impressions of past organisms preserved in sedimentary rocks or other media.
- Different-aged rock sediments in earth's crust indicate the presence of fossils of different life forms which died during the sediment formation.
- A variety of fossils ranging from the modern organisms to extinct organisms can be observed.
- By studying the different sedimentary layers, the geological time period in which the organism existed can be predicted, *e.g.*, Dinosaurs.

(ii) Morphological and comparative anatomical evidences

- The phylogenetic history can be revealed by comparative study of external and internal structures.

A. Homologous Organs

(*a*) The organs with same structural design and origin but different functions are called **homologous organs**. For example, the forelimbs of some animals like whales, bats, cheetah and humans have similar anatomical structure, *i.e.*, all have humerus, radius, ulna, carpals, metacarpals and phalanges.

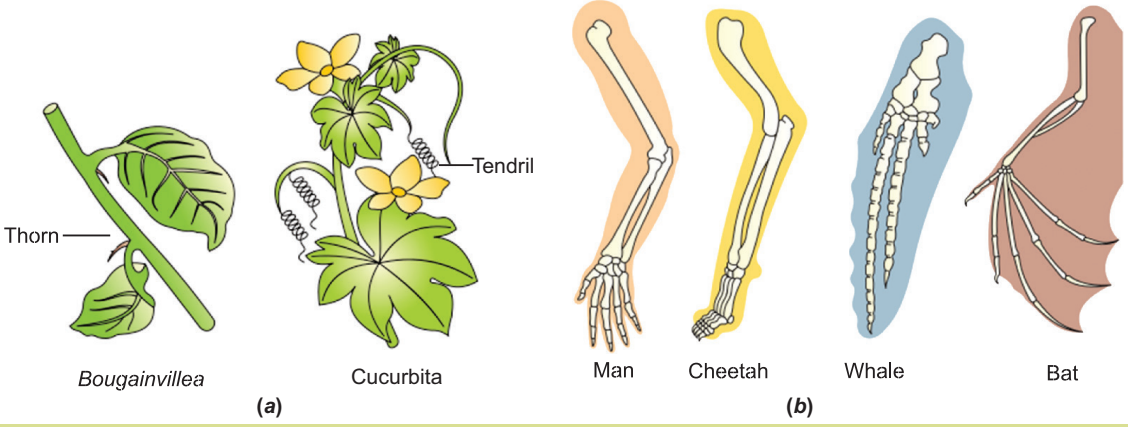


Fig. 7.3 Examples of homologous organs in (*a*) plants and (*b*) animals

(*b*) Due to different needs, some structures developed differently. This is called **divergent evolution**.

(*c*) Homology indicates common ancestry.

(*d*) Other examples include vertebrate hearts or brains in animals, thorn and tendrils of *Bougainvillea* and *Cucurbita* in plants.

B. Analogous Organs

(*a*) The organs which are anatomically different but functionally similar are called **analogous organs**. For example, wings of butterfly and birds.

(*b*) Due to same function, different structures evolve similarly. This is called **convergent evolution**.

(*c*) Other examples include eye of octopus and mammals.

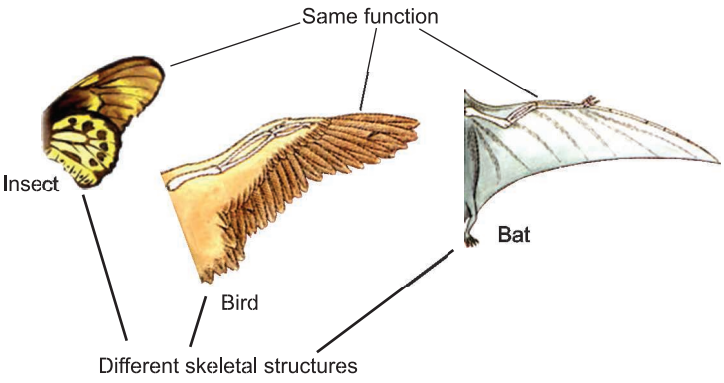


Fig. 7.4 Analogous organs

(*d*) Flippers of penguins and dolphins.

(*e*) Sweet potato (root modification) and potato (stem modification).

(*f*) Similar habitat resulted in selection of similar adaptive features in different groups of organs but towards the same functions.

(iii) Biochemical evidence

- The similarities in proteins and genes performing a common given function among diverse organisms give clues to common ancestry.
- The metabolic processes in organisms are also similar with same new materials and end products.

(iv) Biogeographical evidence

- Species restricted to a region develop unique features. Also, species present in widely separated regions show similarity of ancestry.

6. Adaptive Radiation

- It is the process of evolution of different species in a given geographical area starting from a common point and radiating to other geographical areas (habitats). Examples:

(i) Darwin's finches

- Darwin travelled to Galapages Islands and observed many varieties of finches on the same island.
- All varieties had evolved from original seed-eating finches.
- With alteration in beaks some became insectivorous and some vegetarian.

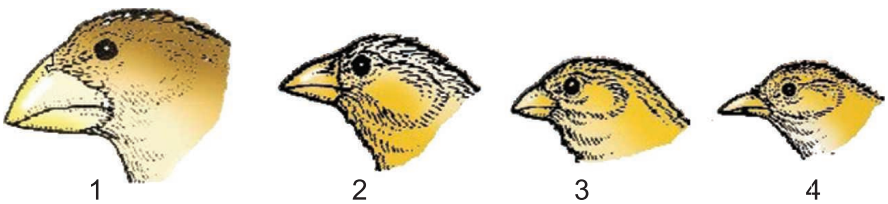


Fig. 7.5 Variety of beaks of finches that Darwin found in Galapagos Island

(ii) Placental animals in Australia

- A variety of placental mammals have evolved which appear similar to a corresponding marsupial. eg. Placental wolf and Tasmanian wolf.
- When more than one adaptive radiation appear to have occurred in an isolated geographical area (representing different habitats), and two or more groups of unrelated animals come to resemble each other for similar mode of life or habitat, it is called **convergent evolution**. For example, Australian marsupials, placental mammals.

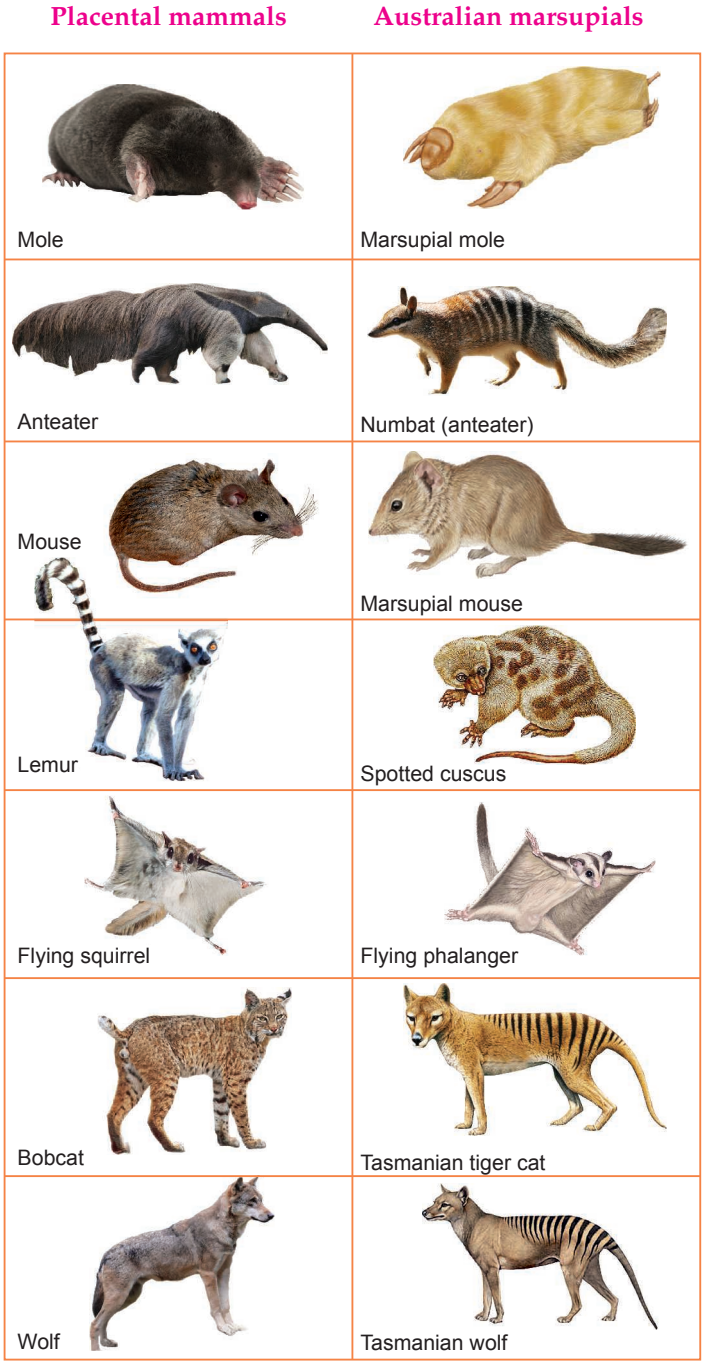


Fig. 7.6 Convergent evolution of Australian marsupials and placental mammals

(iii) Marsupials of Australia

- Within the Australian continent, many different marsupials or pouched animals are seen.
- These have evolved from a common ancestral stock, but all within the Australian island continent.

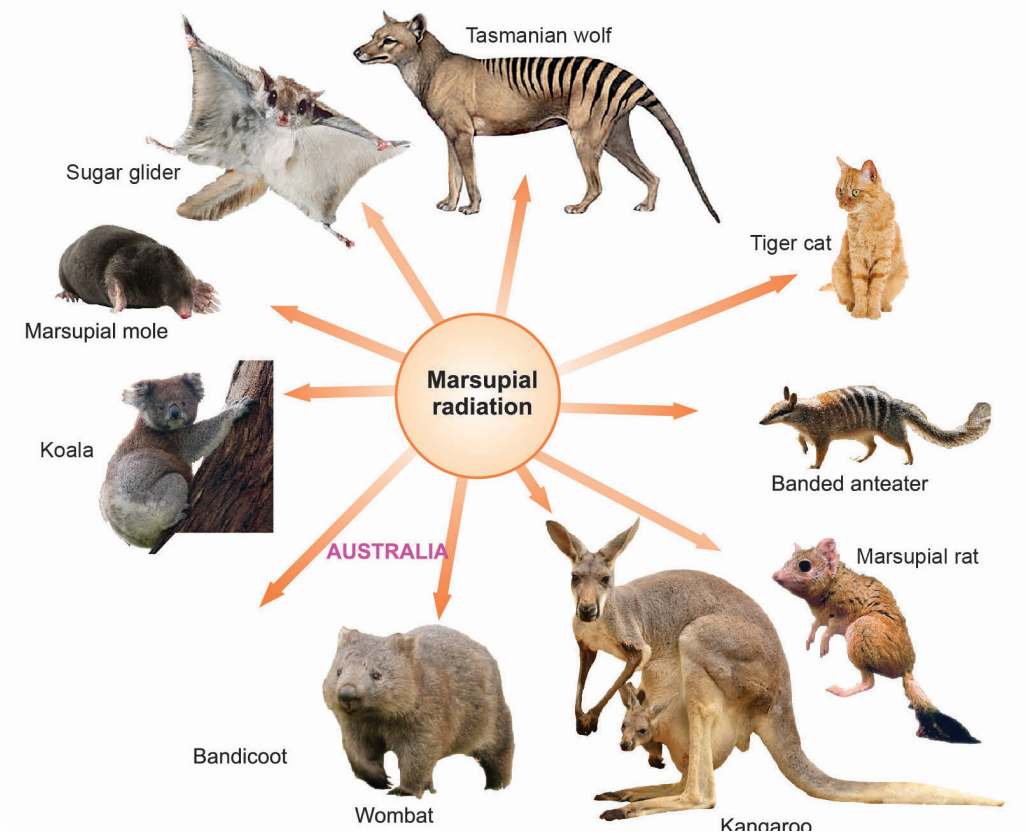


Fig. 7.7 Adaptive radiation of marsupials of Australia

7. Theories of Evolution (Biological Evolution)

(i) Lamarck's theory of evolution or Lamarckism

- According to **Lamarck**, evolution of life forms occurred due to use and disuse of organs.
- Example, giraffes initially did not have long necks. But to access leaves on tall trees, they had to adapt by elongating their necks. By passing this acquired character to succeeding generation, they acquired long necks.
- This theory is no more accepted.

(ii) Darwinian theory of evolution

- Charles Darwin, based on his observations during a sea voyage around the world in the ship H.M.S. Beagle, concluded the following:
  - Varying degrees of similarities can be observed between existing life forms and those that existed millions of years ago.
  - There has been **gradual evolution** of life forms with new forms arising at different periods of history.
  - Any population has built-in variations in characteristics which adapt it better to environment.
  - The characteristics which enable some populations or individuals to survive better in natural conditions (climate, food, physical factors) would out-breed others **(Survival of the fittest)**.

- Those populations which are better fit (reproductively fit) in an environment will be selected by nature and will survive more **(Natural selection)**.
- Adaptability is inherited and fitness is the end result of ability to adapt and get selected by nature.

- Natural selection is based on following factual observations:
  - Limited natural resources.
  - Stable population size except seasonal fluctuation.
  - Varying characteristics of members of a population.
  - Most of the variations are inherited.
  - Limited population size means there had been competition for resources.
- The two key concepts of Darwinian theory are **branching descent** (adaptive radiation) and **natural selection**.
- Theory of special creation has three connotations:
  (*a*) Organisms we see today were created as such.
  (*b*) The diversity was always the same since creation and will be same in future also.
  (*c*) Earth is about 4000 years old.
  - But these ideas were challenged during 19^{th} century based on Darwin's observations as stated above.
  - Alfred Wallace, worked in Malay Archepelago, obtained similar conclusions as Charles Darwin. All existing life forms share similarities and common ancestors as well but these ancestors were present at different periods in history of earth (epochs, periods and eras)
  - **Conclusions:**
    (*a*) Earth is very old, not thousand of years but billions of years.
    (*a*) Geological history of earth closely correlates with the biological history of earth.
- Examples of natural selection.
  (*a*) Industrial melanism:
  - In England, before industrialisation in 1850's, white-winged moths were more in number than dark-winged moths.
  - But after industrialisation in 1920's, dark-winged moths became more in number than white-winged moths.
  - This is because during industrialisation, the tree trunks covered by white lichens became dark due to deposition of dust and coal particles (soot and smoke).
  - As a result, white-winged moths could be easily picked up by predators from the dark background and dark-winged moths survived.
  - In mixed population, those that can better adapt, survived and there was increase in their population size.

  (*b*) Chemical resistance:
  - Excessive use of herbicides and pesticides has resulted in evolution of resistant varieties of microbes in much lesser time scale.
  - Microbes are also becoming resistant to antibiotics and drugs because of same reason.
  - As a result, pathogenic bacteria are appearing in very short period.

  (*c*) Man has bred selected plants and animals and thus created new breeds with in short period of times.

(iii) Mutation theory of evolution

- This was put forth by **Hugo de Vries** based on his work on evening-primrose (*Oenothera lamarckiana*).
- According to him, evolution is caused by sudden large differences in the population, *i.e.*, mutation and not the minor variations as per Darwin.
- He believed that mutation caused speciation and called it **saltation** or **single step large mutation**.
- Mutations are random and directionless in contrast to small directional variations as per Darwin.
- Evolution was gradual for Darwin while de Vries believed saltation.

8. Hardy–Weinberg Principle

- This principle states that allelic frequencies in a population are stable and remain constant from generation to generation, *i.e.*, gene pool (total number of genes and their alleles in a population) is constant. This is called **genetic equilibrium** or **Hardy–Weinberg equilibrium**.
- Sum total of all allelic frequencies is 1.
- It can be expressed as $p^2 + 2pq + q^2 = 1$ where p and q are frequencies of *AA* and *aa* respectively, and $2pq$ is of *Aa*.
- Disturbances in genetic equilibrium result in evolution.

9. Factors Affecting Hardy–Weinberg Equilibrium

- **Gene migration or gene flow:** When individuals migrate to another place or population, new genes or alleles are added to new population and are lost from old population, in turn changing the frequencies. When gene migration occurs many times, it is called **gene flow**.
- **Genetic drift:** Changes occurring in frequencies by chance is called **genetic drift**. Sometimes, due to changes in allele frequency in new population, some form a different species. This effect is called **founder effect** and the original drifted population is called **founder**.
- **Mutation:** Advantageous mutations lead to new phenotypes and over few generations, result in **speciation**.
- **Genetic recombination:** During gametogenesis, variations due to recombination result in new phenotypes.
- **Natural selection:** Heritable variations that enable survival of the fittest will leave greater number of progeny. Natural selection can have following three effects:

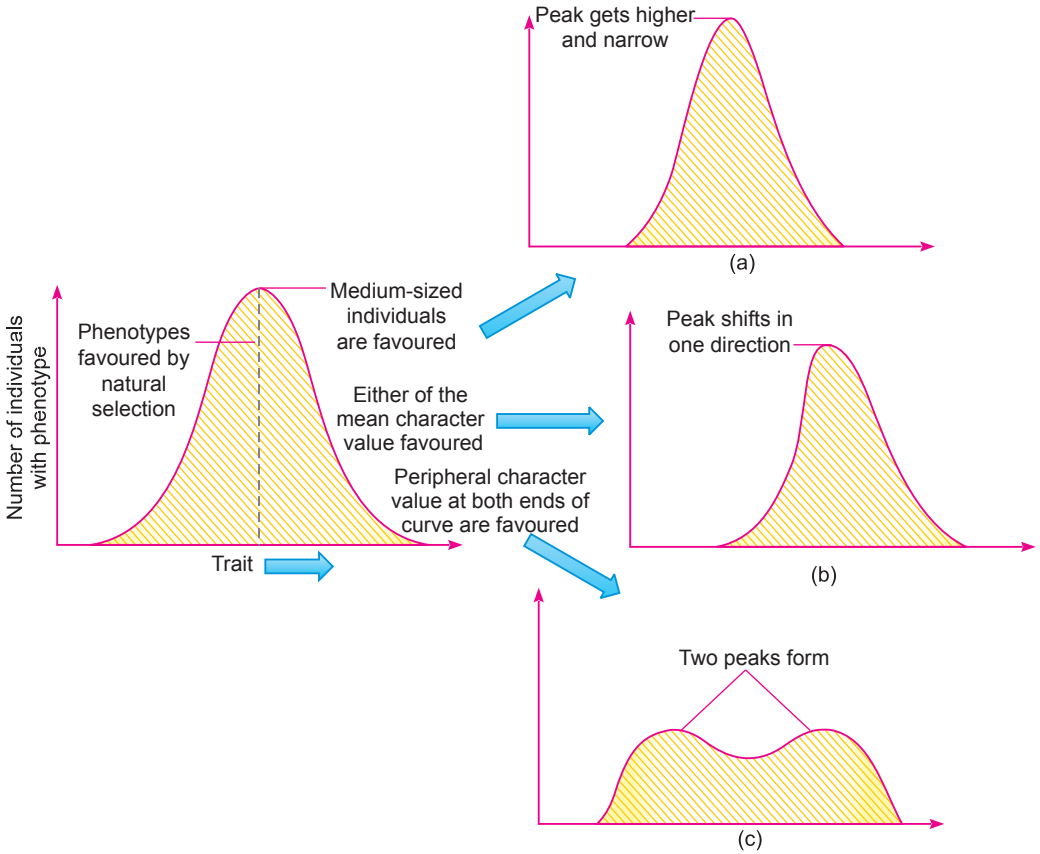


Fig. 7.8 Diagrammatic representation of the operation of natural selection on different traits: (a) Stabilising (b) Directional and (c) Disruptive

(*a*) **Stabilisation:** Larger number of individuals acquire mean character value so peak gets higher and narrower.

(*b*) **Directional change:** Large number of individuals acquire value other than mean character value so peak shifts in one direction.

(*c*) **Disruption:** Large number of individuals acquire peripheral character values at both ends of the distribution curve and hence 2 peaks are formed.

10. Brief Account of Evolution

- First cellular forms of life appeared around 2000 million years ago (mya).
- Some of these cells are said to release oxygen by splitting water with the help of solar energy captured by light harvesting pigments(as in light reaction in photosynthesis).
- Single-celled organisms eventually became multicellular.

(i) Evolution of plants

- Plants invaded land before animals.
- Bryophytes originated earlier than the vascular plants like pteridophytes and gymnosperms.
- The first vascular plants developed in Silurian period.
- Sea weeds and few plants existed around 320 mya.
- Giant ferns (pteridophytes) fell to form coal deposits slowly.

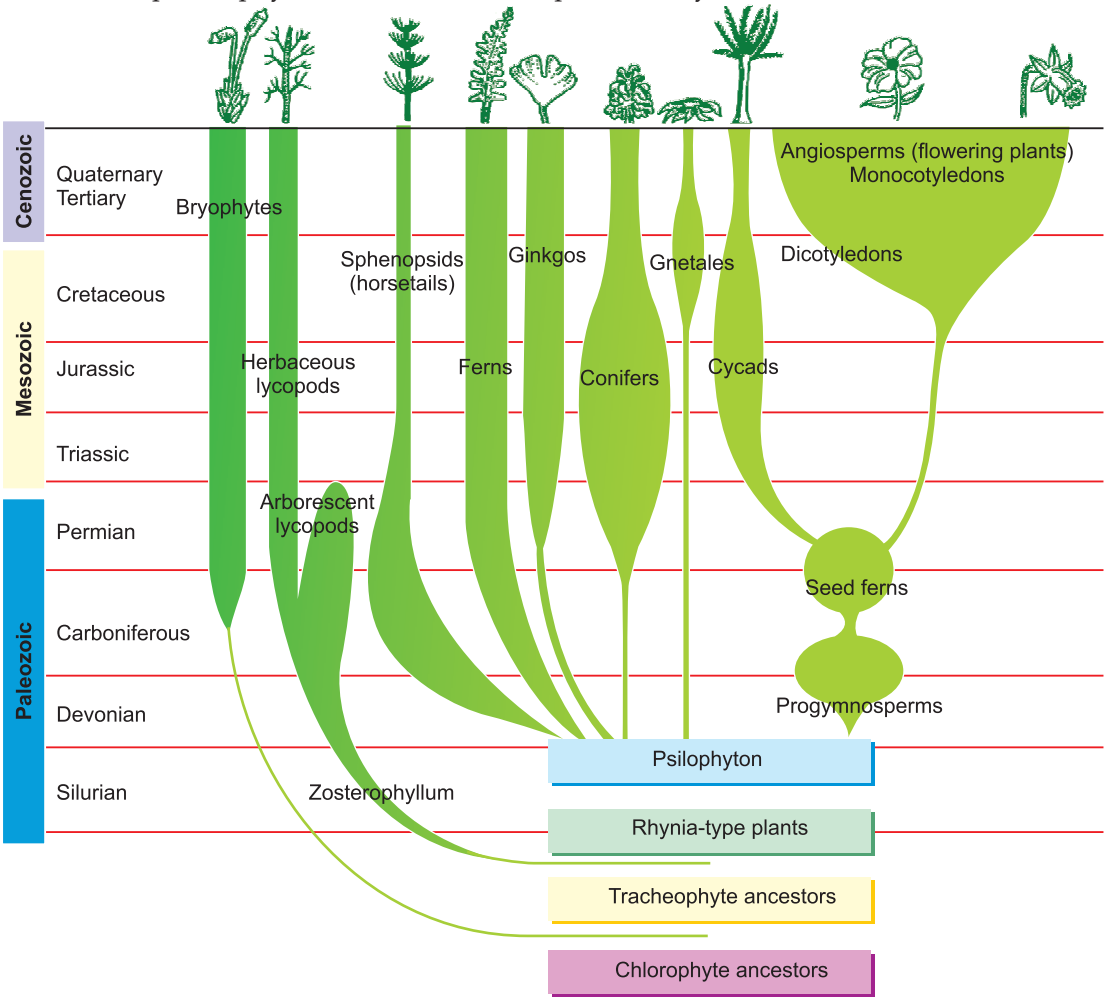


Fig. 7.9 A sketch of the evolution of plant forms through geological periods

(ii) Evolution of animals

- Around 500 mya, invertebrates originated and were active.
- Around 350 mya, jawless fish and amphibious fish with stout and strong fins originated.
- In 1938, a fish caught in South Africa, Coelocanth, which was thought to be extinct and were called lobefins.
- Lobefins were the first amphibians and ancestors of modern-day frogs.
- Around 200 mya, reptiles dominated the earth. They lay thick-shelled eggs which do not dry up in Sun, unlike those of amphibians.
- Some of land reptiles went back into water to evolve into fish-like reptiles 200 mya (*e.g.*, *Ichthyosaurs*).
- The land reptiles were dinosaurs, of which *Tyrannosaurus rex* was biggest. Tyrannosaurus rex was 20 feet height and had huge fearsome dagger-like teeth.
- Dinosaurs suddenly disappeared around 65 mya. Some say reptiles evolved into birds.
- The first mammals that evolved in Jurassic period were like shrews.
- Some mammals lived only in water, *e.g.*, whales, dolphins, seals and sea cows.

Table 7.1: Evolution of man

Human Ancestors	Time of Origin	General Features
1. *(a) Dryopithecus* *(b) Ramapithecus*	15 mya	Ape-like, hairy, arms and legs of same length, large brain, ate soft fruits and leaves, walked like gorillas and chimpanzees. More man-like, walked more erect, teeth like modern man.
2. *Australopithecus*	2 mya	Fossils found in Tanzania and Ethiopia, man-like primates, 4 feet tall, walked upright, ate fruit, hunted with stone weapons, brain capacity was 400–600 cc.
3. *Homo habilis*	2 mya	Fossils found in East Africa, first human-like being, brain capacity 650–800 cc, did not eat meat.
4. *Homo erectus* (Java man)	1.5 mya	Fossils found in Java, brain capacity 900 cc, ate meat.
5. *Homo sapiens neanderthalensis* (Neanderthal man)	100,000–40,000 year ago	Fossils found in east and central Asia, brain size 1400 cc, used hides to protect body, buried their dead.
6. *Homo sapiens* (Modern man)	75,000–10,000 years ago	Developed cave art, agriculture, started human civilisation.
	18,000 years ago	Prehistoric cave art developed.
	10,000 years back	Agriculture started.

NCERT Textbook Questions

Q. 1. Explain antibiotic resistance observed in bacteria in light of Darwinian selection theory.

Ans. Darwinian theory of natural selection states that environment selects organisms with favourable variation and these organisms thus survive and reproduce. It is observed when bacterial populations are exposed to certain antibiotic, the sensitive bacteria could not tolerate and hence died due to the adverse environment. Whereas some bacteria that developed mutation became resistant to the particular antibiotic and survived. As a result such resistant bacteria survive and multiply quickly as compared to other sensitive bacteria. So, the whole population is regained by multiplication of resistant variety and antibiotic resistant gene becomes widespread in the bacterial population.

Q. 2. Find out from newspapers and popular science articles any new fossil discoveries or controversies about evolution.

Ans. A recent study of fossil revealed a small terrestrial dinosaur with feathers covering the limb and body. This finding established that feathers evolved earlier than wing and may be functioning as thermoregulator to face adverse conditions. These newly developed feathers earlier helped in gliding and then flying.

Q. 3. Attempt giving a clear definition of the term species.

Ans. Species can be defined as a group of reproductively isolated population which can interbreed among each other.

Q. 4. Try to trace the various components of human evolution (hint: brain size and function, skeletal structure, dietary preference, etc.)

Ans. Refer to Table 7.1.

Q. 5. Find out through internet and popular science articles whether animals other than man has self-consciousness.

Ans. Many animals other than humans have self consciousness. For example, dolphins and chimpanzees are considered highly intelligent. They have a sense of self and they also recognise others among themselves and others. They communicate with each other by whistles, tail-slapping, and more body movements.

Q. 6. List 10 modern-day animals and using the internet resources link it to a corresponding ancient fossil. Name both.

Ans.

Table 7.2: List of modern day animals and their ancient fossils

S. No.	Modern day animals	Corresponding ancient fossil
(*i*)	Man	*Homo sapiens neanderthalensis*
(*ii*)	Chimpanzee	*Dryopithecus*
(*iii*)	Gorilla	*Dryopithecus*
(*iv*)	Orangutan	*Dryopithecus*
(*v*)	Gibbon	*Propliopithecus*
(*vi*)	Nautilus	*Gypceros*
(*vii*)	Octopus	*Belemnite*
(*viii*)	Elephant	*Stegolophodon*
(*ix*)	Camel	*Procamelus*
(*x*)	Horse	*Pliohippus*

Q. 7. Practice drawing various animals and plants.

Ans. Draw labelled diagrams of various animal and plants from your text book.

Q. 8. Describe one example of adaptive radiation.

Ans. Darwin's finches in the Galapagos Island once had a common ancestor but with evolution they modified into different types according to their food habitat.

Q. 9. Using various resources such as your school library or the internet and discussions with your teacher, trace the evolutionary stages of any one animal, say horse.

Ans. The evolution of horse is represented as

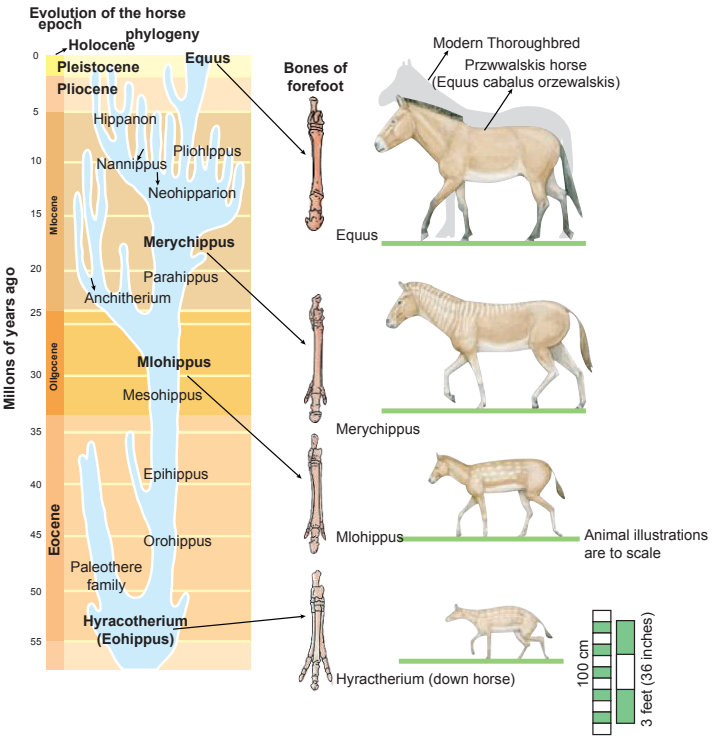
(*i*) ***Eohippus*:** This stage is characterised by a short head and neck. It had four functional toes and a splint of 1 and 5 on each hind limb and a splint of 1 and 3 in each forelimb. The molars were short crowned that were adapted for grinding the plant diet.

(*ii*) ***Mesohippus*:** It was slightly taller than Eohippus. It had three toes in each foot.

(*iii*) ***Merychippus*:** It had the size of approximately 100 cm. Although it still had three toes in each foot, but it could run on one toe. The side toe did not touch the ground. The molars were adapted for chewing the grass.

(*iv*) ***Pliohippus*:** It resembled the modern horse and was around 108 cm tall. It had a single functional toe with splint of second and fourth in each limb.

(*v*) ***Equus*:** *Pliohippus* gave rise to *Equus* or the modern horse with one toe in each foot. They have incisors for cutting grass and molars for grinding food.



Q. 10. Can we call human evolution as adaptive radiation?

Ans. No, human evolution cannot be called as adaptive radiation because parent species of *Homo sapiens* have evolved by progressive evolution from *Homo habilis* to *Homo erectus* lineage.

Multiple Choice Questions [1mark]

Choose and write the correct option in the following questions.

1. The concept of chemical evolution is based on

(*a*) interaction of water, air and clay under intense heat
(*b*) effect of solar radiation on chemicals
(*c*) possible origin of life by combination of chemicals under suitable environmental condition.
(*d*) crystallization of chemicals.

2. When two species of different genealogy come to resemble each other as a result of adaptation, the phenomenon is termed as

(*a*) microevolution (*b*) co-evolution
(*c*) convergent evolution (*d*) divergent evolution.

3. Which one of the following scientist's name is correctly matched with the theory put forth by him?

(*a*) de Vries – Natural selection
(*b*) Mendel – Theory of Pangenesis
(*c*) Weismann – Theory of continuity of germplasm.
(*d*) Pasteur – Inheritance of acquired characters.

4. Thorn of *Bougainvillea* and tendril of Cucurbita are examples of

(*a*) vestigial organs (*b*) retrogressive evolution
(*c*) analogous organs (*d*) homologous organs.

5. Darwin's Finches are an excellent example of

(*a*) brood parasitism (*b*) connecting links (*c*) adaptive radiation (*d*) seasonal migration.

6. Evolution of different species in a given area starting from a point and spreading to other geographical areas is known as

(*a*) adaptive radiation (*b*) natural selection (*c*) migration (*d*) divergent evolution.

7. The theory of spontaneous generation stated that [*NCERT Exemplar*]

(*a*) life arose from living forms only

(*b*) life can arise from both living and non-living

(*c*) life can arise from non-living things only.

(*d*) life arises spontaneously, neither from living nor from the non-living.

8. Palaentological evidences for evolution refer to the [*NCERT Exemplar*]

(*a*) development of embryo (*b*) homologous organs

(*c*) fossils (*d*) analogous organs.

9. The bones of forelimbs of whale, bat, cheetah and man are similar in structure, because [*NCERT Exemplar*]

(*a*) one organism has given rise to another (*b*) they share a common ancestor

(*c*) they perform the same function (*d*) they have biochemical similarities

10. Which of the following organs are homologous?

(*a*) Forelimbs of man and wings of bat (*b*) Wings of Bat and bird

(*c*) Wings of Bat and Petrodactyl (*d*) None of these

11. Homologous organs show

(*a*) natural selection (*b*) divergent evolution

(*c*) parallel evolution (*d*) convergent evolution

12. Analogous organs arise due to

(*a*) divergent evolution (*b*) artificial selection

(*c*) genetic drift (*d*) convergent evolution

13. Evolution of life shows that life forms had a trend of moving from [*NCERT Exemplar*]

(*a*) land to water (*b*) dryland to wet land

(*c*) fresh water to sea water (*d*) water to land

14. Viviparity is considered to be more evolved because [*NCERT Exemplar*]

(*a*) the young ones are left on their own

(*b*) the young ones are protected by a thick shell

(*c*) the young ones are protected inside the mother's body and are looked after they are born leading to more chances of survival

(*d*) the embryo takes a long time to develop

15. Fossils are generally found in [*NCERT Exemplar*]

(*a*) sedimentary rocks (*b*) igneous rocks

(*c*) metamorphic rocks (*d*) any type of rock

16. According to Hugo de Vries, speciation is due to

(*a*) accumulation of small variations (*b*) intraspecific breeding

(*c*) inter specific breeding (*d*) saltation

17. For the MN-blood group system, the frequencies of M and N alleles are 0.7 and 0.3, respectively The expected frequency of MN-blood group bearing organisms is likely to be [*NCERT Exemplar*]

(*a*) 42% (*b*) 49% (*c*) 9% (*d*) 58%

18. Which type of selection explains industrial melanism observed in moth, *Biston bitularia*? [*NCERT Exemplar*]

(*a*) Stabilising (*b*) Directional (*c*) Disruptive (*d*) Artificial

19. The most accepted line of descent in human evolution is

(*a*) *Australopithecus* → *Ramapithecus* → *Homo sapiens* → *Homo habilis*

(*b*) *Homo erectus* → *Homo habilis* → *Homo sapiens*

(*c*) *Ramapithecus* → *Homo habilis* → *Homo erectus* → *Homo sapiens*

(*d*) *Australopithecus* → *Ramapithecus* → *Homo erectus* → *Homo habilis* → *Homo sapiens.*

20. Which of the following is an example for link species? [*NCERT Exemplar*]

(*a*) Lobe fish (*b*) Dodo bird (*c*) Sea weed (*d*) Chimpanzee

21. Match the scientists listed under column 'I' with ideas listed column 'II'. [*NCERT Exemplar*]

Column I	Column II
A. Darwin	(*i*) Abiogenesis
B. Oparin	(*ii*) Use and disuse of organs
C. Lamarck	(*iii*) Continental drift theory
D. Wagner	(*iv*) Evolution by natural selection

(*a*) A-(*i*); B-(*iv*); C-(*ii*); D-(*iii*) (*b*) A-(*iv*); B-(*i*); C-(*ii*); D-(*iii*)

(*c*) A-(*ii*); B-(*iv*); C-(*iii*); D-(*i*) (*d*) A-(*iv*); B-(*iii*); C-(*ii*); D-(*i*)

22. Stabilising selection favours

(*a*) only one extreme form of a trait (*b*) both the extreme forms of a trait

(*c*) intermediate form of a trait (*d*) none of these

23. Disruptive selection favours

(*a*) only one extreme form of a trait (*b*) both the extreme forms of a trait

(*c*) intermediate form of a trait (*d*) none of these

24. The phenomenon of "Industrial melanism" demonstrates

(*a*) natural selection (*b*) induced mutation

(*c*) genetic drift (*d*) geographical isolation

25. In 1953, S. L. Miller created primitive earth conditions in the laboratory and gave experimental evidence for origin of first form of life from pre-existing non-living organic molecules. The primitive earth conditions created include [*NCERT Exemplar*]

(*a*) low temperature, volcanic storms, atmosphere rich in oxygen

(*b*) low temperature, volcanic storms, reducing atmosphere

(*c*) high temperature, volcanic storms, non-reducing atmosphere

(*d*) high temperature, volcanic storms, reducing atmosphere containing CH_4, NH_3, etc.

26. Which is correct formula of Hardy-Weinberg's law?

(*a*) $p^2 + pq + q^2 = 0$ (*b*) $p^2 + pq + q^2 = 1$

(*c*) $p^2 + pq + q^2 =$ infinity (*d*) $p^2 + 2pq + q^2 = 1$

Answers

1. (*c*)	**2.** (*c*)	**3.** (*c*)	**4.** (*d*)	**5.** (*c*)	**6.** (*a*)	**7.** (*c*)	**8.** (*c*)	**9.** (*b*)	**10.** (*a*)
11. (*b*)	**12.** (*d*)	**13.** (*d*)	**14.** (*c*)	**15.** (*a*)	**16.** (*d*)	**17.** (*a*)	**18.** (*b*)	**19.** (*c*)	**20.** (*d*)
21. (*b*)	**22.** (*c*)	**23.** (*b*)	**24.** (*a*)	**25.** (*d*)	**26.** (*d*)				

Assertion-Reason Questions

In the following questions a statement of assertion followed by a statement of reason is given. Choose the correct answer out of the following choices.

(a) Assertion and reason both are correct statements and reason is correct explanation for assertion.

(b) Assertion and reason both are correct statements but reason is not correct explanation for assertion.

(c) Assertion is correct statement but reason is wrong statement.

(d) Assertion is wrong statement but reason is correct statement.

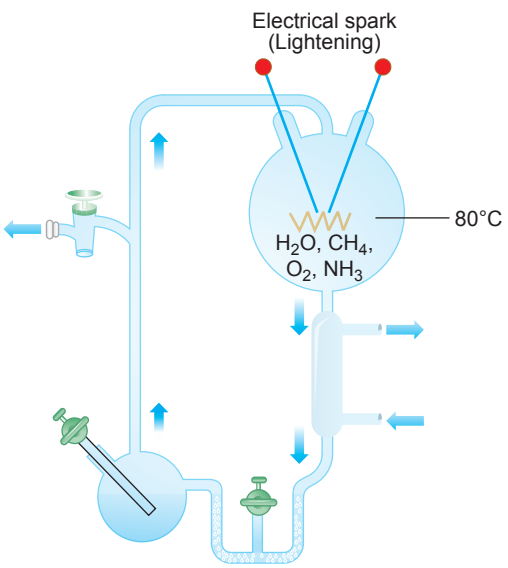
1. **Assertion :** Louis Pasteur's experiments showed that new organisms appeared in an open flask with heat-killed yeast.
   Reason : Life arises from pre-existing life
2. **Assertion :** Wings of butterfly and birds show analogy.
   Reason : Analogous organs are anatomically different but functionally similar.
3. **Assertion :** Disruptive selection changes the population into two or more groups.
   Reason : This type of selection favours average sized individuals.
4. **Assertion :** The earliest cells used RNA as their hereditary molecule.
   Reason : DNA evolved from RNA.
5. **Assertion :** Hardy Weinberg principle explains the occurrence of variations in population and species.
   Reason : It concludes that disturbances in genetic equilibrium results in evolution.
6. **Assertion :** Founder effect may lead to formation of new species.
   Reason : Founders carry all the parental gene pool to a new location.
7. **Assertion :** Excessive use of herbicides and pesticides has no effect on resistant varieties of microbes.
   Reason : Pathogenic bacteria are appearing in very short period of time because of chemical resistance.
8. **Assertion :** Darwin's finches have different types of modified beaks according to their feeding habits.
   Reason : Adaptive radiation leads to development of structures with different function arising from a common ancestor.
9. **Assertion :** Genetic drift refers to changes in allele frequency.
   Reason : Heritable variations enable survival of the fittest.
10. **Assertion :** Among the primates, chimpanzee is the closest relative of the present day humans.
    Reason : DNA matching shows that human similarity is 100% with chimpanzee.

Answers

1. (*b*) **2.** (*a*) **3.** (*c*) **4.** (*b*) **5.** (*d*) **6.** (*c*) **7.** (*d*) **8.** (*a*) **9.** (*b*) **10.** (*a*)

Case-based/Source-based Question

1. **A student was simulating Urey and Miller's experiment to prove the origin of life. The set-up used by the student is given.**



(*i*) Find out the reasons why he could not get desired results.

(*ii*) What conclusion was drawn by Urey and Miller through this experiment?

(*iii*) Compare the conclusion drawn with the theory of spontaneous generation.

Ans. (*i*) He could not get desired results because:

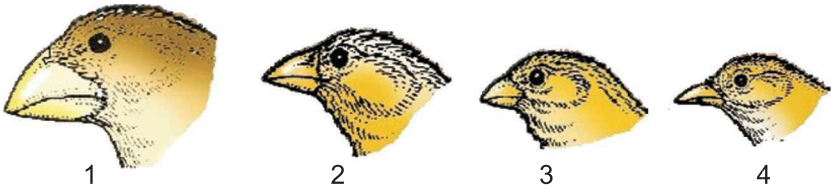
(*a*) O_2 was used instead of H_2.

(*b*) Temperature maintained was 80°C instead of 800°C.

(*ii*) It was concluded that life could have come from pre-existing non-living organic molecules and their formation was preceded by chemical evolution.

(*iii*) Urey and Miller proved that life originated abiogenetically whereas theory of spontaneous generation emphasised that units of life called spores were transferred to different planets including Earth.

2. Darwin found the varieties of finches that in travelled to Galapagos Islands and observed variations in them.



(*i*) What role does an individual organism play as per Darwin's theory of natural selection?

(*ii*) How did Darwin explain the existence of different varieties of finches on Galapagos Islands?

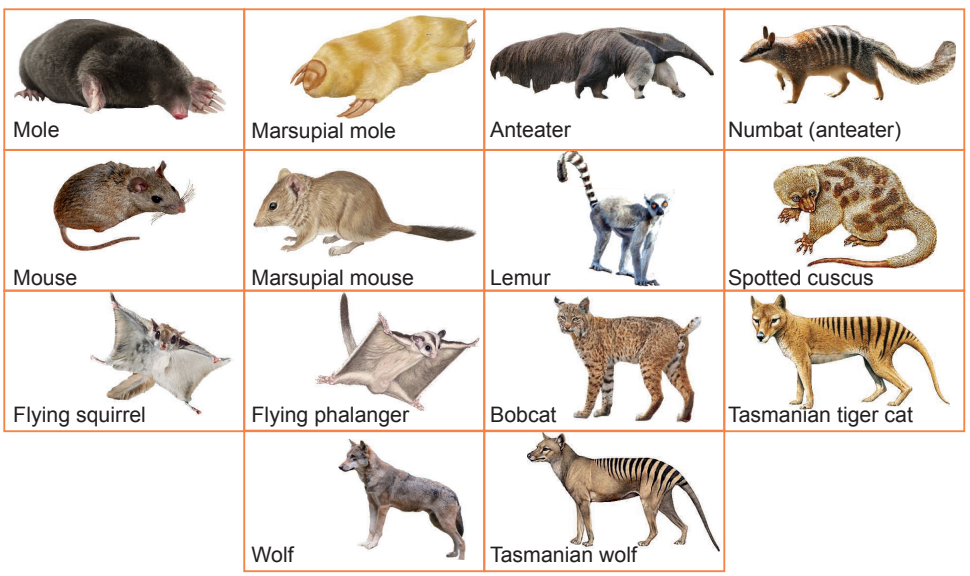
(*iii*) What is "fitness of an individual" according to Darwin?

Ans. (*i*) An individual organism passes on the variations, mutations and adaptations from one generation to another.

(*ii*) Darwin explained it as the process of evolution of different species in a given geographical area starting from a point and literally radiating to other areas of geography (habitats), called adaptive radiation.

(*iii*) According to Darwin, "fitness of an individual" is the ability of an organism to survive and pass on its genes to future generations.

3. Study the diagram given below and answer the following questions:



(*i*) Mention the specific geographical region where these organisms are found.

(*ii*) Name and explain the phenomenon that has resulted in the evolution of such diverse species in the region.

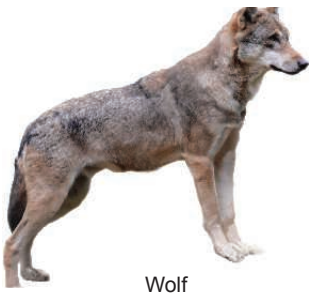
(*iii*) Explain giving reasons the existence of placental wolf and Tasmanian wolf sharing the same habitat.

Ans. (*i*) Australia

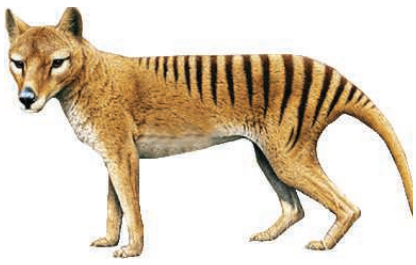
(*ii*) Adaptive radiation (Divergent evolution) has resulted in this evolution. The process of evolution of different species in a given geographical area starting from a point and radiating to other areas of geography (habitats) is called adaptive radiation. It is the development of different functional structures from a common ancestral form.

(*iii*) Placental wolf and Tasmanian wolf share similar habitat due to convergent evolution and evolved into unrelated group of organisms.

4. Refer to the figure given below and answer the questions that follow:



Wolf



Tasmanian wolf

(*i*) Recognise and explain the process by which Tasmanian wolf evolved.

(*ii*) Give one example of an animal that has evolved along with Tasmanian wolf. Name the process that result in evolution of wolf and Tasmanian wolf.

(*iii*) Compare and contrast the two animals shown.

Ans. (*i*) **Tasmanian wolf evolved by the process of adaptive radiation.** It is the process of evolution of different species in a given geographical area starting from a point and literally radiating to other areas of geography (habitats).

(*ii*) **Examples of animals:** Tiger cat/banded ant eater/Marsupial rat. Convergent evolution has resulted in evolution of wolf and Tasmanian wolf.

(*iii*) Wolf is a placental mammal, whereas Tasmanian wolf is a marsupial mammal.

Very Short Answer Questions [1 mark]

Q. 1. Name the scientist who disproved spontaneous generation theory. ***[CBSE Delhi 2010]***

Ans. Louis Pasteur disproved the theory of spontaneous generation.

Q. 2. What did Louis Pasteur's experiment on 'killed yeast' demonstrate? Name the theory that got disproved on the basis of his experiment. ***[CBSE (F) 2013]***

Ans. Louis Pasteur demonstrated that life comes only from pre-existing life. The theory of spontaneous generation was disproved on the basis of his experiment.

Q. 3. When does a species become founders to cause founder effect? ***[CBSE (F) 2010]*** ***[HOTS]***

Ans. When the change in the alleles frequency is so different in the new sample of population that they become a different species, the original drifted population becomes founder.

Q. 4. Write the hypothetical proposals put forth by Oparin and Haldane. ***[CBSE (AI) 2013; (F) 2015]***

OR

State two postulates of Oparin and Haldane with reference to origin of life. ***[CBSE (AI) 2017]***

Ans. Oparin and Haldane proposed that life originated from pre-existing non-organic molecules and the diverse organic molecules were formed from these inorganic constituents by chemical evolution *i.e.*, formation of life was preceded by chemical evolution.

Q. 5. Life originated from earth's inorganic atmosphere in past but not today. Suggest two reason. **[*HOTS*]**

Ans. (*i*) Presence of free oxygen in present day atmosphere.
(*ii*) Very high temperatures.

Q. 6. How can you suggest that biochemistry gives evidence for organic evolution? **[*HOTS*]**

Ans. In the same species or group of organisms, similar type of proteins are found, thus supporting organic evolution.

Q. 7. State the significance of the study of fossils in evolution. **[*CBSE Delhi 2012*]**

Ans. Fossils represent extinct organisms. They show life forms restricted to certain geological time spans existing in the past. Show ancestry of present day organisms are connecting links between two groups of organisms. (*Any one*)

Q. 8. What is fossil?

Ans. Fossils are the remains or impressions of ancient organisms preserved in sedimentary rocks or other media.

Q. 9. How do we compute the age of a fossil? **[*NCERT Exemplar*]**

Ans. By radiocarbon dating.

Q. 10. Identity the examples of convergent evolution from the following: **[*CBSE Delhi 2013*]**

(*i*) Flippers of penguins and dolphins
(*ii*) Eyes of octopus and mammals
(*iii*) Vertebrate brains

Ans. (*i*) Flippers of penguins and dolphins
(*ii*) Eyes of octopus and mammals

Q. 11. Mention one example each from plants and animals exhibiting divergent evolution. **[*CBSE 2019 (57/2/1)*]**

Ans. Thorn of *Bougainvillea* and tendrils of *Cucurbita*, forelimbs of whales, bats, cheetah and humans (all mammals)/vertebrate hearts/vertebrates brains. (*Any one*)

Q. 12. Identify the examples of homologous structures from the following:

(*i*) Vertebrate hearts
(*ii*) Thorns in *Bougainvillea* and tendrils of *Cucurbita*.
(*iii*) Food storage organs in sweet potato and potato. **[*CBSE Delhi 2013*]**

Ans. (*i*) Vertebrate hearts
(*ii*) Thorns in *Bougainvillea* and tendrils of *Cucurbita*.

Q. 13. Write the similarity between the wing of a butterfly and the wing of a bat. What do you infer from the above with reference to evolution? **[*CBSE Delhi 2012*] [*HOTS*]**

Ans. Wings of a bird and a bat perform the same function of flying despite their structural dissimilarity. This infers that they are analogous organs. It can be inferred that it is of convergent evolution.

Q. 14. "Sweet potato tubers and potato tubers are the result of convergent evolution." Justify the statement. **[*CBSE Delhi 2013*] [*HOTS*]**

Ans. Sweet potato tuber is a modified root whereas potato tuber is a modified stem. These are anatomically different structures but perform the same function of food storage. Therefore, they are the result of convergent evolution.

Q. 15. Comment on the similarity between the wing of a cockroach and the wing of a bird. What do you infer from the above, with reference to evolution? **[*CBSE (AI) 2012*] [*HOTS*]**

Ans. They are similar in function. Thus we infer that these organs are analogous which has resulted in convergent evolution.

Q. 16. Comment on the similarity between the flippers of dolphins and penguins, with reference to evolution. **[*CBSE (F) 2012*]**

Ans. Similarity between the flippers of dolphins and penguins is that they perform similar functions though structurally different. Thus, they are analogous organs. These are the result of convergent evolution.

Q. 17. Why are analogous structures a result of convergent evolution? [*CBSE (AI) 2014*] [*HOTS*]

Ans. Analogous structures are not anatomically similar, *i.e.*, they do not have common ancestors and evolve for similar function in the same habitat. Therefore, they are said to be a result of convergent evolution.

Q. 18. Mention the type of evolution that has brought the similarity as seen in potato tuber and sweet potato. [*HOTS*]

Ans. Convergent evolution

Q. 19. When we say "survival of the fittest", does it mean that

(*a*) those which are fit only survive, or

(*b*) those that survive are called fit.

Comment. [*NCERT Exemplar*] [*HOTS*]

Ans. Those individuals which survive and reproduce in their respective environment are called fit.

Q. 20. State a reason for the increased population of dark coloured moths coinciding with the loss of lichens (on tree barks) during industrialisation period in England. [*CBSE Delhi 2015*] [*HOTS*]

Ans. Natural selection or survival of fittest as nature selected the moths which could match with black surroundings due to soot deposition.

Q. 21. According to deVries what is saltation? [*CBSE Delhi 2016*]

Ans. According to de Vries, saltation is single step (large) mutation.

Q. 22. According to Hardy-Weinberg's principle, the allele frequency of a population remains constant. How do you interpret the change of frequency of alleles in a population? [*HOTS*]

Ans. Change of frequency of alleles in a population will result in natural selection leading to the evolution.

Q. 23. If the frequency of one allele is 'p' and for another, it is 'q' for one gene, what will be the formula to calculate allele frequency in future generations according to Hardy–Weinberg genetic equilibrium? [*CBSE Sample Paper 2014*]

Ans. $(p+q)^2 = p^2 + 2pq + q^2 = 1$

Q. 24. What does Hardy-Weinberg equation $p^2 + 2pq + q^2 = 1$ convey? [*CBSE (F) 2011*]

Ans. Hardy–Weinberg equation conveys genetic equilibrium, *i.e.*, sum total of all allelic frequencies is 1.

Q. 25. What is founder effect? [*NCERT Exemplar*]

Ans. Sometimes the change in allele frequency is so different in the new sample of population that they become a different species. The original drifted population becomes founder and the effect is called founder effect.

Q. 26. Name the common ancestor of the great apes and man. [*CBSE (AI) 2011*]

Ans. *Dryopithecus / Ramapithecus*

Q. 27. State the significance of biochemical similarities amongst diverse organism in evolution. [*CBSE Delhi 2012*]

Ans. Biochemical similarities indicate evolution from common or shared ancestry.

Q. 28. State the significance of *Coelacanth* in evolution. [*CBSE (AI) 2012*]

Ans. It is an ancestor of amphibians.

Q. 29. Write the probable differences in eating habits of *Homo habilis* and *Homo erectus*. [*CBSE (AI) 2016*]

Ans. *Homo habilis* did not eat meat. They were vegetarian.
Homo erectus ate meat. They were meat eater.

Q. 30. Write the names of the following:

(*a*) A 15 *mya* primate that was ape-like

(b) A 2 *mya* primate that lived in East African grasslands **[*CBSE Delhi 2018*]**

Ans. (*a*) *Dryopithecus*

(*b*) *Australopithecine/Homo habilis*.

Q. 31. Rearrange the human activities mentioned below as per the order in which they developed after the modern *Homo sapiens* came into existence during ice age:

(*i*) Human settlement

(*ii*) Prehistoric cave art

(*iii*) Agriculture **[*CBSE Delhi 2017*]**

Ans. The order of activities is as follows:

(*i*) Pre-historic cave art

(*ii*) Agriculture

(*iii*) Human Settlement

Q. 32. *Coelacanth* was caught in South Africa. State the significance of discovery of *Coelacanth* in the evolutionary history of vertebrates. **[*CBSE 2019 (57/4/1)*]**

Ans. *Coelacanth* evolved as first amphibian (lived on both land and water). It is an ancestor of modern day frogs and salamanders.

Q. 33. By what Latin name the first hominid was known? **[*NCERT Exemplar*]**

Ans. *Homo habilis*

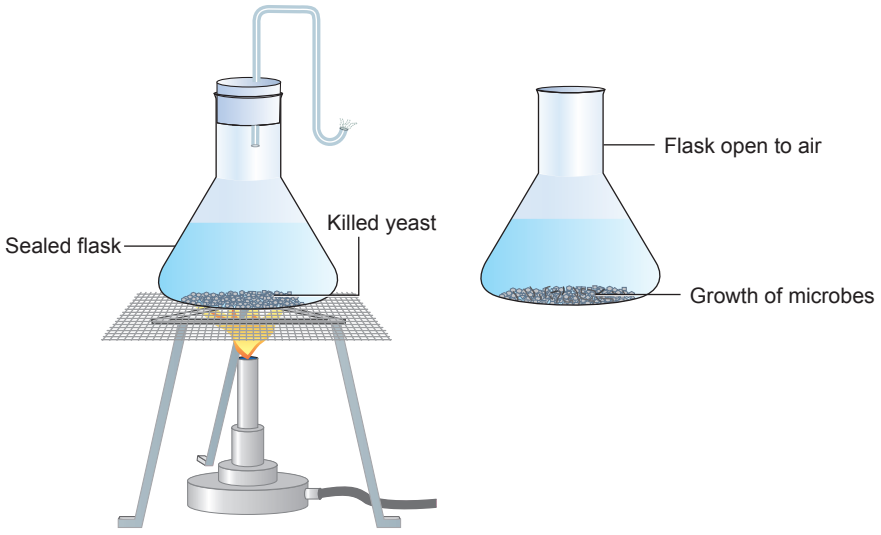
Q. 34. Among *Ramapithecus, Australopithecous* and *Homo habilis,* who probably did not eat meat?

Ans. *Homo habilis* **[*NCERT Exemplar*]**

Short Answer Questions [2 marks]

Q. 1. Describe the experiment that helped Louis Pasteur to dismiss the theory of spontaneous generation of life. **[*CBSE Delhi 2016*]**

Ans. Two pre-sterilised flasks with killed yeast were taken. One of the flask was sealed, and the other was open to air. Differential growth of life were observed in the two flasks. Life was found only in the open flask.



Q. 2. Diagrammatically represent the experimental set up that proves Oparin–Haldane hypothesis. ***[CBSE Sample Paper 2015, 2017]***

Ans. Refer to Fig. 7.1.

Q. 3. Protein synthesis machinery revolves around RNA but in the course of evolution it was replaced by DNA. Justify. ***[CBSE Sample Paper 2016]***

Ans. Since RNA was unstable and prone to mutations, DNA evolved from RNA with chemical modifications that makes it more stable.

DNA has double stranded nature and has complementary strands. These further resist changes by evolving a process of repair.

Q. 4. If abiotic origin of life is in progress on a planet other than earth, what should be the condition there? Explain. ***[HOTS]***

Ans. The atmosphere will be reducing, *i.e.*, no free oxygen will be present. There must be continuous supply of energy like that from lightning, thunder, volcanic eruption and stellar radiation. The presence of autocatalyst or self-replicating molecules is essential.

Q. 5. What must have provided energy for the warmth for life to originate on primitive earth? Name the first organism to release oxygen into the atmosphere. ***[HOTS]***

Ans. Energy for life to originate must have been provided by heat, cosmic rays and lightning. Cyanobacteria was the first organism to release oxygen into the atmosphere.

Q. 6. Write the Oparin and Haldane's hypothesis about the origin of life on Earth. How does meteorite analysis favour this hypothesis? ***[CBSE (AI) 2013]***

Ans. The hypothesis stated that life originated from pre-existing non-living organic molecules (*e.g.*, RNA, protein, etc.). When the meteorites were analysed, it was observed that presence of similar compounds was confirmed which conclude that similar process is going on elsewhere in the space.

Q. 7. Mention the contribution of S.L. Miller's experiments on Origin of Life. ***[CBSE (AI) 2013]***

Ans. S.L. Miller created an environment in laboratory similar to the one that existed before life originated. In a closed flask containing CH_4, H_2, NH_3 and water vapour at 800°C, electric discharge was created. The conditions were similar to those in primitive atmosphere. After a week, they observed presence of amino acids and complex molecules like sugars, nitrogen bases, pigments and fats in the flask. This provided experimental evidence for the theory of chemical origin.

Q. 8. Convergent evolution and divergent evolution are the two concepts explaining organic evolution. Explain each one with the help of an example. ***[CBSE Delhi 2010; (F) 2011]***

OR

Differentiate between divergent and convergent evolution. Give one examples of each. ***[CBSE (AI) 2016]***

Ans. **Convergent evolution:** When more than one adaptive radiation appeared to have occurred in an isolated geographical area and two or more groups of unrelated animals resemble each other for similar mode of life or habitat, it is called convergent evolution, *e.g.*, Australian marsupials, placental mammals.

Divergent evolution: In some animals, the same structures developed along different directions due to adaptations to different needs. This is known as divergent evolution. For example, forelimbs of whales, bats, cheetah and human perform different functions but have similar anatomical structure with similar bones arranged in similar segments.

Q. 9. Explain convergent evolution with the help of two examples. ***[CBSE (F) 2015]***

Ans. Different structures evolved similarly due to same functions. This is called convergent evolution. Examples:

(*i*) Wings of butterfly and birds.

(*ii*) Sweet potato (root modification) and potato (stem modification).

Q. 10. Explain divergent evolution with two examples. **[*CBSE (F) 2015*]**

Ans. Some structures developed along different directions due to adaptations to different needs performing different functions. This is called divergent evolution. Examples:

(*i*) Forelimbs of whales, bat, cheetah and humans have similar pattern of bones.

(*ii*) Thorns of *Bougainvillea* and tendrils of *Cucurbita* are modifications of stem.

Q. 11. Select two pairs from the following which exhibit divergent evolution. Give reasons for your answer.

(*i*) Forelimbs of Cheetah and mammals

(*ii*) Flippers of dolphins and penguins

(*iii*) Wings of butterflies and birds

(*iv*) Forelimbs of whales and mammals **[*CBSE (AI) 2015*] [*HOTS*]**

Ans. (*i*) and (*iv*) exhibit divergent evolution.

There pairs have similar anatomical structure or origin but perform different functions.

Q. 12. (*a*) Select the homologous structures from the combinations given below:

(*i*) Forelimbs of whales and bats

(*ii*) Tuber of potato and sweet potato

(*iii*) Eyes of octopus and mammals

(*iv*) Thorns of *Bougainvillea* and tendrils of *Cucurbita*

(*b*) State the kind of evolution they represent. **[*CBSE (AI) 2015*] [*HOTS*]**

Ans. (*a*) (*i*) Forelimbs of whales and bats.

(*iv*) Thorns of *Bougainvillea* and tendrils of *Cucurbita*.

(*b*) Divergent evolution.

Q. 13. How do homologous organs represent divergent evolution? Explain with the help of a suitable example. **[*CBSE (AI) 2016*] [*HOTS*]**

Ans. Organs with similar structure or same origin developed along different directions due to adaptation or different needs, to perform different functions are called homologous organs.

For example, the fore limbs of some animals (Vertebrates) like whales, bats, cheetah and human have similar anatomical structure (*i.e.*, humerus, radius, ulna, carpals, metacarpals and phalanges) develop differently to meet different need and to perform different functions.

Q. 14. (*a*) Select the analogous structures from the combinations given below:

(*i*) Forelimbs of whales and bats

(*ii*) Eyes of octopus and mammals

(*iii*) Tuber of sweet potato and potato

(*iv*) Thorns of *Bougainvillea* and tendrils of *Cucurbita*.

(*b*) State the kind of evolution they represent. **[*CBSE (AI) 2015*] [*HOTS*]**

Ans. (*a*) (*ii*) and (*iii*) are analogous structures.

(*b*) Convergent evolution.

Q. 15. Identify the following pairs as homologous or analogous organs:

(*i*) Sweet potato and potato

(*ii*) Eye of octopus and eye of mammals

(*iii*) Thorns of *Bougainvillea* and tendrils of *Cucurbits*

(*iv*) Forelimbs of Bat and Whale **[*CBSE Delhi 2014*] [*HOTS*]**

Ans. (*i*) and (*ii*) are analogous organs.

(*iii*) and (*iv*) are homologous organs.

Q. 16. Branching descent and natural selection are the two key concepts of Darwinian theory of evolution. Explain each concept with the help of a suitable example. ***[CBSE (AI) 2011]***

Ans. **Branching descent:** Different species descending from the common ancestor get adapted in different habitats, *e.g.*, Darwin's finches—varieties of finches arose from grain eaters; Australian marsupials evolved from common marsupial.

Natural selection: It is a process in which heritable variations enable better survival of the species to reproduce in large number, *e.g.*, white moth surviving before the industrial revolution and black moth surviving after industrial revolution; long-necked giraffe survived the evolution process; DDT-resistant mosquitoes survive. (*Any suitable example*)

Q. 17. While creation and presence of variation is directionless, natural selection is directional as it is in the context of adaptation. Comment. ***[NCERT Exemplar]*** ***[HOTS]***

Ans. Creation and variation occur in a sexually reproducing population as a result of crossing-over during meiosis and random fusion of gametes and independent assortment of genes. It is however the organisms that are selected over a period of time which are determined by the environmental conditions. In other words, the environment provides the direction with respect to adaptations so that the organisms are more and more fit in terms of survival.

Q. 18. Explain adaptive radiation with the help of a suitable example. ***[CBSE Delhi 2015; (F) 2010]***

Ans. Refer to Basic Concepts Point 6.

Q. 19. Why are the wings of butterfly and birds said to be analogous organs? Name the type of evolution of which the analogous organs are a result of. ***[CBSE (F) 2010]***

Ans. Wings of butterfly and birds are not anatomically similar structures though they perform similar functions. Hence, they are called analogous structures. Analogous organs result from convergent evolution.

Q. 20. What do you infer from the resemblance between flying squirrel and flying phalanger with reference to their evolution? ***[CBSE Delhi 2015]***

Ans. Evolution of marsupial mammals has resulted in flying phalanger through adaptive radiation. Evolution of placental mammals has led to the evolution of a flying squirrel (independently). The resemblance between the two proves convergent evolution.

Q. 21. "Post-industrialisation, the population of melanised moth increased in England at the expense of white-winged moths." Provide explanations. ***[CBSE (F) 2016]***

OR

Explain the increase in the numbers of melanic (dark winged) moths in the urban areas of post-industrialisation period in England. ***[CBSE (AI) 2013]***

OR

In England, during the post-industrialised period, the count of melanic moths increased in urban areas but remained low in rural areas. Explain. ***[CBSE (F) 2010]***

Ans. Pre-industrialisation period had more white winged moth against grey lichens on tree trunks. During industrialisation large amount of soot and smoke deposited on tree trunks, making the bark dark. Against the dark background white moths could easily be preyed upon. Melanised moth could camouflage against dark bark. This natural selection increased their number.

Q. 22. Explain the interpretation of Charles Darwin when he observed a variety of small black birds on Galapagos Islands. ***[CBSE Delhi 2015]***

Ans. In Galapagos Islands, the small black birds amazed Darwin and he later called them finches. He realised that there were many varieties of finches in the same island. All the varieties evolved on the island itself. This process of evolution was called adaptive radiation, According to Darwin this evolution was based on available resources, food and space. There is survival of the fittest.

Q. 23. Anthropogenic action can hasten the evolution. Explain with the help of a suitable example. ***[CBSE (F) 2010]***

Ans. Excessive use of herbicides, pesticides, etc., has only resulted in selection of resistant varieties in a much lesser time scale which is equally true for microbes against which we employ antibiotics or drugs against eukaryotic organisms/cells. As a result of which resistant organisms/cells are appearing in a time scale of months or years and not centuries. For example, when DDT was used for the first time, maximum mosquitoes died but few survived due to variation in the population. These mosquitoes showed resistance to DDT and survived to reproduce successfully in the presence of DDT and gradually such mosquito population became DDT resistant, following natural selection.

Q. 24. With the help of any two suitable examples explain the effect of anthropogenic actions on organic evolution. ***[CBSE Delhi 2013]***

Ans. Refer to Basic Concepts Point 7(*ii*)(*a*) & (*b*).

Q. 25. According to the Darwinian theory, the rate of appearance of new forms is linked to their life cycles. Explain. ***[CBSE (AI) 2014]***

Ans. Microbes have a very short life cycle and divide fast. They can produce millions of organisms within few hours. Thus, it is easy to see variant population in less span of time. On the other hand, higher organisms have a long time span and the variations are not visible in a short time.

Q. 26. What does the following equation represent? Explain.

$$p^2 + 2pq + q^2 = 1$$

[CBSE (AI) 2015]

Ans. The equation represents Hardy-Weinberg's Principle which states that allele frequencies in a population are stable and are constant from generation to generation. 1 represents stable allelic frequency indicating no evolution occurring. p represents frequency of homozygous dominant (AA), 2 pq represents frequency of heterozygous (Aa) and q represents frequency of homozygous recessive (aa).

Q. 27. Gene flow occurs through generations and can occur across language barriers in humans. If we have a technique of measuring specific allele frequencies in different population of the world, can we not predict human migratory patterns in pre-history and history? Do you agree or disagree? Provide explanation to your answer. ***[NCERT Exemplar]*** ***[HOTS]***

Ans. Yes, I agree. Gene flow occurs through generations. By studying specific allele frequencies, we can predict the human migratory patterns in pre-history and history. Studies have used specific genes/chromosomes/mitochondrial DNA to trace the evolutionary history and migratory patterns of humans. (The project is known as the Human Genographics Project).

Q. 28. In a certain population, the frequency of three genotypes is as follows.

Genotypes:	**BB**	**Bb**	**bb**
Frequency:	**22%**	**62%**	**16%**

What is the likely frequency of B and b alleles? ***[NCERT Exemplar]*** ***[HOTS]***

Ans. Frequency of B allele = all of BB + ½ of Bb = 22 + 31 = 53%

Frequency of b allele = all of bb + ½ of Bb = 16 + 31 = 47%.

Q. 29. State Hardy–Weinberg principle of genetic equilibrium. Knowing that genetic drift disturbs this equilibrium, mention what does this disturbance in genetic equilibrium leads to. ***[HOTS]***

Ans. Hardy–Weinberg principle states that gene pool remains constant, *i.e.*, the allele frequencies in a population are stable and remains constant from generation to generation. Genetic drift refers to change in allele frequencies of a population occurring by chance. The change in allele frequency may be so different that the population becomes a different species. This effect is called founder effect.

Q. 30. (*a*) Rearrange the following in an ascending order of evolutionary tree:
reptiles, salamanders, lobefins, frogs.

(*b*) Name two reproductive characters that probably make reptiles more successful than amphibians. ***[HOTS]***

Ans. (*a*) Lobefins, frogs, salamanders, reptiles

(*b*) Reptiles are more successful than amphibians as:

(*i*) reptiles lay eggs on land.

(*ii*) reptiles lay thick shelled eggs which do not dry up in sun unlike those of amphibians.

Q. 31. What are we referring to when we say 'simple organisms' or 'complex organisms'?

[*NCERT Exemplar*]

Ans. These are the terms to classify organisms according to their evolutionary history. Simple organisms have simple structural and functional organisation and are considered primitive, whereas complex organisms have complex structural and functional organisation and are said to have arise from simple organisms.

Q. 32. How can you say the lobefin fish were the ancestors of amphibian? **[*HOTS*]**

Ans. Lobefins fish have stout and strong fins, so they can move on land and swim in water to maintain a dual lives like amphibians.

Q. 34. Fill in the blank (*i*), (*ii*), (*iii*), (*iv*) with name of the mammals of Australia. **[*HOTS*]**

Placental mammal	Marsupial mammal
Anteater	**(*i*)**
(*ii*)	**Spotted cuscus**
Bob cat	**(*iii*)**
(*iv*)	**Tasmanian wolf**

Ans. (*i*) Numbat (*ii*) Lemur

(*iii*) Tasmanian tiger cat (*iv*) Wolf

Long Answer Questions–I [3 marks]

Q. 1. State the theory of Biogenesis. How does Miller's experiment support this theory?

[*CBSE (Delhi) 2012*]

Ans. The theory of biogenesis states that a living organism arises from another living organism.

For Miller's experiment: Refer to Basic Concepts Point 3 (Experimental Evidence of Chemical Evolution).

Q. 2. (*a*) State Oparin–Haldane's hypothesis.

(*b*) How does S.L. Miller's experiment supports it? **[*CBSE (F) 2016*]**

Ans. (*a*) Oparin-Haldane's hypothesis states that life could have come from pre-existing non-living organic molecules and that formation of life was preceded by chemical evolution.

(*b*) Refer to Fig. 7.2 and Basic Concepts Point 3 (Experimental Evidence of Chemical Evolution).

Q. 3. Diagrammatically represent the experimental set up that proved Oparin-Haldane hypothesis.

[*CBSE Sample Paper 2015, 2017*]

Ans. Refer to Fig. 7.2.

Q. 4. Describe the experiment of S.L. Miller on the origin of life. Write the conclusion drawn at the end of the experiment. **[*CBSE (F) 2017*]**

Ans. Refer to Basic Concepts Point 3 (Experimental evidence of chemical evolution/Miller's experiment)

Q. 5. State the contribution of Louis Pasteur in understanding the origin of life on earth. Explain the procedure that he followed to arrive at his conclusion. **[*CBSE (F) 2016*]**

Ans. Louis Pasteur dismissed the theory of spontaneous generation and demonstrated that life came from pre-existing life. He took two long-necked flasks. He left one flask with a straight neck and

the other was bent to from an 'S' shape. He put sterile broths in both the flasks. He placed killed yeast in pre-sterilised bent flask and the other flask was left open to air.

After several weeks he observed that the straight neck flask was discoloured and cloudy, while the curved flask had not changed. Thus he concluded that the germs in air were able to fall unobstructed down the straight necked flask while they got trapped in the curved flask.

Q. 6. How do fossils help us in understanding the evolutionary history? ***[CBSE (F) 2017]***

Ans. Refer to Basic Concepts Point 5 (*i*).

Q. 7. What are analogous structures? How are they different from homologous structures? Provide one example for each. ***[CBSE (F) 2015]***

OR

Differentiate between homology and analogy. Give one example of each. ***[CBSE (AI) 2016]***

Ans.

Table 7.3: Differences between homology and analogy

S.No.	Homology	Analogy
(*i*)	Organisms having the same structure developed along different directions due to adaptations/ different functions.	Different structures having the same function (in different organisms).
(*ii*)	Result of divergent evolution.	Result of convergent evolution.
(*iii*)	Indicates common ancestry.	Does not indicate common ancestry.
(*iv*)	Anatomically same structures.	Anatomically different structures.
(*v*)	**Example:** Forelimbs of whale—bats—cheetah—human/ Thorns of *Bougainvillea* and tendrils of *cucurbits*	**Example:** Wings of butterfly and birds, Sweet potato and potato

Q. 8. (*a*) Differentiate between analogous and homologous structures.

(*b*) Select and write analogous structures from the list given below:

(*i*) Wings of butterfly and birds

(*ii*) Vertebrate hearts

(*iii*) Tendrils of *Bougainvillea* and *Cucurbita*

(*iv*) Tubers of sweet potato and potato ***[CBSE 2018]***

Ans. (*a*)

Table 7.4: Differences between analogous and homologous structures

S.No.	Analogous structures	Homologous structure
(*i*)	These are anatomically not similar but perform similar functions.	These are anatomically similar but perform different functions.
(*ii*)	They are a result of convergent evolution.	They are a result of divergent evolution.

(*b*) Wings of butterfly and birds.

Tubers of sweet potato and potato.

Q. 9. (*a*) What is adaptive radiation?

(*b*) Explain with the help of a suitable example where adaptive radiation has occurred to represent convergent evolution.

OR

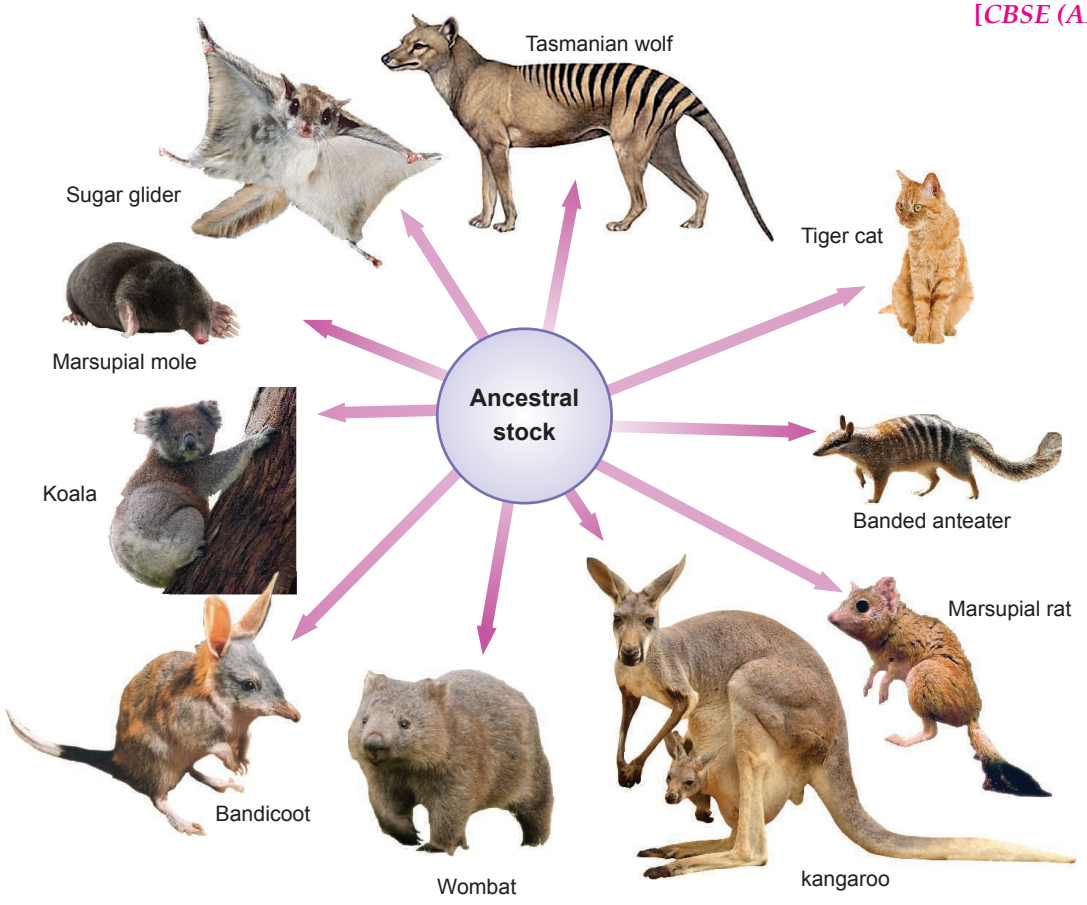
What is adaptive radiation? When can adaptive radiation be referred to as convergent evolution? Give an example. ***[CBSE Delhi 2015]***

Ans. (*a*) The process of evolution of different species in a given geographical area starting from a point and radiating to other areas of geography (habitats) is called adaptive radiation.

(*b*) When more than one adaptive radiation occurs in an isolated geographical area (representing different habitats), it can be called as convergent evolution.

For example, similarity between some individual members of placental mammals and marsupial mammals argues strongly that they are the result of convergent evolution. These animals have similar forms because of evolution in different, isolated areas because of similar selective pressures in similar environments. This means marsupials in Australia resemble placental mammals in the rest of the world. They evolved in isolation after Australia separated from other continents.

Q. 10. Name and explain the evolutionary concept represented in the illustration given below:
[*CBSE (AI) 2012*]



Ans. The illustration represents adaptive radiation.

For explanation, refer to Basic Concepts Point 6(*iii*).

Q. 11. (*a*) Explain adaptive radiation with the help of a suitable example.

(*b*) Cite an example where more than one adaptive radiations have occurred in an isolated geographical area. Name the type of evolution your example depicts and state why it is so named. **[*CBSE (AI) 2014*]**

Ans. (*a*) Adaptive radiation can be observed in black birds of Galapagos islands, which are also called Darwin's finches. These birds evolved on the island itself from the original seed eating features. Many forms with offered beaks arose which enabled them to become insectivorous and vegetarian in different habitats of the island.

(*b*) More than one adaptive radiation have occurred in Australian marsupials and placental mammals.

The example depicts convergent evolution. It is named so, because more than one adaptive radiation occurred in isolated geographical area.

Q. 12. Evolution is a change in gene frequencies in a population in response to changes in the environment in a time scale of years and not centuries. Justify this statement with reference to DDT. How does the theory of Hugo de Vries support this? ***[CBSE (F) 2012]***

Ans. When DDT was used for the first time, maximum mosquitoes died but few survived due to variation in a population. These mosquitoes showed resistance to DDT and survived to reproduce successfully in the presence of DDT and gradually such mosquito population became DDT resistant within a time span of few years.

According to Hugo de Vries, evolution is caused by sudden large differences in the population and not minor variations.

Q. 13. Describe the three different ways by which Natural Selection can affect the frequency of a heritable trait in a population. ***[CBSE (F) 2014]***

Ans. Refer to Basic Concepts Point 9 and Fig. 7.8.

Q. 14. According to Darwinian theory of natural selection the rate of appearance of new forms is linked to the life-cycle or the life-span of an organism. Explain with the help of an example. ***[CBSE 2019 (57/2/1)]***

Ans. A colony of bacteria (say A) growing in a given medium has built in variation in terms of ability to utilise a feed component, a change in the medium composition would bring out only that part of the population(say B) that can survive under the new conditions.

In due course of time this variant population outgrows the others and appears as new species, thus organisms with shorter life-cycle or life-span will undergo evolution faster. For the same thing to happen in fish or fowl it would take millions of years as life spans of these animals are in years,

Q. 15. How does industrial melanism support Darwin's theory of Natural Selection? Explain. ***[CBSE (AI) 2012; CBSE 2019 (57/3/1)]***

Ans. Before industrial evolution the environment was unpolluted. The lichens on the barks of trees were pale. The white-winged moths could easily camouflage, while the dark-winged were spotted out by the birds for food. Hence, they could not survive. After industrial revolution the lichens became dark (due to soot deposit). This favoured the dark-winged moths while the white-winged were picked by birds. The population of the former which was naturally selected increased.

Q. 16. What is natural selection? How is artificial selection different from natural selection? Give one example each from plants and animals where artificial selection has operated.

Ans. The nature builds some pressure on the population of a species and as a result few individuals are eliminated and few adapt to adjust with changes and become fit. This biological phenomenon is called natural selection.

Table 7.6: Differences between natural selection and artificial selection

S. No.	Natural selection	Artificial selection
(*i*)	It is a natural phenomenon.	It is the practice done by man.
(*ii*)	As a result only fit individuals increase in a population.	As a result commercially high yielding and disease resistance varieties increase.

Artificial selection have been operated in the followings cases:

Plants: Cabbage, wheat.

Animals: High milk yielding varieties of cows.

Q. 17. Differentiate between the explanations given by Darwin and de vries respectively on the mechanism of evolution. ***[CBSE (F) 2013]***

Ans. **Table 7.5: Differences between Darwin's and de Vries' theory of evolution**

S. No.	Darwin's evolution	de Vries' evolution
(*i*)	According to Darwin, evolution was gradual (stepwise).	According to de Vries, evolution occurred in a single step (saltation).
(*ii*)	Variations and natural selection occurs through a number of generations and are responsible for speciation.	Single step mutation caused speciation.
(*iii*)	Darwin's variations are small and directional.	de Vries' mutations are random and directionless.

Q. 18. $p^2 + 2pq + q^2 = 1$. Explain this algebraic equation on the basis of Hardy Weinberg's principle. ***[CBSE Delhi 2017]***

Ans. In a diploid if p represents the frequency of allele A and q represents the allele frequency of a, then frequency of AA individuals in a population is p^2. Similarly of aa is q^2 and of Aa is $2pq$. Hence $p^2 + 2pq + q^2 = 1$. This is a binomial expansion of $(p+q)^2$.

According to Hardy–Weinberg principle, total genes and their alleles in a population or gene pool remains constant. This is called genetic equilibrium. Sum total of all the allelic frequencies is 1 $[p+q = 1/(p+q)^2 = 1]$.

Q. 19. (*a*) How does the Hardy–Weinberg's expression ($p^2 + 2pq + q^2 = 1$) explain that genetic equilibrium is maintained in a population?

(*b*) List any two factors that can disturb the genetic equilibrium. ***[CBSE (AI) 2010]*** ***[HOTS]***

Ans. **(*a*)** (*i*) **Sum total of all the allele frequencies is 1:** Let there be two alleles *A* and *a* in a population. The frequencies of alleles *A* and *a* are *p* and *q*, respectively. The frequency of *AA* individual in a population is p^2 and it can be explained that the probability that an allele *A* with a frequency of *P* appear on both the chromosomes of a diploid individual is simply the product of the probabilities, *i.e.*, p^2. Similarly, the frequency *aa* is q^2 and that of *Aa* is $2pq$.

$p^2 + 2pq + q^2 = 1$, where p^2 represents the frequency of homozygous dominant genotype, $2pq$ represents the frequency of the heterozygous genotype and represents the frequency of the homozygous recessive.

(*ii*) Genetic equilibrium states the status of evolution. If there is some fluctuation or disturbance in genetic equilibrium or Hardy–Weinberg equilibrium, *i.e.*, change of frequencies of alleles in a population then it can predicted that evolution is in progress.

(*b*) Factors that affect Hardy–Weinberg equilibrium:

(*i*) Gene migration or gene flow

(*ii*) Genetic drift

(*iii*) Mutation (*Any two*)

Q. 20. What is disturbance in Hardy-Weinberg genetic equilibrium indicative of? Explain how it is caused. ***[CBSE (AI) 2017]***

Ans. Disturbance in Hardy-Weinberg equilibrium is an indicator of change of frequency of allele in a population, resulting in evolution.

It is caused by any of the following factors:

(*i*) Genetic drift

(*ii*) Gene flow or gene migration

(*iii*) Mutation

(*iv*) Genetic recombinations

(*v*) Natural selection

Q. 21. Rearrange *Ramapithecus, Australopithecus* and *Homo habilis* in the order of their evolution on the Earth. Comment on their evolutionary characteristics. ***[CBSE (AI) 2017]***

Ans. **The order of evolution on the earth is:**

Ramapithecus → *Australopithecus* → *Homo habilis*

Ramapithecus were hairy and walked–like gorilla and chimpanzees. They were more man like.

Australopithecus hunted with stone weapons and ate fruit.

Homo habilis had a brain capacity 650-800 cc and probably did not eat meat.

Q. 22. Write the characteristics of *Ramapithecus, Dryopithecus,* and Neanderthal man. ***[CBSE (AI) 2017]***

Ans. ***Ramapithecus*:** hairy, walked–like gorillas and chimpanzees, more man like.

***Dryopithecus*:** hairy, walked–like gorillas and chimpanzees, more ape-like.

Neanderthal man: brain size is 1400 cc, used hides to protect their body, buried their dead.

Q. 23. (*a*) Name the ancestors of progymnosperm.

(*b*) Name the ancestors of herbaceous and arborescent lycopod.

(*c*) Name the ancestors of cycads. ***[HOTS]***

Ans. (*a*) *Psilophyton*

(*b*) *Zosterophyllum*

(*c*) Progymnosperm.

Long Answer Questions–II [5 marks]

Q. 1. (*a*) What was proposed by Oparin and Haldane on origin of life? How did S.L. Miller's experiment support their proposal?

(*b*) Which human chromosome has (*i*) maximum number of genes, and which one has (*ii*) fewest genes?

(*c*) Write the scientific importance of single nucleotide polymorphism identified in human genome. ***[CBSE (F) 2014]***

Ans. (*a*) **Theory of chemical evolution or Oparin–Haldane theory:** This theory states that life originated from pre-existing non-living organic molecules (*e.g.*, RNA, protein, etc.). S.L. miller conducted an experiment where he created conditions similar to primitive atmosphere in a flask like high temperature, reducing atmosphere consisting of HCl, NH_3, etc. When an electric discharge was created at 800°C, after a week, presence of amino acids and complex molecules like sugars, nitrogen bases, pigments, fats were observed in the flask.

(*b*) Chromosome 1 has most genes (2968) and the Y chromosome has fewest genes (231).

(*c*) This information promises to revolutionise the processes of finding chromosomal locations for disease-associated sequences and tracing human history.

Q. 2. (*a*) Differentiate between analogy and homology giving one example each of plant and animal respectively.

(*b*) How are they considered as an evidence in support of evolution? ***[CBSE Delhi 2016]***

Ans. (*a*) In some animals, the same structure developed along different directions due to adaptations to different needs. This is divergent evolution and is called homology. Homology indicates common ancestry. For example, vertebrate hearts or brains. In plants also, the thorn and tendrils of *Bougainvillea* and *Cucurbita* represent homology.

(*b*) Wings of butterfly and of birds look alike. They are not anatomically similar structures though they perform similar functions. Analogy results from convergent evolution in which different structures evolve for the same function and hence have similarity. Sweet potato (root modification) and potato (stem modification) is another example for analogy.

Q. 3. (*a*) Explain "founder effect". **[*CBSE (F) 2013*]**

(*b*) State Oparin and Haldane Hypothesis.

(*c*) Describe Stanley and Miller's experiment and give its significance.

Ans. (*a*) Sometimes the change in allele frequency is so different in the new sample of population that they become a different species. The original drifted population becomes founder and the effect is called founder effect.

(*b*) Oparin–Haldane's theory states that the first life form originated from non-living organic molecules like RNA, protein, etc.

(*c*) Refer to Basic Concepts Point 3 (Experimental evidence of chemical evolution/Miller's experiment).

Q. 4. (*a*) What are fossils? How are they an evidence for evolution?

(*b*) "Anthropogenic action can lead to evolution." Explain with the help of an example.

[*CBSE (F) 2016*]

Ans. (*a*) Fossils are remains or impression of hard parts of life-forms that existed in past. They are found in rocks.

Study of fossils in different sedimentary layers indicates the geological periods in which they existed and showed that life forms varied over time.

(*b*) Excess use of herbicides, pesticides, etc., has only resulted in selection of resistant varieties in a much lesser time scale. This is also true for microbes against which we employ antibiotics or drugs against eukaryotic organisms/ cell. Hence, resistant organisms/cells are appearing in a time scale of months or years and not centuries. These are examples of evolution by anthropogenic action.

Q. 5. (*i*) Natural selection operates when nature selects for fitness. Explain.

(*ii*) The rate of appearance of new forms is linked to the lifespan of an organism. Explain with the help of a suitable example. **[*CBSE Delhi 2010*]**

Ans. (*i*) Natural resources are limited, populations are stable in size, members of a population vary in characteristics even though they look superficially similar. Theoretically, population will increase exponentially but the population sizes in reality are limited thus leading to competition. Only the ones which are fit and adapt themselves are able to survive. They grow at the cost of others and flourish. This was called as natural selection by Darwin.

(*ii*) According to Darwin, the fitness of an organism is measured by its reproductive ability. Also the appearance of new forms is linked to the lifespan of an organism. The greater its lifespan, the more it can reproduce and hence, greater new forms would appear. This can be observed in the development of dark-winged moths due to industrial melanism. For details, refer to the above qustion.

Q. 6. (*a*) List the various causes of variations in the progeny of the population.

(*b*) Describe the three different ways in which the natural selection operates in nature with regard to organic evolution. **[*CBSE (F) 2013*]**

Ans. (*a*) The various causes of variation are:

(*i*) Gene migration or gene flow

(*ii*) Genetic drift

(*iii*) Mutation

(*iv*) Genetic recombination

(*v*) Natural selection

(*b*) Refer to Basic Concepts 9 and Fig. 7.8.

Q. 7. Explain the salient features of Hugo de Vries theory of mutation. How is Darwin's theory of natural selection different from it? Explain. **[*CBSE Delhi 2011*]**

Ans. Salient features of theory of Hugo de Vries:

(*i*) Mutations cause evolution.

(*ii*) New species originate due to large mutations.

(*iii*) Evolution is a discontinuous process and not gradual.

(*iv*) Mutations are directionless,

(*v*) Mutations appear suddenly.

(*vi*) Mutations exhibit their effect immediately.

Refer to Table 7.6.

Q. 8. (*a*) How did Darwin explain adaptive radiation? Give another example exhibiting adaptive radiation.

(*b*) Name the scientist who influenced Darwin and how? **[*CBSE Delhi 2016*]**

Ans. (*a*) During his journey Darwin went to Galapagos Islands. There he observed an amazing diversity of creatures. Of particular interest were small black birds, later called Darwin's Finches which amazed him. He realised that there were many varieties of finches in the same island. All the varieties, he conjectured, evolved on the island itself. From the original seed-eating features, many other forms with altered beaks arose, enabling them to become insectivorous and vegetarian finches. This process of evolution of different species in a given geographical area starting from a point and literally radiating to other areas of geography (habitats) is called adaptive radiation. Darwin's finches represent one of the best examples of this phenomenon. Another example is Australian marsupials.

(*b*) Thomas Malthus influenced Darwin.

According to Malthus, population size grows exponentially (due to maximum reproduction). However, the population size remains limited due to limited natural resources which leads to competition.

Q. 9. (*a*) Write and explain the conclusion Darwin arrived at after observing the variations seen in the beaks of finches during his sea voyage.

(*b*) Marsupials and Australian placental mammals exhibit convergent evolution. Explain how. **[*CBSE (F) 2013*]**

Ans. (*a*) Refer to Basic Concepts Point 7 (*ii*).

(*b*) A number of marsupials, each different from the other evolved from an ancestral stock, but all within the Australian island continent. Placental mammals in Australia also exhibit adaptive radiation in evolving into varieties of such placental mammals each of which appears to be 'similar' to a corresponding marsupial (*e.g.*, Placental wolf and Tasmanian wolf).

Q. 10. (*a*) Explain Darwinian theory of evolution with the help of one suitable example. State the two key concepts of the theory.

(*b*) Mention any three characteristics of Neanderthal man that lived in near east and central Asia. **[*CBSE Delhi 2014*]**

Ans. (*a*) According to Darwin, evolution took place by selection. The rate of appearance of new forms is linked to the life cycle at the life span. Some organisms are better adapted to survive in an otherwise hostile environment (Survival of the fittest). For example, antibiotic resistance in bacteria. When a bacterial population was grown on an agar plate containing antibiotic penicillin, the colonies sensitive to penicillin died, whereas the ones resistant to penicillin survived due to adaptation.

Key concepts of the theory are

(*i*) Branching descent

(*ii*) Natural selection

(*b*) Characteristics of *Neanderthal* man:

(*i*) Their brain size was 1400 cc.

(*ii*) They used hides to protect their bodies.

(*iii*) They buried their dead.

Q. 11. Fitness is the end result of the ability to adapt and get selected by nature. Explain with suitable example. ***[CBSE Delhi 2010]***

Ans. Fitness is based on certain characteristics which are inherited and the ability to adapt to the changing environment. It is the end result of adaptation because a fit individual survives and unfit individuals are eliminated from the population. Individuals continuously compete with each other in a population for food, space and light. The one which is better adapted and naturally selected by nature survives and reproduces.

For example, industrial evidence: It is a case of natural selection.

In England, it was observed before industrialisation that white-winged moths were more than dark-winged moths. But the situation became reversed after industrialisation. During pre-industrialisation, the tree trunks were covered by white lichens and on white-background dark-coloured moths can be picked up. During post industrialisation, the tree trunks were covered by dust, coal particles and thus became dark. On such trunks, white moths could be easily picked up. Thus, it was found that industrial melanism supports evolution by natural selection.

Q. 12. (*a*) How do the observations made during moth collection in pre- and post-industrialized era in England support evolution by Natural Selection?

(*b*) Explain the phenomenon that is well represented by Darwin's finches other than natural selection. ***[CBSE Delhi 2017]***

Ans. (*a*) Refer to Basic Concepts Point 7 (*ii*) (*a*)

(*b*) The process of evolution of different species in a given geographical area starting from a point, radiating to other areas of geography (habitats) is called adaptive radiation. Finches evolved in the same island from original seed eating features. Many other altered beaks arose enabling them to became insectivorous and vegetarian finches.

Q. 13. (*a*) Explain the process of natural selection that leads to speciation.

(*b*) List the three different ways in which this process operates in nature. Explain any one of the processes. ***[CBSE (F) 2012]***

Ans. Refer to Basic Concepts Point 7(*ii*).

Q. 14. (*a*) Describe Hardy-Weinberg Principle.

(*b*) List any four factors which affect genetic equilibrium.

(*c*) Describe Founder effect. ***[CBSE (F) 2014]***

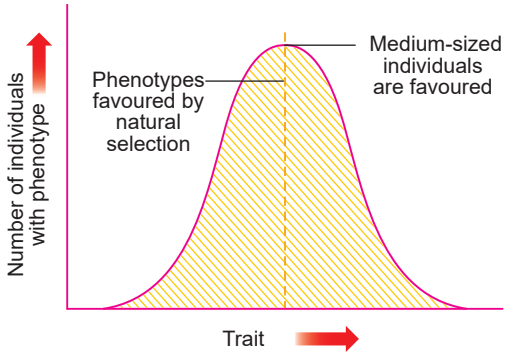
Ans. (*a*) Refer to Basic Concepts Point 8.

(*b*) Refer to Basic Concepts Point 9.

(*c*) Refer to Basic Concepts Point 9 (Genetic drift).

Q. 15. (*a*) Write the Hardy–Weinberg principle.

(*b*) Explain the three different ways in which natural selection can affect the frequency of a heritable trait in a population shown in the graph given below. ***[CBSE Delhi 2010]***



Ans. **(*a*)** Hardy–Weinberg principle states that the gene pool (total genes and their alleles in a population) remains constant, *i.e.*, the allele frequencies in a population are stable and constant from generation to generation. This biological phenomenon is called genetic equilibrium.

(*b*) Natural selection can lead to stabilisation (in which more individuals acquire mean character value), directional change (more individuals acquire value other than the mean character value) or disruption (more individuals acquire peripheral character value at both ends of the distribution curve).

For diagram, refer to Fig. 7.8.

Q. 16. (*a*) Describe Hardy-Weinberg's principle.
(*b*) How does variation lead to speciation?
(*c*) How is the genetic equilibrium affected by the variations leading to speciation?
[*CBSE (F) 2016*]

Ans. (*a*) Refer to Basic Concepts Point 8.

(*b*) Accumulation of small and directional variation over the generations become heritable. This enables better survival. The variant species reproduce and leave greater number of progeny, ultimately forming a new species.

(*c*) As per genetic equilibrium the sum total of all the allelic frequencies in a population is 1. Change of frequency of alleles in a population, due to variation causes disturbance in the genetic equilibrium resulting in speciation (evolution).

Q. 17. How does the process of natural selection affect Hardy-Weinberg equilibrium? Explain. List the other four factors that disturb the equilibrium. **[*CBSE (AI) 2013*]**

Ans. Refer to Basic Concepts Point 9.

Q. 18. (*a*) How does Hardy–Weinberg equation explain genetic equilibrium?
(*b*) Describe how does this equilibrium get disturbed which may lead to founder effect.
[*CBSE (F) 2012*]

Ans. (*a*) Hardy-Weinberg equation is $p^2 + 2pq + q^2 = 1$. This means that the sum total of all the allelic frequencies is 1. In a diploid, p^2 means that the probability an allele *AA* with a frequency of p appear on both the chromosomes of a diploid individual will be p^2. Similarly of allele aa is q^2, and of *Aa* is $2pq$.

(*b*) The equilibrium gets disturbed due to genetic drift which refers to the changes in allele frequencies of a population occurring by chance. The change in allele frequency may be so different that the population becomes a different species, the original population becomes founders and such an effect is called founder effect.

Q. 19. (*a*) Name the primates that lived about 15 million years ago. List their characteristic features.
(*b*) (*i*) Where was the first man-like animal found?
(*ii*) Write the order in which Neanderthals, *Homo habilis* and *Homo erectus* appeared on earth. State the brain capacity of each one of them.
(*iii*) When did modern *Homo sapiens* appear on this planet? **[*CBSE Delhi 2011*]**

Ans. (*a*) Primates called *Dryopithecus* and *Ramapithecus* lived 15 million years ago.

Their characteristic features are:

(*i*) They were hairy and walked like gorillas and chimpanzees.

(*ii*) *Ramapithecus* was more man-like.

(*iii*) *Dryopithecus* was more ape-like.

(*b*) (*i*) First man-like animal was found in Ethiopia and Tanzania.

(*ii*) The order of appearance from the earliest to the latest is:
Homo habilis, *Homo erectus*, Neanderthals.

The brain capacity of *Homo habilis* is 650–800 cc, of *Homo erectus* is 900 cc and of Neanderthals is 1400 cc.

(*iii*) Modern *Homo sapiens* appeared between 75,000–10,000 years ago.

Self-Assessment Test

Time allowed: 1 Hour **Max. marks: 30**

1. Choose and write the correct option in the following questions. **(3×1 = 3)**

(i) Animal husbandry and plant breeding programmes are the examples of

(a) reverse evolution (b) artificial selection

(c) mutation (d) natural selection

(ii) DDT resistance in mosquito is an example of

(a) stabilizing selection (b) directional selection

(c) disruptive selection (d) No selection

(iii) Darwin's finches are an excellent example of

(a) divergent evolution (b) adaptive selection

(c) connecting links (d) both (a) and (b)

2. In the following questions a statement of assertion followed by a statement of reason is given. Choose the correct answer out of the following choices. **(3×1 = 3)**

(a) Assertion and reason both are correct statements and reason is correct explanation for assertion.

(b) Assertion and reason both are correct statements but reason is not correct explanation for assertion.

(c) Assertion is correct statement but reason is wrong statement.

(d) Assertion is wrong statement but reason is correct statement.

(i) Assertion : Sediments of different aged rocks contain fossils and different life forms.

Reason : The age of fossils is estimated by radiocarbon dating.

(ii) Assertion : Pasteur's experiment supported the theory of abiogenesis.

Reason : Theory of abiogenesis states that first form of life arose from non-living molecules.

(iii) Assertion : Darwin's finches show adaptive radiation.

Reason : All finches arose from common ancestral seed-eating stock and underwent adaptive changes.

3. What is divergent evolution? **(1)**

4. What causes speciation according to Hugo de Vries? **(1)**

5. What is the significance of *Archoeopteryx* in the study of organic evolution? **(2)**

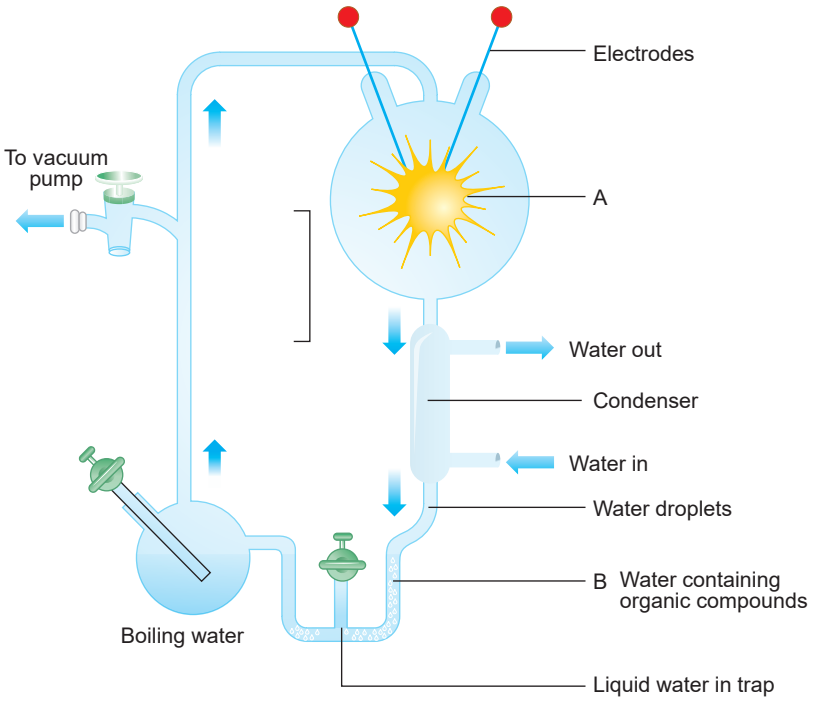
6. DDT was known to be a highly effective insecticide in the past. Why did it not wipe out all the mosquito population? **(2)**

7. Discovery of lobefins is considered very significant by evolutionary biologists. Explain. **(2)**

8. How do Darwin's finches illustrate adaptive radiation? **(2)**

9. What are fossils? Mention any two ways in which the study of fossils supports biological evolution of an organism. **(3)**

10. Given below is a diagrammatic representation of the experimental set-up used by S.L. Miller for his experiment: **(3×1 = 3)**



(i) Write the names of different gases contained and the conditions set for the reaction in the flask.

(ii) State the type of organic molecule he collected in the water.

(iii) Write the conclusion he arrived at.

11. How does Darwin's theory of Natural Selection explain the appearance of new forms of life on earth? **(3)**

12. Describe Miller and Urey's experiment, along with the product obtained. What is the significance of this experiment? **(5)**

Answers

1. (*i*)—(*b*), (*ii*)—(*b*), (*iii*)—(*b*) **2.** (*i*)—(*b*), (*ii*)—(*d*), (*iii*)—(*a*)

Chapter–8

Human Health and Diseases

basic concepts

1. Health

- It is a state of complete physical, mental and social well-being.
- Health increases the longevity of people and reduces infant and maternal mortality rate.
- Good health is maintained by balanced diet, personal hygiene, regular exercise, yoga, vaccination against infectious diseases, proper disposal of wastes, control of vectors and maintenance of hygienic food and water resources.
- Health is affected by
  - Genetic disorders (defects inherited from parents from birth)
  - Infections
  - Life-style: (*a*) food and water we take in (*b*) rest (*c*) exercise (*d*) habits

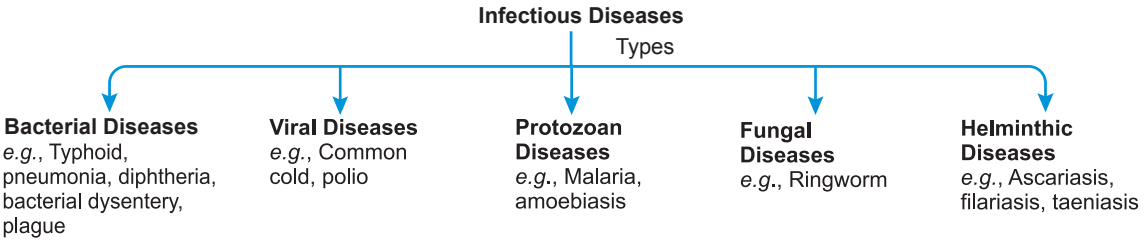
2. Disease

- Any condition which interferes with the normal functioning of the body and causes disorder of the mind or body is called a **disease**.
- The disease causing organisms are called **pathogens**.
- All parasites are pathogens as they cause harm to the host by living in/on them. They enter our body, multiply and interfere with vital activities, causing morphological and functional damage. So pathogens adapt to life within environment of host. For example, pathogen living in gut must survive at low pH and resist digestive juices.

Table 8.1: Differences between infectious and non-infectious diseases

S. No.	Infectious diseases	Non-infectious diseases
(*i*)	These are easily transmitted from one infected person to the other.	These are not transmitted from one person to the other.
(*ii*)	Such diseases are due to extrinsic factors, *i.e.*, pathogens.	Extrinsic as well as intrinsic factors, like deficiencies and hereditary factors, can cause these diseases.
(*iii*)	Public health and personal hygiene reduces the probability of disease.	Public health and personal hygiene are ineffective.
(*iv*)	For example, HIV, tetanus, hepatitis-B.	For example, cancer.

Table 8.2: Classification of infectious diseases based on pathogens



3. Bacterial Diseases

(i) Typhoid

- It is caused by pathogenic bacterium ***Salmonella typhi***.
- It is **spread** by contaminated food and water.
- It generally enters the small intestine and then migrates to other organs through blood.

Symptoms

(*a*) Constant high fever (39°C to 40°C) (*b*) Weakness (*c*) Stomach pain
(*d*) Loss of appetite (*e*) Constipation (*f*) Headache
(*g*) Intestinal perforation and death may occur in severe cases.

- Typhoid fever can be confirmed by **Widal test**.
- **Mary Mallon**, called **Typhoid Mary**, was a cook and a typhoid carrier who continued to spread the disease for several years through the food prepared by her, before it was discovered.

(ii) Pneumonia

- It is caused by ***Streptococcus pneumoniae*** and ***Haemophilus influenzae***.
- They infect alveoli (air-filled sacs) of the lungs where the alveoli get filled with a fluid resulting in the decrease of respiratory efficiency of the lungs.
- It is spread by inhaling droplets/aerosol from infected persons and sharing glasses and utensils with an infected person.

Symptoms

(*a*) Fever (*b*) Chills (*c*) Cough
(*d*) Headache (*e*) In severe cases, lips and finger nails turn gray to bluish in colour.

4. Viral Diseases

(i) Common cold

- It is caused by a group of viruses called **rhino viruses**.
- These viruses infect the nasal epithelium and respiratory passage but not the lungs.
- Their attack lasts for about 3–7 days.
- It **spreads** by (*a*) contaminated objects like pens, books, cups, etc., (*b*) cough and sneeze droplets from an infected person.

Symptoms

(*a*) Nasal congestion and discharge (*b*) Sore throat (*c*) Hoarseness
(*d*) Cough (*e*) Headache (*f*) Tiredness

(ii) Dengue fever

- It is caused by virus ***Flavivirus***.
- Dengue is **transmitted** by the bite of a mosquito infected with one of the four dengue virus serotypes.
- It affects infants, young children and adults with symptoms appearing 3–14 days after the infective bite.
- There is no vaccine or any specific medicine to treat dengue. People who have dengue fever should rest and drink plenty of fluids.

Symptoms

(*a*) High fever (*b*) Severe headache (*c*) Pain behind the eyes
(*d*) Muscle and joint pain (*e*) Rash

(iii) Chikungunya

- It is caused by an alphavirus called **Chikungunya virus**.
- It is generally **spread** through bites from *A. aegypti* mosquitoes.
  - The best means of prevention is overall mosquito control and the avoidance of bites by any infected mosquitoes.
  - No specific treatment is known, but medications can be used to reduce symptoms.

Symptoms

(*a*) Fever up to 104°F (*b*) Severe joint pain (*c*) Muscle pain (*d*) Headache
(*e*) Nausea (*f*) Fatigue (*g*) Rash

5. Protozoan Diseases

(i) Malaria

- It is caused by a protozoan ***Plasmodium*** (*P. vivax*, *P. malaria* and *P. falciparum*).
- *P. falciparum* causes the most serious and fatal malignant malaria.
- The **vector** of *Plasmodium* is female *Anopheles* mosquito which transfers the sporozoites (infectious form).
- Treatment is by antimalarial drugs like quinine, chloroquin.
- Malaria can be prevented by killing mosquitoes by spraying DDT, BHC, etc., and using insect repellents, mosquito nets, etc.

Life cycle of *Plasmodium*

- *Plasmodium* requires two hosts to complete its life cycle—human and mosquito.
- The infected female *Anopheles* mosquito transfers the infectious form of *Plasmodium*, *i.e.*, sporozoites to the human body by biting.
- The sporozoites reach the liver cells, where they multiply.
- This is followed by their attack on red blood cells resulting in their rupture.
- The ruptured RBCs release a toxin called **haemozoin**, which is responsible for high recurring fever, chills and shivering.
- Sexual stages (gametocytes) develop in red blood cells, from where these parasites enter the female *Anopheles* mosquitoes when they bite an infected person.
- In the body of mosquitoes, they fertilise and multiply in the stomach wall.
- Sporozoites are now stored in the salivary gland of mosquito till it is again transferred to human body by a mosquito bite. After entering the human body, all the events are repeated.

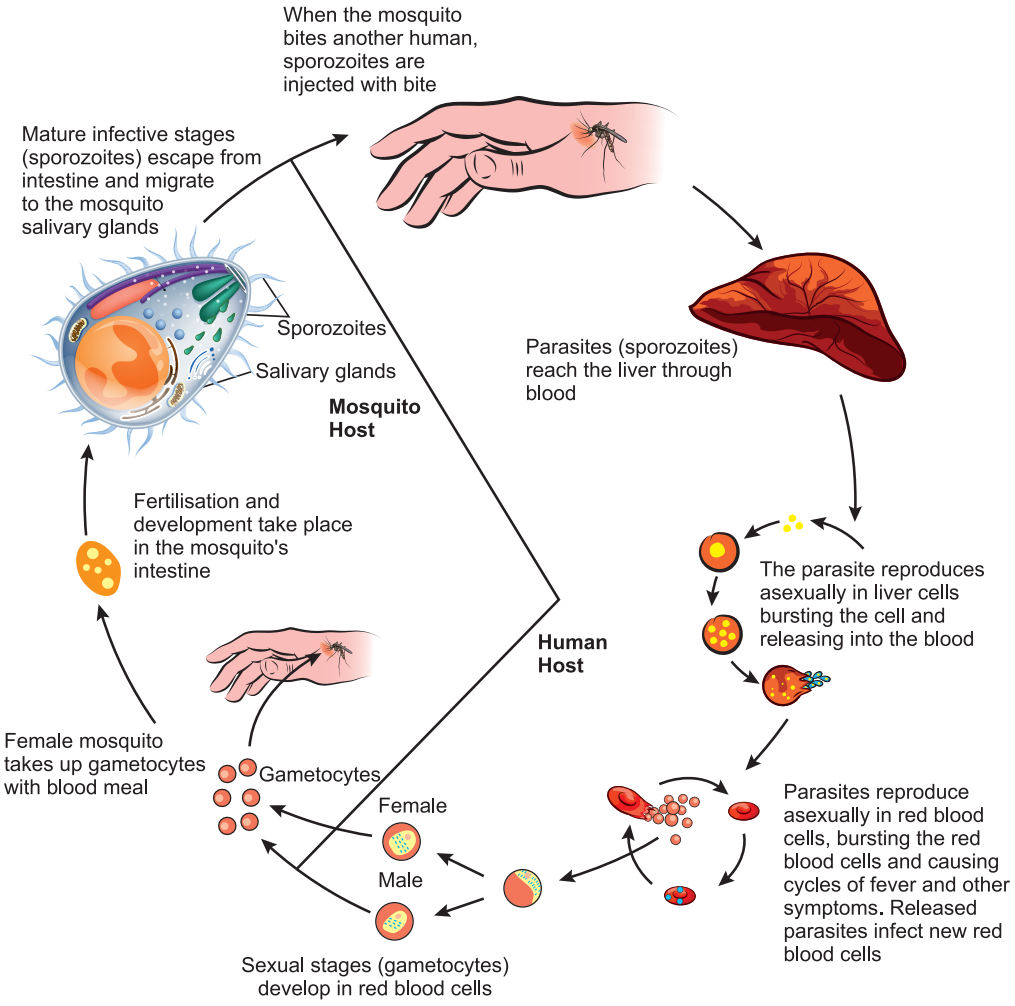


Fig. 8.1 Stages in the life cycle of *Plasmodium*

(ii) Amoebic dysentery (Amoebiasis)

- It is caused by a protozoan endoparasite, ***Entamoeba histolytica***, found in large intestine of humans.
- **Housefly** acts as mechanical carrier and transmits the parasite from faeces of infected person to the food.
- Infection takes place through food and water contaminated by faecal matter.

Symptoms

(*a*) Abdominal pain
(*b*) Constipation
(*c*) Cramps
(*d*) Stool with excess mucous and blood clots.

6. Fungal Diseases

Ringworm

- It is caused by fungi of genera ***Microsporum, Trichophyton*** and ***Epidermophyton***.
- Human **infection** occurs either through contact with an infected person or from soil. It also spreads through towels, clothes, combs, etc., of the infected persons.
- Heat and moisture help these fungi to grow that makes them thrive in skinfolds like in groin or between toes.

Symptoms

(*a*) Dry and scaly lesions on skin, nails and scalp.

(*b*) Lesions are accompanied by intense itching.

7. Helminthic Diseases

(i) Ascariasis

- It is caused by an intestinal endoparasite of human, ***Ascaris lumbricoides***, commonly called roundworm.
- Eggs of parasite are excreted along with faeces of infected person, which contaminates water, soil and plants.
- Infection takes place through contaminated vegetables, fruits and water.

Symptoms

(*a*) Abdominal pain (*b*) Indigestion

(*c*) Internal bleeding (*d*) Muscular pain

(*e*) Fever (*f*) Anaemia

(*g*) Nausea and headache (*h*) Blockage of the intestinal passage.

(ii) Filariasis/Elephantiasis

- It is caused by filarial worms, ***Wuchereria bancrofti*** and ***Wuchereria malayi***.
- Female *Culex* mosquito is the vector.

Symptoms

(*a*) Inflammation of organs in which they live

(*b*) Blockage of lymph vessels of lower limbs resulting in swelling. Lower limbs appear like legs of elephant, thus the name.

(*c*) Genital organs may also be affected, leading to deformation.

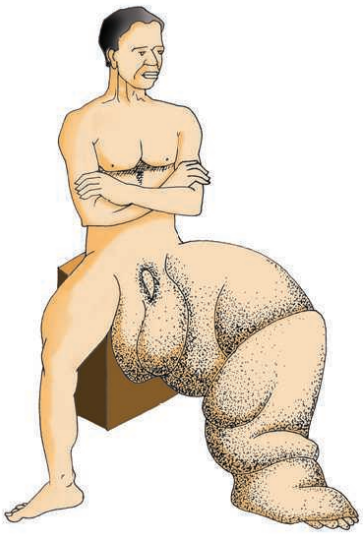


Fig. 8.2 Diagram showing inflammation in one of the lower limbs due to elephantiasis

8. Prevention and Control of Infectious Diseases

- The following measures can prevent/control the infectious diseases:

A. For diseases transmitted through food and water like typhoid, amoebiasis, ascariasis.

(*i*) Maintenance of personal hygiene: By keeping the body clean, consuming clean drinking water, food, vegetables and fruits.

(*ii*) Maintenance of public hygiene: Proper disposal of wastes and excreta, periodic cleaning and disinfection of water reservoirs and pools, tanks, standard practice of hygiene in public catering.

B. For Air-borne diseases like pneumenia, common cold:

(*i*) Maintain personal hygiene.

(*ii*) Maintain public hygiene.

(*iii*) Close contact with infected persons or their belongings should be avoided.

C. For vector-borne diseases like malaria, filariasis dengue chikunguniya to above measures, close contact with infected persons or their belongings should be avoided.

(*i*) Eradication of vectors and their breeding places.

(*ii*) Use of mosquito nets.

(*iii*) Avoid stagnation of water

(*iv*) Introduce fishes like *Gambusia* in ponds that feed on mosquito larvas.

(*v*) Spray insecticides in ditches drainage areas, swamps.

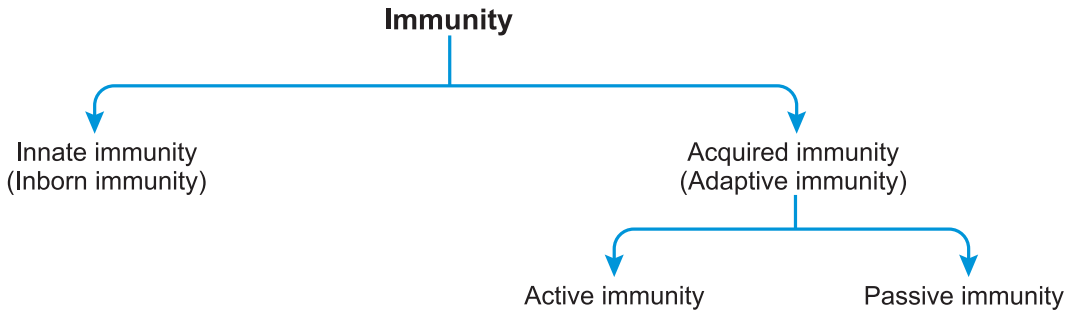
(*vi*) Wire mesh at doors and windows to prevent entry of mosquitoes.

D. Vaccination and immunisation programmes for diseases like polio, diphtheria, tetanus, etc.

E. Use of antibiotics and drugs to treat the infected person.

9. Immunity

- It is the ability of an organism to resist or defend itself from the development of a disease.



(i) Innate immunity

- It is present from the birth and is inherited from parents.
- It is non-specific type of defence.
- It is accomplished by providing different types of barriers to entry of foreign agents 4 types of barriers are:

(a) Physical barriers

These barriers do not allow pathogens and foreign agents to enter the body, *e.g.*, skin, mucous membranes of digestive, respiratory and urinogenital tracts trapping microorganisms.

(b) Physiological barriers

Sweat, tears from eyes, acid in the stomach and saliva in mouth prevent microbial growth.

(c) Cellular barriers

WBCs (polymorphonuclear leukocytes PMNL-neutrophils), and monocytes (natural killer lymphocytes) and macrophages phagocytose and destroy microbes.

(d) Cytokine barriers

Proteins called interferons produced by virus-infected cells protect non-infected cells from further viral infection.

(ii) Acquired immunity

- It is not present from the birth and develops during an individual's lifetime.
- It is pathogen specific.
- It has the ability to distinguish diverse types of foreign molecules or antigens (specificity).
- When the immune system encounters a pathogen for the first time, a primary response is produced which is of low intensity. The memory of this encounter with the same pathogen is also formed. On subsequent encounter with the same pathogen, a secondary or anamnestic response is produced which is of very high intensity because of memory of first encounter.
- Immune responses are produced by two types of lymphocytes:

(*a*) B-lymphocytes or **B-cells** produce an army of proteins called antibodies in blood, in response to pathogens.

(*b*) T-lymphocytes or **T-cells** help B-cells to produce antibodies.

- Two types of acquired immune responses or immunities develop in the body:

(*a*) Humoral immune response or **antibody mediated immunity (AMI):** It is mediated by antibodies in the blood and lymph (humor).

(*b*) Cell-mediated immune response or **cell-mediated immunity (CMI):** It is mediated by T-lymphocytes. It is responsible for graft rejection in organ transplant because of its ability to differentiate between 'self' and 'non-self'. Tissue matching, blood group matching are thus essential before any graft/transplant and even after this, patients are given immune-suppressant all their lives.

Table 8.3: Differences between active and passive immunity

S. No.	Active immunity	Passive immunity
(*i*)	It is developed due to contact with pathogen (dead or living) or its antigen, that leads to production of antibodies in the host body.	It is developed when readymade antibodies are injected into the body to protect body against foreign agents.
(*ii*)	It has no or only few side effects.	It may cause a reaction.
(*iii*)	It is slow but long lasting.	It is fast but lasts only for few days.
(*iv*)	It takes time to develop its response.	It is used when the immune response has to be faster.
(*v*)	For example, vaccination for polio, etc.	For example, administration of tetanus antitoxins, antibodies in colostrum, etc.
(*vi*)	Injecting microbes deliberately during immunisation or infections organisms entering body induce active immunity.	Foetus receives some antibodies from their mother through placenta during pregnancy, which induce passive immunity.

10. Antibodies

- Antibodies are protein molecules called immunoglobulins (Ig) and are of 4 types—IgA, IgM, IgE and IgG.
- An antibody has a Y-shaped structure.
- Each antibody molecule consists of four polypeptide chains, two are long called **heavy (H) chains** while the other two are short called **light (L) chains**. Hence, an antibody is represented as H_2L_2.
- IgG is the most prevalent antibody in the blood followed by IgA and IgM.
- IgA is present in breast milk (colostrum).

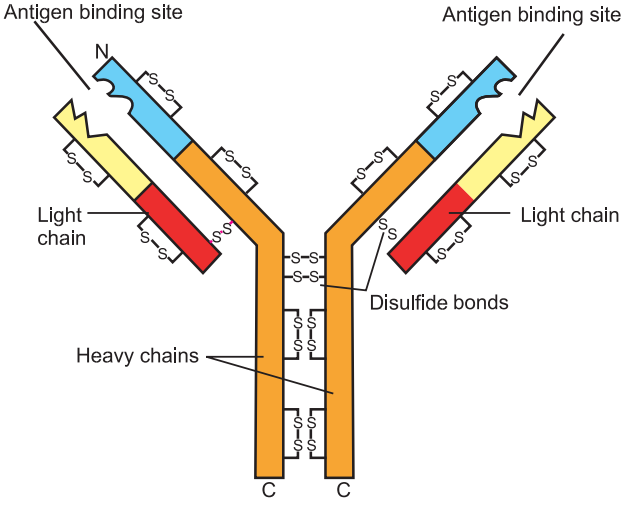


Fig. 8.3 Structure of an antibody molecule

11. Vaccination and Immunisation

- **Vaccination** is the process of introduction of weakened or inactivated pathogens or proteins (**vaccine**) into a person to provide protection against a disease.
- Vaccines are weakened or inactivated pathogens or proteins introduced into a person to provide protection against a disease.

- **Immunisation** is the process by which the body produces antibodies against the vaccine (primary response) and develops the ability to neutralise pathogens during actual infection (secondary response).
- Vaccination provides immunisation after a time gap.
- Vaccination and immunisation are based on the property called **'Memory'** of the immune system.
- The vaccine generates memory B- and T-cells that recognise the pathogen on subsequent exposure and produce an intense immune response.
- If a quick immune response is needed, as in tetanus infection or snake bite, preformed antibodies or antitoxin is injected into the patient. This type of immunisation is called **passive immunisation**.
- By recombinant DNA technology, vaccines have been produced on large scale, *e.g.*, hepatitis-B vaccine is produced from yeast.

12. Allergy

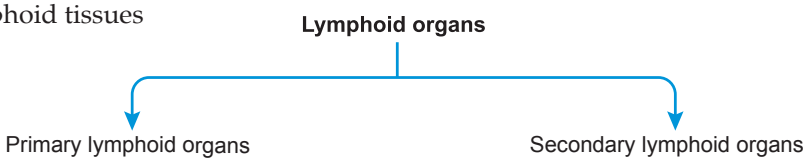
- The exaggerated or hypersensitive reaction of the immune system to certain antigens present in the environment is called **allergy**.
- The substances/agents which produce an immune response in an individual are called **allergens**, *e.g.*, pollen grains, animal dander, dust, feathers, drugs like penicillin, etc.
- IgE antibodies are produced in response to allergens.
- **Cause:** Chemicals like histamine and serotonin released from the mast cells.
- **Symptoms:** (*i*) Sneezing (*ii*) Watery eyes (*iii*) Running nose (*iv*) Difficulty in breathing.
- Drugs like anti-histamine, adrenalin and steroids quickly reduce the symptoms of allergy.
- To determine cause of allergy, patient is injected with very small doses of suspected allergens and the reactions are studied.
- Modern day lifestyle has lowered immunity and increased sensitivity to allergens.

13. Auto Immunity

- It is an abnormal immune response in which the immune system of the body starts rejecting its own body cells or 'self' cells and molecules, hence body attacks self cells thus damaging the body.
- For example, rheumatoid arthritis, Addison's disease.

14. Immune System

- Components of immune system:
  - Lymphoid organs
  - Immune cells
  - Soluble molecules like antibodies
  - Lymphoid tissues



(i) Primary lymphoid organs

- The organs where lymphocytes originate and mature to become antigen-sensitive, *e.g.*, bone marrow and thymus, are called primary lymphoid organs where immature lymphocytes differentiate into antigen sensitive lymphocytes.

(a) Bone marrow

- It is the primary lymphoid organ where all blood cells including lymphocytes originate.
- Bone marrow provides the micro-environment for the development and maturation of B-lymphocytes.

(b) Thymus

- Thymus is a lobed organ located near the heart and beneath the breastbone.
- It is quite large at the time of birth but reduces with age.
- It provides the micro-environment for the development and maturation of T-lymphocytes.

(ii) Secondary lymphoid organs

- After maturation, lymphocytes migrate to secondary lymphoid organs.
- The organs where lymphocytes interact with the antigen and proliferate to become effector cells, *e.g.*, spleen, lymph nodes, tonsils, Peyer's patches of small intestine and appendix are called secondary lymphoid organs.

(a) Spleen

- It is a large bean-shaped organ and contains lymphocytes and phagocytes.
- It acts as a filter of the blood by trapping blood-borne microorganisms.
- It has a large reservoir of erythrocytes.

(b) Lymph nodes

- These are small solid structures present at different points along the lymphatic system.
- They trap the microorganisms or other antigens that enter the lymph and tissue fluid.
- Antigens trapped in the lymph nodes activate the lymphocytes and produce an immune response.

(c) Mucosal associated lymphoid tissue (MALT)

- It is formed of masses of lymphoid tissue lining the mucosa of respiratory, digestive and urinogenital tracts.
- 50 per cent of the lymphoid tissue in human body is formed by MALT.

15. Acquired Immuno Deficiency Syndrome (AIDS)

- It was first reported in U.S.A. in 1981 and in last 25 years, it has killed more than 25 million people.
- It is caused by the **Human Immunodeficiency Virus (HIV)**.
  - HIV belongs to the group **retrovirus**.
  - It has RNA genome enclosed in an envelope.
- Transmission of HIV occurs through following ways:
  - (*i*) By sexual contact with the infected person.
  - (*ii*) By transfusion of contaminated blood and blood products.
  - (*iii*) By sharing infected needles.
  - (*iv*) From infected mother to her child through placenta.
- It is not spread by more touch or physical contact. It only spreads through body fluids. Hence the infected persons should not be isolated from family and society.

High risk individuals

(*i*) Those having multiple sexual partners.
(*ii*) Drug addicts taking the drugs intravenously.
(*iii*) Individuals who require repeated blood transfusions.
(*iv*) Children born to an HIV infected mother.

- Diagnosis is done by **enzyme linked immunosorbent assay (ELISA)**.
- **Incubation Period:** Time gap between infection and appearance of AIDS symptoms is called the incubation period. It may vary from few months to 5–10 years.

Life cycle of HIV

- After getting into the body of a person, the virus enters the macrophages.
- Here, RNA is replicated to form viral DNA by enzyme reverse transcriptase.
- The viral DNA now gets incorporated into the host cell's DNA and directs the infected cells to produce viruses.
- The macrophages continue to produce virus particles and hence act like HIV factory.
- The virus particles enter helper T-lymphocytes (T_H cells) in the blood, where they continue to replicate and produce viral progenies.
- Thus, the number of helper T-lymphocytes progressively decreases in the body of the infected persons.

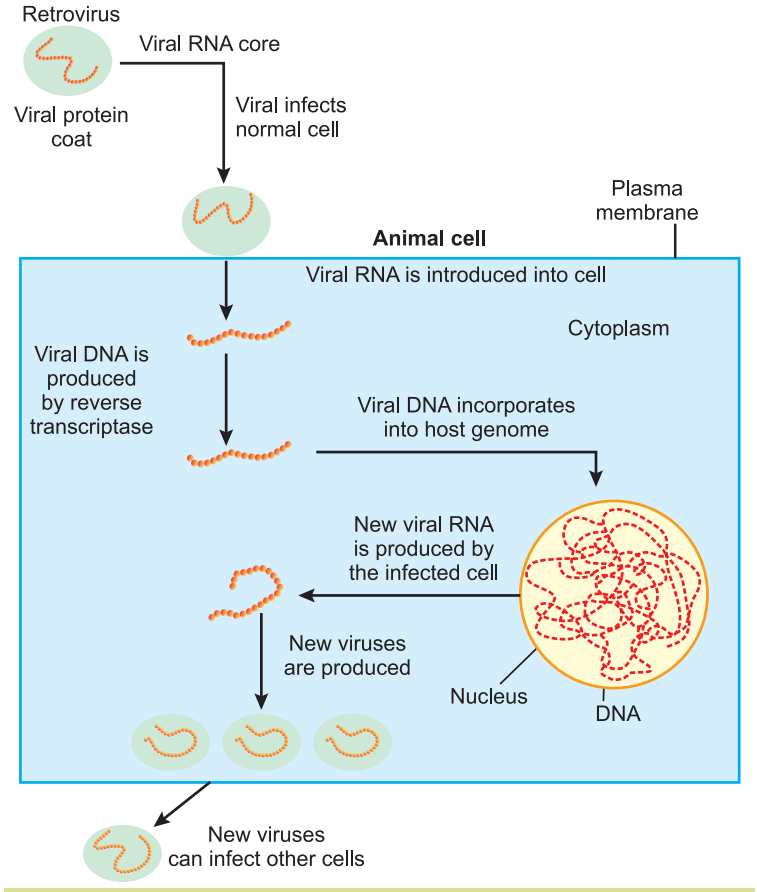


Fig. 8.4 Replication of retrovirus

- With the decrease in number of T-cells, the immunity also decreases. The person is unable to produce any immune response even against common bacteria like *Mycobacterium*, parasites like *Toxoplasma*, viruses and fungi.
- Infected cells can survive while viruses are being replicated and released.

Treatment

- There is no permanent cure for HIV.
- **Anti-retroviral drugs:** They can only prolong life of patient but cannot prevent death.

Preventive measures

- As no cure is there so prevennttion is best option. As it spreads due to conscious behaviour so prevention is easy.
- National AIDS Control Organisation (NACO) established in 1991 and other non-governmental organisations (NGOs) educate people about AIDS.
- WHO has started a number of programmes to prevent the spreading of HIV infection that includes:
  - (*i*) making blood from blood banks safe from HIV.
  - (*ii*) ensuring the use of only disposable needles and syringes.
  - (*iii*) free distribution of condoms.
  - (*iv*) controlling drug abuse.
  - (*v*) advocating safe sex and promoting regular check-ups for HIV susceptible populations.

16. Cancer

- Cancer is defined as an uncontrolled division or proliferation of cells without any differentiation.
- **Characteristics of cancer cells:**
  - (*i*) The cells divide repeatedly with uncontrolled cell division.
  - (*ii*) The cancer cells do not require extracellular growth factors.
  - (*iii*) Cancer cells have lost the property of **contact inhibition**.
  - (*iv*) Due to repeated division, cells form a large mass of tissue called **tumour**.
  - (*v*) The cells pass out from the tumour to new sites for forming secondary tumours.
  - (*vi*) The invasion of cancerous cells from one part to the other parts by body fluid is called **metastasis**.
  - (*vii*) Tumours are of two types—benign and malignant.

Table 8.4: Differences between benign and malignant tumours

S. No.	Benign tumour	Malignant tumour
(*i*)	It is a non-cancerous tumour.	It is a cancerous tumour.
(*ii*)	Benign tumour does not show metastasis and is non-invasive.	It shows metastasis and thus invades other body parts.
(*iii*)	It stops growth after reaching a certain size.	Malignant tumour shows indefinite growth as proliferating cells, called Neoplastic or tumor cells, grow rapidly, invade and damage other tissues.
(*iv*)	Limited adherence occurs amongst cells of benign tumour.	There is no adherence amongst cells. They tend to slip past one another.
(*v*)	It is less fatal to the body.	It is more fatal to the body.

- Oncogenic viruses have cancer-causing **viral oncogenes**.
- Normal cells have genes called **cellular oncogenes** (***c-onc***) or **proto-oncogenes,** which are present in inactivated state but under certain conditions (like mutation) get transformed to cancer-causing **oncogenes**.

(i) Causes of cancer

- The cancer-causing agents are called **carcinogens**. These are of following types:

(*a*) Chemical agents: Aniline dyes, N-nitrosodimethylamine, benzopyrene, chemicals in cigarette smoke.

(*b*) Physical agents: Ionising radiations like X-rays and γ-rays, non-ionising radiations like UV-rays, damage DNA causing neoplastic transformation.

(*c*) Biological agents: Oncogenic viruses, some parasites.

(ii) Types of cancer

(*a*) **Carcinoma:** It is cancer of epithelial tissue, *e.g.*, skin cancer.

(*b*) **Melanoma:** It is cancer of melanocytes of skin.

(*c*) **Sarcoma:** It is cancer of mesodermal tissue.

(*d*) **Leukemia and lymphoma:** It is cancer of haemopoietic cells (blood cells).

(iii) Cancer detection

(*a*) **Blood and bone marrow tests** are done for increased cell count in case of leukemia.

(*b*) **Histopathological study or biopsy:** In biopsy, a piece of the suspected tissue cut into thin sections is stained and examined under microscope by a pathologist.

(*c*) **Radiography:** X-rays are used to detect cancer of the internal organs.

(*d*) **Computed tomography:** It uses X-rays to generate a three-dimensional image of the internal of an object.

(*e*) **MRI (Magnetic Resonance imaging):** Non-ionising radiation and strong magnetic field are used in MRI to accurately detect pathological and physiological changes in the living tissue.

(*f*) **Monoclonal antibodies:** Antibodies against cancer-specific antigens are also used for detection of certain cancers.

(*g*) **Techniques in molecular biology:** Used to detect genes in individuals with inherited susceptibility to certain cancers. Identification of such genes can help in prevention by advising to avoid exposure to particular carcinogen to which they are susceptible like tobacco smoke for lung cancer.

(iv) Cancer treatment

- The common approaches for treatment of cancer are:

(*a*) **Surgery:** The tumour cells are removed with the help of surgery to check the spread of cancerous cells.

(*b*) **Radiation therapy:** A lethal irradiation of tumour cell is done, taking proper care of the normal tissues surrounding the tumour mass.

(*c*) **Chemotherapy:** Cancerous cells are killed by several chemotherapeutic drugs. These drugs exhibit side-effects like hair loss, anaemia.

(*d*) **Immunotherapy:** In this method, biological modifiers like α-interferons are used which activate the immune system and help in destroying the tumour as tumor cells avoid detection and destruction by immune system. Majority of treatments require combination of surgery, radiotherapy and chemotherapy.

17. Drugs and Alcohol Abuse

- When drugs and alcohol are taken for purposes other than medicinal or taken in amounts or frequencies that impairs physical, physiological or psychological functions, it is called **drug abuse** and **alcohol abuse**, respectively.
- Drugs belong to different categories which are as follows.

(i) Opioids

- Heroin is a depressant and slows down body functions.
- **Source:** **Morphine** is extracted from the latex of poppy plant *Papaver somniferum*. **Heroin** is obtained by acetylation of morphine, is a white, odourless, bitter, crystalline compound; commonly called **smack**.
- **Mode of intake:** By snorting and injection.
- **Mode of action:** They bind to specific opioid receptors in the central nervous system (CNS) and gastrointestinal tract.

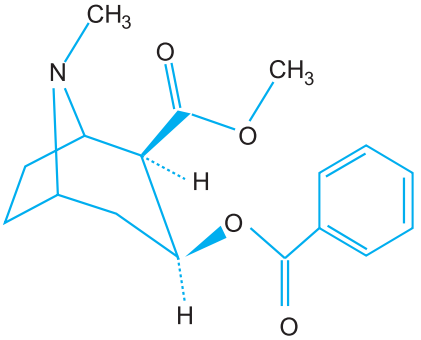


Fig. 8.5. Chemical structure of morphine

- **Effects:** Heroin is a depressant and slows down body functions. Morphine is an effective sedative and painkiller useful in patients who have undergone surgery.

(ii) Cannabinoids

- **Source:** Obtained from inflorescence of the plant *Cannabis sativa*. Flower tops, leaves and resins of *C. sativa* in various combinations produce hashish, charas, marijuana and ganja.
- **Mode of intake:** By inhalation and oral ingestion.
- **Mode of action:** They interact with the cannabinoid receptors present in the brain.
- **Effects:** Effect the cardiovascular system of the body.

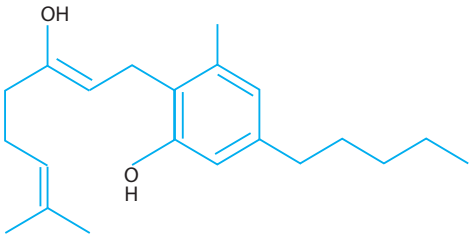


Fig. 8.6. Skeletal structure of cannabinoid molecule

(iii) Coca alkaloid or cocaine

- **Source:** Derived from the leaves and young branches of South American plant called *Erythroxylum coca (coca plant)*. Cocaine is commonly called coke or crack.
- **Mode of intake:** By sniffing and snorting.
- **Mode of action:** It has a potent stimulating action on central nervous system and interferes with the transport of the neurotransmitter dopamine.
- **Effect:** It is a strong stimulant of CNS and produces sense of euphoria and increased energy. When taken in excess it causes headache, convulsions, hallucinations and even death due to cardiovascular or respiratory failure.

(iv) Hallucinogens

- **Source:** Obtained from plants like *Atropa belladona* and *Datura sps*. Lysergic acid diethyl amide (LSD) is derived from the fungus *Claviceps purperea*. Plants with hallucinogenic properties have even been used as medicines in religious ceremonies and rituals.
- **Mode of action:** These drugs are called **psychedelic drugs** because of their effects on the cerebrum and sense organs.
- **Effect:** These drugs effect thoughts, feelings and perceptions of an individual. Medically these are given to patients to cope with mental illnesses like depression and insomnia.

(v) Tobacco

- **Source:** Tobacco plant.
- **Mode of intake:** It is smoked, chewed or used as a snuff.
- **Mode of action:** It has nicotine, an alkaloid, which stimulates the adrenal gland to release adrenaline and noradrenaline which in turn increases the blood pressure and heart rate.
- **Effects:**
  - (*a*) Smoking increases the chances of lung cancer, bronchitis, emphysema, coronary heart disease, cancer of throat, gastric ulcer, cancer of urinary bladder, etc.
  - (*b*) Smoking leads to increase in carbon monoxide content of blood and reduces concentration of haem-bound oxygen, as a result of which oxygen deficiency in the body is created.
  - (*c*) Chewing of tobacco causes oral cancer which becomes fatal in extreme conditions.

(vi) Alcohol

- **Mode of intake:** Oral intake.
- **Mode of action:** Alcohol has an anaesthetic effect on nervous system affecting cerebrum, cerebellum and other parts.
- **Effect:** It may cause euphoria, peptic ulcer, gastric carcinoma, hepatitis, liver failure, liver cell carcinoma.

18. Addiction and Dependence

- The psychological attachment to certain effects such as euphoria and temporary feeling of well-being, associated with drugs and alcohol is called **addiction**.
- People take drugs/alcohol when not needed, but with repeated use, tolerance level of receptions in body increases; receptors thus respond to higher doses, leadinng to greater intake and addition.
- Reasons for alcohol abuse in adolescents:
  - (*i*) Social pressure.
  - (*ii*) Curiosity and need for adventure, excitement and experiment.
  - (*iii*) To escape from stress, depression and frustration.
  - (*iv*) To overcome hardships of daily life.
  - (*v*) Unstable or unsupportive family structure.
  - (*vi*) Effects might be perceived as beneficial for relieving stress
  - (*vii*) Perception that it is cool or progressive to smoke and consume alcohol. TV, movies, internet, newspapers promote this perception.
  - (*viii*) Pressure to excel in academics or exams.
- The tendency of the body to manifest characteristic and unpleasant **withdrawal syndrome** on abrupt discontinuation of regular dose of drugs/alcohol is called **dependence.**
- Characteristics of withdrawal symptoms:
  - (*i*) Anxiety
  - (*ii*) Shakiness
  - (*iii*) Nausea
  - (*iv*) Sweating
  - (*v*) Vomiting
  - (*vi*) Diarrhoea
  - (*vii*) Insomnia
  - (*viii*) Muscular and abdominal cramps
  - (*ix*) Restlessness
  - (*x*) Depressed mood
  - (*xi*) Irritability

  Withdrawal symptoms are at peak after 1–2 days of stopping the intake and slowly fade away. They mostly disappear 3–4 weeks after abstinence.

19. Effects of Drug and Alcohol Abuse

- Alcohol has an anaesthetic effect on nervous system, affecting cerebrum followed by cerebellum and other parts.
- It affects the nervous system in following ways:
  - (*i*) Loss of judgement, will power and self control.
  - (*ii*) Loss of emotional control.
  - (*iii*) Loss of moral sense.
  - (*iv*) Visual problem.
  - (*v*) Staggering and incoherent speech.
  - (*vi*) Inflammation of axon of neuron leading to neuritis.
- **Side-effects of drugs on males:** Acne, aggressiveness, reduction in size of testicles, decreased sperm production, premature baldness, enlargement of prostate gland, mood swings, depression, breast enlargement, potential for kidney and liver dysfunction.
- **Side-effects of drugs on females:** Masculinisation, aggressiveness, mood swings, depression, abnormal menstrual cycles, enlargement of clitoris and excessive facial and body hair; deapening of voice.
- **Warning signs of drug and alcohol abuse:**
  - (*i*) Drop in academic performance.
  - (*ii*) Absence from school/college.

(*iii*) Lack of interest in personal hygiene.
(*iv*) Isolation, depression, fatigue, aggressive and rebellious behaviour.
(*v*) Deteriorating relationships with family and friends.
(*vi*) Fluctuation in weight, etc.
(*vii*) Loss of interest in hobbies.
(*viii*) Change in eating and sleeping habits and appetite.

- Those who take drugs intravenously develop a risk of AIDS and hepatitis-B.
- Use of alcohol during adolescence may lead to heavy drinking in adulthood.
- The chronic use of drug and alcohol damages nervous system and liver (**cirrhosis**) and the alcoholism during pregnancy affects the foetus.
- May turn to stealing to get money for buying drugs/Alcohol.
- Becomes cause of mental and financial distress to one's family.
- May manifest reckless behaviour, vandalism and violence.

20. Prevention and Control

- **Avoid undue pressure:** Every child has his own choice and personality and hence should be respected and nurtured accordingly. They should not be forced to perform beyond their threshold limits, be in sports or studies, etc.
- **Educating and counselling:** Children should be educated and counselled to face problems, stresses, to accept disappointments and features as part of life. We shold put in efforts to channellise child's energy into healthy pursuits like sports, reading, music, yoga etc.
- **Seeking help from parents and peers:** Parents and friends can guide appropriately to sort out their problems and can thus help the youth to vent out their feelings of anxiety and guilt.
- **Looking for danger signs:** Parents and teachers should be careful enough to look for and identify the danger signs and if there, it should be brought to the notice of parents so that appropriate measures can be taken to diagnose the malody and underlying causes. This would help in initiating proper remedial steps and measures.
- Seeking professional and medical help whenever required. Help from psychologist, psychiatrists, deaddiction and rehabilitation programmes and with sufficient will power, one can get rid of problem completely.

NCERT Textbook Questions

Q. 1. What are the various public health measures which you would suggest as safeguard against infectious disease?

Ans. The common preventive measures are as follows:

(*i*) **Education:** People should be educated about communicable diseases to protect themselves from such diseases.

(*ii*) **Isolation:** The infected person should be isolated to minimise the spread of infection.

(*iii*) **Vaccination:** People should get vaccination on time to avoid infection.

(*iv*) **Sanitation:** The sanitation condition should be improved to avoid infection from polluted water, contaminated food, etc.

(*v*) **Eradication of vectors:** The breeding places of vectors should be destroyed and adult vectors should be killed by suitable methods.

(*vi*) **Sterilisation:** The patient's surroundings and articles of use should be completely sterilised so as to reduce the chances of infection.

Q. 2. In which way has the study of biology helped us to control infectious diseases?

Ans. Study of biology helps us to diagnose the pathogen in following ways:

(*i*) The life cycle of many pathogens is studied.

(*ii*) Alternate and reservoir hosts are known.

(*iii*) The mechanisms of transmission of disease is known.

(*iv*) The protective measures are suggested against disease and pathogen based on above studies.

(*v*) Suitable medicines against infectious diseases are suggested.

(*vi*) The preparation of vaccines against many pathogens also entitle the use of study of biology.

Q. 3. How does the transmission of each of following diseases take place?

(*a*) Amoebiasis **(*b*) Malaria**

(*c*) Ascariasis **(*d*) Pneumonia.**

Ans. **(*a*) Amoebiosis**

Caused by *Entamoeba histolytica* (Protozoan parasite).

Transmission:

(*i*) By ingesting cysts with food and water.

(*ii*) The cysts are carried by flies from faeces to food and drinks.

(*b*) Malaria

Caused by *Plasmodium* sps.

Transmission:

(*i*) Transmitted by female *Anopheles* mosquito.

(*ii*) Female *Anopheles* injects sporozoites along with saliva while sucking blood.

(*c*) Ascariasis

Caused by *Ascaris lumbricoides*. Is transmitted through contaminated food and water with *Ascaris* eggs.

(*d*) Pneumonia

Caused by *Streptococcus pneumoniae*. Transmission is through sputum, droplets or aerosols of the patient.

Q. 4. What measures would you take to prevent water-borne diseases?

Ans. Measures to prevent water-borne diseases are:

(*i*) Use clean drinking water.

(*ii*) Periodic cleaning and disinfection of water reservoirs, pools and tanks.

(*iii*) Proper sanitary conditions.

(*iv*) Prevention of passage of garbage and sewage into water reservoirs.

Q. 5. Discuss with your teacher what does 'a suitable gene' mean, in the context of DNA vaccines.

Ans. The term 'suitable gene' refers to that specific segment of DNA which forms immunogenic protein. Such genes can be cloned and then integrated with vector for introducing into an individual to be immunised for certain disorder producing a particular vaccine against the pathogen.

Q. 6. Name the primary and secondary lymphoid organs.

Ans. Primary lymphoid organs are bone marrow and thymus. Secondary lymphoid organs are spleen, lymph nodes, tonsils, Peyer's patches of small intestine and appendix.

Q. 7. The following are some well-known abbreviations, which have been used in this chapter. Expand each one to its full form:

(*a*) MALT **(*b*) CMI** **(*c*) AIDS** **(*d*) NACO** **(*e*) HIV**

Ans. (*a*) MALT—Mucosal associated lymphoid tissues.

(*b*) CMI—Cell-mediated immunity.

(*c*) AIDS—Acquired immunodeficiency syndrome.

(*d*) NACO—National AIDS Control Organisation.

(*e*) HIV—Human Immunodeficiency Virus.

Q. 8. Differentiate the following and give examples of each:

(*a*) Innate and acquired immunity

(*b*) Active and passive immunity

Ans. (*a*)

Table 8.5: Differences between innate and acquired immunity

S. No.	Innate immunity	Acquired immunity
(*i*)	It is present from birth and is inherited from parents.	It is not present from the birth.
(*ii*)	It is non-specific.	It is pathogen specific.
(*iii*)	The various physical, physiological, cellular, cytokine barriers are the basis of innate immunity.	The memory cells formed by B and T-cells are the basis of acquired immunity.
(*iv*)	The innate immunity remains throughout life.	The acquired immunity can be short-lived or life long.

(*b*) Active and passive immunity: Refer to Table 8.1.

Q. 9. Draw a well labelled diagram of an antibody molecule.

Ans. Refer to Fig. 8.3.

Q. 10. What are the various routes by which transmission of human immunodeficiency virus takes place?

Ans. Various routes by which transmission of HIV takes place:

(*i*) Transfusion of contaminated blood and blood products.

(*ii*) By sharing infected needles in case of intravenous drug abusers.

(*iii*) Sexual contact with an infected person.

(*iv*) From mother to child through placenta.

Q. 11. What is the mechanism by which the AIDS virus causes deficiency in the immune system of the infected person?

Ans. The virus enters macrophages after getting into the body of individual where RNA forms viral DNA by reverse transcription. The viral DNA gets incorporated in the host cell's DNA and directs the infected cells to produce viral copies. The newly produced virus particles attack helper T-cells and thus the number of T-cells decrease. Since the helper T-cells are essential for functioning of immune system, the person suffers from various diseases due to deficient immune system.

Q. 12. How is a cancerous cell different from a normal cell?

Ans. (*i*) There is no adherence in cancerous cell whereas normal cells remain adhered to one another.

(*ii*) Tumour is formed in cancerous cells due to repeated uncontrolled cell division whereas it is absent in normal cells.

(*iii*) Cancerous cells have no definite lifespan but normal cells have definite lifespan and old cells are replaced by new cells.

Q. 13. Explain what is meant by metastasis.

Ans. Metastasis is the spread of cancerous cells through migration from one tissue to other tissue and organs resulting in formation of secondary tumour. Malignant tumour is a mass of proliferating cells called neoplastic cells. They grow rapidly and invade surrounding unaffected normal cells or tissues. Cells get sloughed off from such tumour and migrate to distant sites through blood. A new place of infection is thus established and a new tumour is formed. This property is called metastasis.

Q. 14. List the harmful effects caused by alcohol/drug abuse.

Ans. The following are the harmful effects caused by alcohol/drug abuse:

(*i*) It affects the nervous system resulting in loss of judgement, will power and self-control, visual problem, etc.

(*ii*) It may cause peptic ulcer, gastric carcinoma, etc.

(*iii*) It may affect liver by causing hepatitis, liver failure, liver cell carcinoma, etc.

(*iv*) Reckless behaviour, vandalism and violence, isolation, depression, fatigue, aggressive, fluctuations in weight, appetite, etc.

(*v*) Those who take drugs intravenously are much more likely to acquire serious infections like AIDS and hepatitis-B.

(*vi*) Damages nervous system and may cause liver cirrhosis.

Q. 15. Do you think that friends can influence one to take alcohol/drugs? If yes, how may one protect himself/herself from such an influence?

Ans. Yes, friends can influence a person to take alcohol or drugs. It can be avoided by

(*i*) avoiding addicted friends.

(*ii*) avoiding experimental use of alcohol/drug just for curiosity and pressure.

Q. 16. Why is that once a person starts taking alcohol or drugs, it is difficult to get rid of this habit? Discuss it with your teacher.

Ans. The repeated use of alcohol or drugs increases the tolerance level of the receptors present in our body. Therefore, the receptors respond only to higher doses of alcohol or drugs. This leads to greater intake and addiction. Addiction drives the people to consume more knowing that their use makes them destructive. Hence, it is difficult to get rid of this habit.

Q. 17. In your view what motivates youngsters to take to alcohol or drugs and how can this be avoided?

Ans. **Reasons for alcohol abuse in children:**

(*i*) Social pressure.

(*ii*) Curiosity and need for adventure, excitement and experiments.

(*iii*) To overcome hardships of daily life.

(*iv*) In order to escape from stress, depression and frustration.

(*v*) Unsupportive family structure.

Alcohol and drugs can be avoided by following ways:

(*i*) Avoiding undue peer pressure.

(*ii*) Educating and counselling problems and stresses to avoid disappointments and failure in life.

(*iii*) Seeking help from parents and peers.

(*iv*) Seeking professional and medical help whenever required.

Multiple Choice Questions [1mark]

Choose and write the correct option in the following questions.

1. HIV that causes AIDS, first starts destroying

(*a*) helper T-lymphocytes (*b*) B-lymphocytes

(*c*) leucocytes (*d*) thrombocytes

2. Antibodies in our body are complex

(*a*) glycoproteins (*b*) lipoproteins (*c*) steroids (*d*) prostaglandins

3. Lysozyme that is present in perspiration, saliva and tears, destroys

(*a*) certain types of bacteria (*b*) all viruses

(*c*) most virus-infected cells (*d*) certain fungi

4. Increased asthmatic attacks in certain seasons are related to

(*a*) eating fruits preserved in tin containers (*b*) inhalation of seasonal pollen

(*c*) low temperature (*d*) hot and humid environment.

5. To which type of barriers under innate immunity, do the saliva in the mouth and the tears from the eyes, belong?

(*a*) Physiological barriers (*b*) Physical barriers (*c*) Cytokine barriers (*d*) Cellular barriers.

6. A person likely to develop tetanus us immunized by administering

(*a*) performed antibodies (*b*) wide spectrum antibotics

(*c*) weakened germs (*d*) dead germs.

7. The term 'Health' is defined in many ways. The most accurate definition of the health would be: [*NCERT Exemplar*]

(*a*) Health is the state of body and mind in a balanced condition

(*b*) Health is the reflection of a smiling face

(*c*) Health is a state of complete physical, mental and social well-being

(*d*) Health is the symbol of economic prosperity.

8. The clinical test that is used for diagnosis of typhoid is

(*a*) ELISA (*b*) ESR (*c*) PCR (*d*) Widal

9. Diseases are broadly grouped into infectious and non-infectious diseases. [*NCERT Exemplar*]
In the list given below, identify the infectious diseases.

(*i*) Cancer (*ii*) Influenza (*iii*) Allergy (*iv*) Small pox

(*a*) (*i*) and (*ii*) (*b*) (*ii*) and (*iii*) (*c*) (*iii*) and (*iv*) (*d*) (*ii*) and (*iv*)

10. The sporozoites that cause infection when a female *Anopheles* mosquito bites a person, are formed in [*NCERT Exemplar*]

(*a*) liver of the person (*b*) RBCs of mosquito

(*c*) salivary glands of mosquito (*d*) gut of mosquito

11. Dengue in humans is caused by

(*a*) Viruses (*b*) Bacteria (*c*) Fungi (*d*) Helminthes

12. The disease chikungunya is transmitted by [*NCERT Exemplar*]

(*a*) house fly (*b*) *Aedes* mosquito (*c*) cockroach (*d*) female *Anopheles*

13. Many diseases can be diagnosed by observing the symptoms in the patient. Which group of symptoms are indicative of pneumonia? [*NCERT Exemplar*]

(*a*) Difficulty in respiration, fever, chills, cough, headache

(*b*) Constipation, abdominal pain, cramps, blood clots

(*c*) Nasal congestion and discharge, cough, constipation, headache

(*d*) High fever, weakness, stomach pain, loss of appetite and constipation

14. In malignant tumors, the cells proliferate, grow rapidly and move to other parts of the body to form new tumors. This stage of disease is called [*NCERT Exemplar*]

(*a*) metagenesis (*b*) metastasis (*c*) teratogenesis (*d*) mitosis

15. When an apparently healthy person is diagnosed as unhealthy by a psychiatrist, the reason could be that [*NCERT Exemplar*]

(*a*) the patient was not efficient at his work

(*b*) the patient was not economically prosperous

(*c*) the patient shows behavioural and social maladjustment

(*d*) he does not take interest in sports

16. Which of the following are the reason(s) for rheumatoid arthritis? Choose the correct option. [*NCERT Exemplar*]

(*i*) The ability to differentiate pathogens or foreign molecules from self cells increases.

(*ii*) Body attacks self cells

(*iii*) More antibodies are produced in the body

(*iv*) The ability to differentiate pathogens or foreign molecules from self cells is lost

(*a*) (*i*) and (*ii*) (*b*) (*ii*) and (*iv*) (*c*) (*iii*) and (*iv*) (*d*) (*i*) and (*iii*)

17. B-lymphocytes are associated with

(*a*) Humoral immunity (*b*) Inflammatory response

(*c*) Cell mediated immunity (*d*) Phagocytosis

18. The substance produced by a cell in viral infection that can protect other cells from further infection is *[NCERT Exemplar]*

(*a*) serotonin (*b*) colostrum (*c*) interferon (*d*) histamine

19. Transplantation of tissues/organs to save certain patients often fails due to rejection of such tissues/organs by the patient. Which type of immune response is responsible for such rejections? *[NCERT Exemplar]*

(*a*) Auto-immune response (*b*) Humoral immune response

(*c*) Physiological immune response (*d*) Cell-mediated immune response

20. Which of the following antibodies form innate immunity?

(*a*) IgE (*b*) IgD (*c*) IgM (*d*) IgG

21. Tobacco consumption is known to stimulate secretion of adrenaline and nor-adrenaline. The component causing this could be *[NCERT Exemplar]*

(*a*) nicotine (*b*) tannic acid (*c*) curamin (*d*) catechin

22. Which of the following is not a lymphoid tissue? *[NCERT Exemplar]*

(*a*) Spleen (*b*) Tonsils (*c*) Pancreas (*d*) Thymus

23. Which of the following glands is large sized at birth but reduces in size with ageing? *[NCERT Exemplar]*

(*a*) Pineal (*b*) Pituitary (*c*) Thymus (*d*) Thyroid

24. Haemozoin is a *[NCERT Exemplar]*

(*a*) precursor of hemoglobin (*b*) toxin released from *Streptococcus* infected cells

(*c*) toxin released from *Plasmodium* infected cells (*d*) toxin released from *Haemophilus* infected cells

25. Which of the following is not the causal organism for ringworm? *[NCERT Exemplar]*

(*a*) *Microsporum* (*b*) *Trichophyton* (*c*) *Epidermophyton* (*d*) *Macrosporum*

26. LSD is obtained from

(*a*) *Erythroxylum coca* (*b*) *Cannabis sativa* (*c*) *Claviceps purpurea* (*d*) *Papaver somniferum*

Answers

1. (*a*)	**2.** (*a*)	**3.** (*a*)	**4.** (*b*)	**5.** (*a*)	**6.** (*a*)	**7.** (*c*)	**8.** (*d*)	**9.** (*d*)	**10.** (*d*)
11. (*a*)	**12.** (*b*)	**13.** (*a*)	**14.** (*b*)	**15.** (*c*)	**16.** (*b*)	**17.** (*a*)	**18.** (*c*)	**19.** (*d*)	**20.** (*d*)
21. (*a*)	**22.** (*c*)	**23.** (*c*)	**24.** (*c*)	**25.** (*d*)	**26.** (*c*)				

Assertion-Reason Questions

In the following questions a statement of assertion followed by a statement of reason is given. Choose the correct answer out of the following choices.

(a) Assertion and reason both are correct statements and reason is correct explanation for assertion.

(b) Assertion and reason both are correct statements but reason is not correct explanation for assertion.

(c) Assertion is correct statement but reason is wrong statement.

(d) Assertion is wrong statement but reason is correct statement.

1. Assertion : Interferons are glycoproteins which are produced by virally infected cells.

Reason : Interferons stimulate inflammation at the site of injury.

2. Assertion : Tapeworm, roundworm and pinworm are endoparasites of human intestine.

Reason : Improperly cooked food is the source of intestinal infections.

3. Assertion : Dope test is blood test to know whether a person taking part in a competition used and drug.

Reason : A drunken person usually feels tense and less talkative.

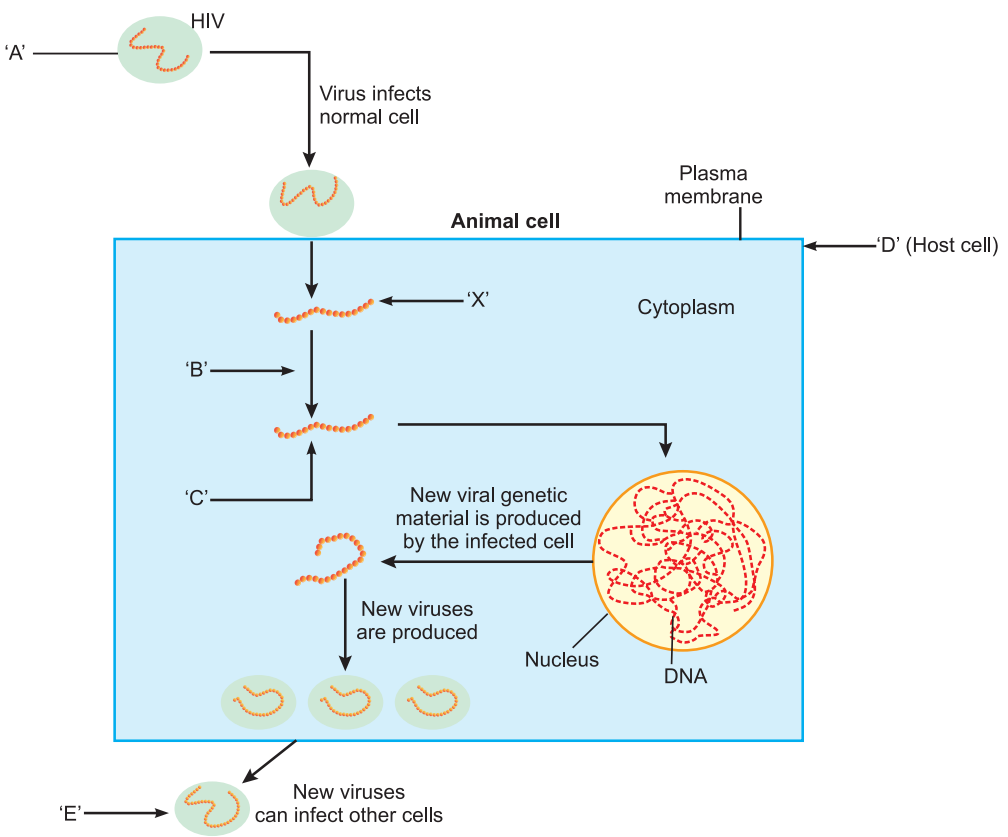
4. **Assertion :** Mast cells in the human body release excessive amounts of inflammatory chemicals, which cause allergic reactions.
   Reason : Allergens in the environment on reaching human body stimulate mast cells in certain individuals.
5. **Assertion :** Second infection of the same pathogen is quickly eliminated.
   Reason : Preformed memory B and T-cells elicit a quick and vigorous attack on pathogens.
6. **Assertion :** Immunisation is done by successful delivery of vaccines.
   Reason : Vaccines are microbial preparations used to induce protective immunity.
7. **Assertion :** Proto-oncogenes are cellular genes required for normal growth.
   Reason : Under certain conditions they lead to the oncogenic transformation of the cell.
8. **Assertion :** Morphine is useful for patients under depression.
   Reason : Morphine is a very effective sedative painkiller.
9. **Assertion :** Tobacco contains nicotine which stimulates the adrenal gland.
   Reason : Nicotine increases the blood pressure and the heart rate.
10. **Assertion :** Opioids help to enhance respiratory activity.
    Reason : Opioids bind to the receptors in the central nervous system and gastrointestinal tract.

Answers

1. (*c*) **2.** (*b*) **3.** (*c*) **4.** (*a*) **5.** (*a*) **6.** (*a*) **7.** (*b*) **8.** (*d*) **9.** (*b*) **10.** (*d*)

Case-based/Source-based Question

1. **Study the diagram showing replication of HIV in humans and answer the following questions accordingly:**



(*i*) What type of virus causes AIDS? Name its genetic material.

(*ii*) Name the enzyme 'B' acting on 'X' to produce molecule 'C'. Name 'C'.

(*iii*) Name the type of cells the AIDS virus enters into after getting in the human body.

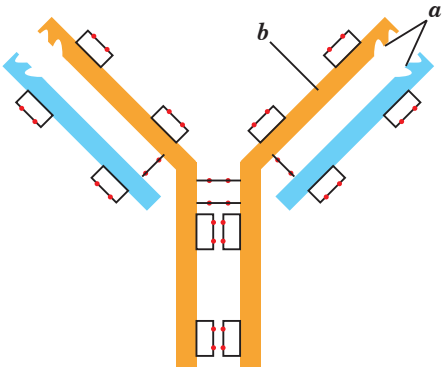
Ans. (*i*) Retrovirus causes AIDS. RNA is its genetic material.

(*ii*) The enzyme 'B' is reverse transcriptase, 'C' is viral DNA.

(*iii*) Monocytes and helper T-lymphocytes.

2. Study the figures given below and answer the questions that follow.

(*i*) Identify (*a*) and (*b*) in the diagram of an antibody molecule given below.



(*ii*) Name the type of cells that produce this molecule.

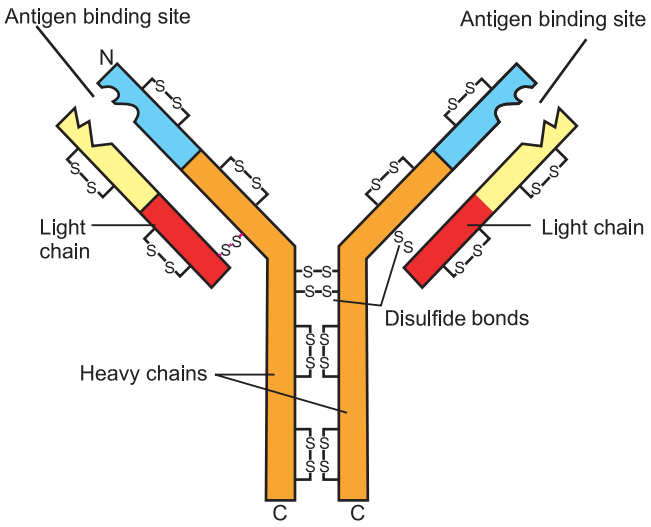
(*iii*) Why is an antibody represented as 'H_2L_2' ?

Ans. (*i*) (*a*) Antigen binding site (*b*) Heavy chain

(*ii*) B-lymphocytes (B-cells).

(*iii*) Each antibody molecule has four polypeptide chains. The two smaller chains are called light chains while the two longer chains are called heavy chains. Therefore an antibody is represented as H_2L_2.

3. Given below is the structure of an antibody.



(*i*) A boy of ten years had chicken pox. He is not expected to have the same disease for the rest of his life. Mention how it is possible.

(*ii*) Why is secondary immune response more intense than the primary immune response in humans?

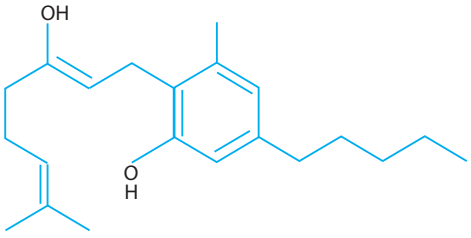
(*iii*) Some allergens trigger sneezing and wheezing in human beings. What causes this type of response by the body?

Ans. (*i*) The boy when encounters a pathogen for the first time, his body produces antibodies that results in the memory of the first encounter, to protect the body in future.

(*ii*) This is because of presence of antibodies developed during primary.

(*iii*) The exaggerated response of the immune systems to certain antigens (allergens) present in the environment is the cause of this type of response.

4. Study the figures given below and answer the questions that follow.



(*i*) Why do sports persons often fall a victim to cocaine addiction?

(*ii*) Why sharing of injection needles between two individuals is not recommended?

(*ii*) Mention the useful as well as the harmful drug obtained from the latex of Poppy plant.

Ans. (*i*) Plant source of cocaine is *Erythroxylum coca*. It has a potent stimulating action on central nervous system, producing a sense of euphoria and increased energy. Excessive dosage of cocaine causes hallucinations.

(*ii*) Sharing of needles can transmit diseases like HIV, AIDS, Hepatitis B or C from infected to non-infected individuals.

(*ii*) Useful drug—morphine, Harmful drug—heroin.

5. Observe the life cycle of HIV given in the diagram in Q. 1 above, and answer the questions below.

(*i*) Retroviruses have no DNA. However, the DNA of the infected host cell does possess viral DNA. How is it possible?

(*ii*) Name the group of viruses responsible for causing AIDS in humans. Why are these viruses so named?

(*iii*) List any two ways of transmission of HIV infection in humans, other than sexual contact.

Ans. (*i*) On infecting the host cell, the viral RNA transforms into viral DNA by reverse transcription. This viral DNA then incorporates into the host DNA.

(*ii*) Retrovirus cause AIDS in humans. These are named so because they have RNA genome and reverse transcriptase enzyme which carries on the processes RNA $\rightarrow$ DNA $\rightarrow$ RNA.

(*iii*) Infected blood transfusion, sharing syringes/needles, children born to HIV mothers.

Very Short Answer Questions [1 mark]

Q. 1. Malaria, typhoid, pneumonia and amoebiasis are some of the human infectious diseases. Which ones of these are transmitted through mechanical carriers? ***[CBSE (F) 2011]***

Ans. Malaria and amoebiasis are transmitted through mechanical carriers.

Q. 2. Name the two intermediate hosts which the human liver fluke depends on to complete its life cycle so as to facilitate parasitization of its primary host. ***[CBSE Delhi 2014]***

Ans. Snail and Fish

Q. 3. Why is *Gambusia* introduced into drains and ponds? ***[CBSE (AI) 2014]***

Ans. To feed on mosquito larvae so as to eliminate the vectors responsible for causing malaria.

Q. 4. How does haemozoin affect the human body when released in blood during malarial infection? ***[CBSE (F) 2014]***

Ans. Haemozoin is responsible for the chill and high fever recurring every three to four days during malarial infection

Q. 5. State two different roles of spleen in the human body. ***[CBSE (AI) 2012]***

Ans. Spleen is the secondary lymphoid organ that stores lymphocytes, it filters microbes and acts as a reservoir to store erythrocytes (*Any two*).

Q. 6. Name any two physiological barriers that provide innate immunity? ***[CBSE 2019 (57/2/1)]***

Ans. Acid in stomach/saliva in mouth/tears in eyes. (*Any two*)

Q. 7. What is it that prevents a child to suffer from a disease he/she is vaccinated against? Give one reason. ***[CBSE Delhi 2010]***

Ans. The immunological memory induced by the vaccine in a child prevents the recurrence of a disease.

Q. 8. How does colostrum provide initial protection against diseases to new born infants? Give one reason.

Ans. Colostrum contains several antibodies which are absolutely essential for developing resistance in the new-born babies.

Q. 9. Name two diseases whose spread can be controlled by the eradication of *Aedes* mosquitoes. ***[CBSE Delhi 2018]***

Ans. Dengue/Chikungunya/yellow fever/Eastern equine encephalitis/West Nile fever/Zika virus disease. (*Any two*)

Q. 10. What are interferons?

Ans. Virus infected cells secrete proteins called interferons which protect non-infected cells from further viral infection.

Q. 11. "Pranay suffered from measles at the age of 10 years. There are rare chances of his getting infected with the same disease for the rest of his life." Give reason for the statement. ***[CBSE Sample Paper 2014]***

Ans. First exposure to the infection works as vaccination, the immune system of the body gets familiar with the nature of microorganisms and specific antibodies can be produced against infection.

Q. 12. In what way are monocytes a cellular barrier in immunity?

Ans. Monocytes can phagocytose (by the process called phagocytosis) and thereby destroy the pathogens.

Q. 13. High fever, loss of appetite, stomach pain and constipation are some of the symptoms seen in a patient. How would the doctor confirm that the patient is suffering from typhoid and not amoebiasis?

Ans. By performing Widal test.

Q. 14. Millions of chickens were killed in West Bengal, Orissa and Maharashtra recently. What was the reason? ***[NCERT Exemplar]***

Ans. Millions of chickens were killed (culled) in West Bengal, Orissa and Maharashtra because they were found to be infected with H5N1 virus, the causal organism of Bird Flu.

Q. 15. Why do pollen grains of some flowers trigger 'sneezing' in some people? ***[CBSE (F) 2012]***

Ans. Pollen grains trigger sneezing by causing allergic reaction.

Q. 16. How do interferons protect us? ***[CBSE (AI) 2012; 2019 (54/4/1)]*** ***[HOTS]***

Ans. Interferons protect non-infected cells from further viral infections, by creating cytokine barriers.

Q. 17. When does a human body elicit an anamnestic response? ***[CBSE (AI) 2013]***

Ans. At the time of secondary response.

Q. 18. State the functions of mast cells in allergy response. ***[CBSE (F) 2013; 2019 (54/4/1)]***

Ans. Mast cells release chemicals like histamine and serotonin in allergic response.

Q. 19. What is an autoimmune disease? Give an example. ***[CBSE (F) 2014]***

Ans. It is an abnormal immune response in which the immune system of the body starts rejecting its own body cells or 'self' cells and molecules. For example, rheumatoid arthritis.

Q. 20. Name two STDs which can be transmitted through contaminated blood.

Ans. Hepatitis-B and AIDS are the two STDs which can be transmitted through contaminated blood.

Q. 21. Name the category of the disease: Rheumatoid arthritis. *[CBSE (F) 2012]*

Ans. Auto-immune disease.

Short Answer Questions [2 marks]

Q. 1. Define the term 'health'. Mention any two ways of maintaining it. *[CBSE (AI) 2010]*

Ans. Health is a state of complete physical, mental and social well-being.

Good health is maintained by balanced diet/personal hygiene/regular exercise. (*Any two*)

Q. 2. List the symptoms of ascariasis. How does a healthy person acquire this infection? *[CBSE (AI) 2014]*

Ans. **Symptoms of ascariasis:** Internal bleeding, muscular pain, anaemia, blockage of intestinal passage.

A healthy person can acquire this infection by intake of water, vegetables/fruits/foods contaminated with eggs of the parasite.

Q. 3. Name the causative organism of the disease amoebiasis. List three symptoms of the disease. *[CBSE Delhi 2016]*

Ans. *Entamoeba histolytica* causes amoebiasis.

Symptoms are constipation, abdominal pain/cramps, stool with excess mucous/blood clots.

Q. 4. Write the scientific names of the causal organisms of elephantiasis and ringworm in humans. Mention the body parts affected by them. *[CBSE Delhi 2011]*

Ans.

Disease	Causal Organism	Body parts affected
Elephantiasis	*Wuchereria bancrofti* and *Wuchereria malayi*.	Lymph vessels of lower limbs and genital organs.
Ringworm	*Microsporum*, *Trichophyton* and *Epidermophyton*	Skin, nails and scalp.

Q. 5. Identify *a*, *b*, *c* and *d* in the following table: *[CBSE (F) 2010]*

S. No.	Name of the human disease	Name of the causal bacteria/virus	Specific organ or its part affected
(*i*)	Typhoid	*Salmonella typhi*	*a*
(*ii*)	Common cold	*b*	*c*
(*iii*)	Pneumonia	*Streptococcus pneumoniae*	*d*

Ans. (*a*) small intestine (*b*) Rhino virus

(*c*) nose and respiratory passage (*d*) alveoli of lungs

Q. 6. Write the biological (binomial) names of causal organisms of the following diseases:

(*a*) Typhoid (*b*) Pneumonia *[CBSE Sample Paper 2014]*

Ans. (*a*) *Salmonella typhi*

(*b*) *Streptococcus pneumoniae*

Q. 7. Write the biological (binomial) names of causal organisms of the following diseases:

(*a*) Elephantiatis (Filariasis) (*b*) Amoebiasis *[CBSE Sample Paper 2014]*

Ans. (*a*) *Wuchereria bancrofti* and *Wuchereria malayi*

(*b*) *Entamoeba histolytica*

Q. 8. Name the host and the site where the following occur in the life-cycle of a malarial parasite:

(*a*) Formation of gametocytes]

(*b*) Fusion of gametocytes **[*CBSE Delhi 2010*]**

Ans.

	Host	Site of occurrence
(*a*) Formation of gametocytes	Human	Red blood cells
(*b*) Fusion of gametocytes	*Anopheles* mosquito	Intestine

Q. 9. Why does a doctor administer tetanus antitoxin and not a tetanus vaccine to a child injured in a roadside accident with a bleeding wound? Explain. **[*CBSE (AI) 2010*] [*HOTS*]**

OR

Why is a person with cuts and bruises following an accident administered tetanus antitoxin? Give reasons. **[*CBSE (AI) 2013*] [*HOTS*]**

Ans. Tetanus is caused by a microbe which has a deadly and fast action. Action of vaccine is slow and this delay may become fatal. Therefore, antitoxins are administered which neutralise the effect of the bacterial toxin.

Q. 10. A student on a school trip started sneezing and wheezing soon after reaching the hill station for no explained reasons. But, on return to the plains, the symptoms disappeared. What is such a response called? How does the body produce it? **[*CBSE Delhi 2013*] [*HOTS*]**

Ans. Such a response is called allergic reaction or allergy. On exposure to allergens like dust, pollens, etc., chemicals like histamine and serotonin are released from the mast cells, resulting in an allergic response.

Q. 11. A young boy when brought a pet dog home started to complain of watery eyes and running nose. The symptoms disappeared when the boy was kept away from the pet.

(*a*) Name the type of antibody and the chemicals responsible for such a response in the boy.

(*b*) Mention the name of any one drug that could be given to the boy for immediate relief from such a response. **[*CBSE Delhi 2013*] [*HOTS*]**

Ans. (*a*) Antibody: IgE; chemicals: Histamine and serotonin

(*b*) Drugs: Antihistamine, adrenalin, steroids. (*Any one*)

Q. 12. Name and explain the two types of immune responses in humans. **[*CBSE (AI) 2012*]**

Ans. The two types of immunity are active immunity and passive immunity.

Active immunity: Immunity developed in the host body due to production of antibodies in response to antigens.

Passive immunity: When ready-made antibodies are directly given to protect the body against foreign agents.

OR

The two types of immunity are humoral immunity and cell-mediated immunity.

Humoral immunity: Immune responses given by antibodies found in the blood.

Cell-mediated immunity: Activation of T-lymphocytes mediate this immunity.

OR

The two types of immunity are primary immunity and secondary immunity.

Primary immunity: When our body encounters a pathogen for the first time, it produces primary response.

Secondary immunity: Subsequent encounter with the same pathogen generates highly intensified secondary response or secondary immunity.

Q. 13. List the two types of immunity a human baby is born with. Explain the differences between the two types. **[*CBSE (AI) 2011*]**

Ans. The two types of immunity a human baby is born with are innate and passive/acquired immunity.

Innate immunity is a non-specific type of defence that provides barrier to the entry of antigens.

Passive immunity is a pathogen-specific type of defence in which readymade antibodies are directly given to protect body against foreign agents. The foetus receives antibodies through the placenta.

Q. 14. Name the two types of immune systems in a human body. Why are cell-mediated and humoral immunities so called? ***[CBSE Delhi 2011]***

Ans. The two types of immune systems in a human body are innate and adaptive immunity.

Humoral immunity is called so because it consists of antibodies that are present in humors or body fluids, whereas cell-mediated immunity is provided by T-cells and defends body against viruses, fungi and some bacteria which enter host cells. T-cells recognise non-self cells and kill them.

Q. 15. Explain the relationship between B-lymphocytes and T-lymphocytes in developing an immune response. ***[CBSE 2019 (57/3/1)]***

Ans. **B-lymphocytes** produce antibodies to fight pathogen.

T-lymphocytes do not produce antibodies but help B cells to produce them. They can also destroy pathogen directly.

Q. 16. Name the two special types of lymphocytes in humans. How do they differ in their roles in immune response? ***[CBSE (AI) 2012]***

Ans. B-lymphocytes and T-lymphocytes are the lymphocytes in humans.

B-cells produce pathogen specific antibodies and are responsible for humoral immune response.

T-cells help the B-cells to produce antibodies and are responsible for cell-mediated immunity.

Q. 17. What is colostrum? Why is it important to be given to the newborn infants?

Ans. The milk that comes out of the mammary glands during initial days of lactation is called colostrum. It contains several antibodies (IgA most abundantly), absolutely essential for developing resistance in the new-born babies.

Q. 18. Describe the role of lymph nodes in providing immunity. ***[CBSE (F) 2012]***

Ans. Lymph nodes trap microorganisms or other antigens. These trapped antigens activate lymphocytes present in the lymph and cause an immune response.

Q. 19. State the functions of primary and secondary lymphoid organs in humans. ***[CBSE Delhi 2011]***

Ans. Primary lymphoid organs are the sites where immature lymphocytes differentiate into antigen sensitive lymphocytes.

Secondary lymphoid organs are the sites where the lymphocytes interact with antigens and proliferate to become effector cells.

Q. 20. (*a*) Name one primary and one secondary lymphoid organ in the human body.

(*b*) How do they differ in their functions? ***[CBSE (F) 2013]***

Ans. (*a*) Primary lymphoid organ: Bone marrow/thymus. (*Any one*)

Secondary lymphoid organ: Spleen/Lymph nodes/Mucosal associated lymphoid tissue (MALT). (*Any one*)

(*b*) Primary lymphoid organs are the sites where immature lymphocytes differentiate into antigen sensitive lymphocytes.

Secondary lymphoid organs are the sites where the lymphocytes interact with antigens and proliferate to become effector cells.

Q. 21. (*a*) Name the lymphoid organ in humans where all the blood cells are produced.

(*b*) Where do the lymphocytes produced by the lymphoid organ mentioned above migrate and how do they affect immunity?

Ans. (*a*) Bone marrow.

(*b*) The lymphocytes produced migrate to secondary lymphoid organs like spleen, lymph nodes, etc. They trap the microorganisms thereby activating the lymphocytes present in the lymph nodes and produce an immune response.

Q. 22. **(*a*) Highlight the role of thymus as a lymphoid organ.**

(*b*) Name the cells that are released from the above mentioned gland. Mention how they help in immunity. **[*CBSE Delhi 2012*]**

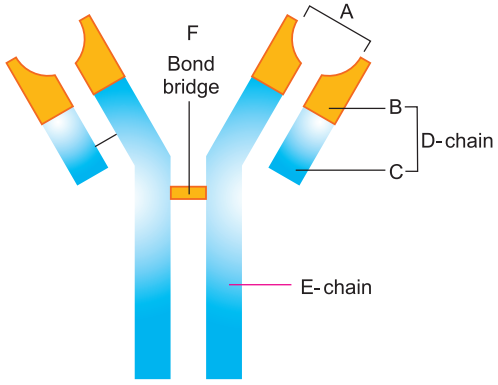
Ans. (*a*) Immature lymphocytes differentiate into mature T-lymphocytes and become antigen-sensitive in thymus.

(*b*) T-lymphocytes are released from thymus. T-cells help B-cells to produce antibodies and provide cell-mediated immunity.

Q. 23. **How does spleen act as a lymphoid organ? Explain.**

Ans. The spleen is a large bean-shaped organ. It mainly contains lymphocytes and phagocytes. It acts as a filter of the blood by trapping blood-borne microorganisms. Spleen also has a large reservoir of erythrocytes.

Q. 24. **Identify A, D, E and F in the diagram of an antibody molecule given below:**



[*CBSE Delhi 2011*]

Ans. A—Antigen binding site D—Light chain

E—Heavy chain F—Disulfide bridge.

Q. 25. **Why is tobacco smoking associated with rise in blood pressure and emphysema (oxygen deficiency in the body)? Explain.** **[*CBSE (AI) 2011*] [*HOTS*]**

Ans. Tobacco has nicotine that stimulates the release of adrenaline and noradrenaline which raise blood pressure. Smoking tobacco releases carbon monoxide which reduces the concentration of haem-bound oxygen. This causes emphysema.

Q. 26. **When you go for a trek/trip to any high altitude places, you are advised to take it easy and rest for the first two days. Comment, giving reasons.** **[*CBSE (F) 2015*] [*HOTS*]**

OR

Why do tribes who live in high altitude of Himalayas experience discomfort in respiration? How do they get adapted to survive in such a situation? **[*CBSE (AI) 2015*] [*HOTS*]**

Ans. At high altitudes it is advised to take easy due to low oxygen availability. This may also cause altitude sickness. It is also advised to take rest because body compensates the low oxygen availability during rest by increasing RBC production and decreasing the binding capacity of haemoglobin, in turn increasing the breathing rate.

Q. 27. **What would happen to immune system, if thymus gland is removed from the body of a person?** **[*NCERT Exemplar*] [*HOTS*]**

Ans. Thymus is the primary lymphoid organ. In thymus gland, immature lymphocytes differentiate into antigen-sensitive lymphocytes. If thymus gland is removed from the body of a person, his immune system becomes weak. As a result the person's body becomes prone to infectious diseases.

Q. 28. **Why an immunosuppressive agent is taken after an organ transplant?** **[*HOTS*]**

Ans. Our immune system is capable to differentiate between 'self' and 'non-self' cells/tissues. The graft (grafting) is a non-self tissue which may be rejected by our immune system. So, to prevent the rejection, immunosuppressants are taken after the transplant.

Q. 29. How are auto-immune diseases different from immunodeficiency disease? Give one example of each in human.

Ans. **Table 8.6: Differences between auto-immune and immunodeficiency diseases**

S. No.	Auto-immune disease	Immunodeficiency disease
(*i*)	When the immune system of the body starts attacking 'self-cells' and molecules, the disease is called auto-immune disease.	When the immune system fails to function properly against pathogen or antigen, it is called immunodeficiency disease.
(*ii*)	For example, rheumatoid arthritis.	For example, AIDS.

Q. 30. In the metropolitan cities of India, many children are suffering from allergy/asthma. What are the main causes of this problem? Give some symptoms of allergic reactions.

[*NCERT Exemplar*]

Ans. Allergy is the exaggerated response of the immune system to certain antigens present in the environment. In metropolitan cities lifestyle is responsible in lowering of immunity and sensitivity to allergens. More polluted environment increases the chances of allergy in children. Some symptoms of allergic reactions are sneezing, watery eyes, running nose and difficulty in breathing.

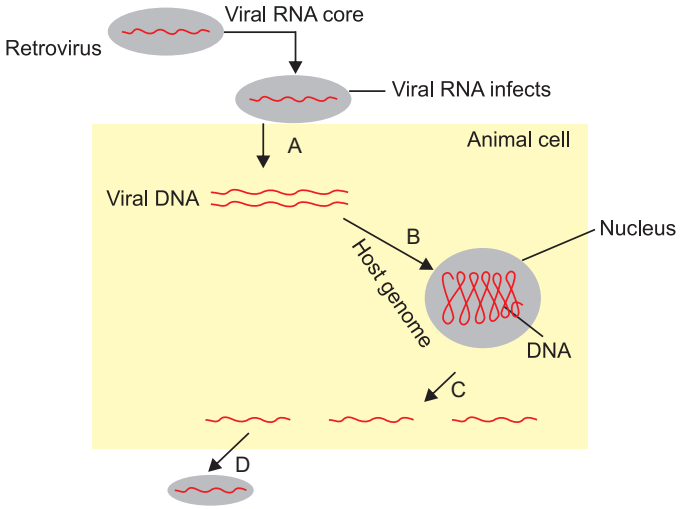
Q. 31. (*a*) Name the virus that causes AIDS in humans.

(*b*) Explain the sequence of events that follows when this virus attacks to cause immune deficiency in humans.

Ans. (*a*) Human Immunodeficiency Virus.

(*b*) Refer to Basic Concepts Point 15 (Life cycle of HIV).

Q. 32. Identify A, B, C and D in the replication of HIV (retrovirus). **[*HOTS*]**



Ans. (A) Reverse transcription.

(B) Viral DNA incorporates into host genome.

(C) New viral RNA produced by infected cell.

(D) New viruses can infect other cells.

Q. 33. Name the cells that act as HIV factory in humans when infected by HIV. Explain the events that occur in the infected cell. **[*CBSE (AI) 2012*]**

OR

Name the type of cells the AIDS virus first enters into after getting inside the human body. Explain the sequence of events that the virus undergoes within these cells to increase their progeny.

Ans. Macrophages/Helper T-cells act as HIV factory.

The virus enters macrophages or helper T-cells where RNA genome of the virus forms viral DNA with the help of the enzyme reverse transcriptase. The viral DNA then gets incorporated into host cell's DNA and directs infected cells to produce new virus particles.

Q. 34. Differentiate between benign and malignant tumours. [*NCERT Exemplar*] [*CBSE (AI) 2011*]

Ans. Refer to Table 8.4.

Q. 35. What is "withdrawal syndrome"? List any two symptoms it is characterised by. [*CBSE (F) 2014*]

Ans. It is the state experienced by addicts when their regular dose of alcohol/drug is abruptly discontinued. It is often characterised by anxiety, shakiness, nausea and sweating.

Q. 36. How does smoking tobacco in human lead to oxygen deficiency in their body? [*CBSE Delhi 2012*]

Ans. Smoking increases the carbon monoxide (CO) content in the blood which has greater affinity to haemoglobin than oxygen. CO forms a stable bond with haemoglobin and does not allow binding of oxygen. Smoking also damages alveolar walls, which reduces respiratory surface (emphysema).

Q. 37. (*a*) Name the source plant of heroin drug. How is it obtained from the plant?
(*b*) Write the effects of heroin on the human body. [*CBSE Delhi 2018*]

OR

Name an opioid drug and its source plant. How does the drug affect the human body? [*CBSE (AI) 2010*]

Ans. (*a*) The source drug of heroin is poppy plant (*Papaver somniferum*).
It is derived by acetylation of morphine, which is obtained from the latex of the poppy plant.
(*b*) Heroin is a depressant and slows down the body functions.

Q. 38. Name the plant source of the drug popularly called "smack'. How does it affect the body of the abuser? [*CBSE Delhi 2012*]

Ans. Plant source of 'smack' is *Papaver somniferum* or poppy.
Smack is a depressant and slows down body functions.

Q. 39. Name the plant source of cocaine. How does it affect the human body? [*CBSE (F) 2012*]

OR

Name the drug obtained from *Erythroxylum coca* and write its effects on the human body.

Ans. Plant source of cocaine is *Erythroxylum coca*. It has a potent stimulating action on central nervous system, producing a sense of euphoria and increased energy. Excessive dosage of cocaine causes hallucinations.

Q. 40. Name the plant source of *ganja*. How does it affect the body of the abuser? [*CBSE (AI) 2012*]

OR

From which plant are cannabinoids obtained? Name any two cannabinoids. Which part of the body is affected by consuming these substances? [*NCERT Exemplar*]

Ans. Cannabinoids are obtained from the inflorescence of the plant *Cannabis sativa*. Marijuana, hashish, *charas*, *ganja* are some cannabinoids. These chemicals interact with cannabinoid receptors of the body, mainly present in the brain. Cardiovascular system is affected adversely.

Q. 41. Name the blank spaces *a*, *b*, *c* and *d* in the table given below:

S. No.	Name of the drug	Plant source	Organ system affected
(*i*)	*a*	Poppy plant	*b*
(*ii*)	Marijuana	*c*	*d*

Ans. (*a*) Morphine (*b*) Central nervous system
(*c*) *Cannabis sativa* (*d*) Cardiovascular system.

Q. 42. If a regular dose of drugs or alcohol is not provided to an addicted person, he shows some withdrawal symptoms. List any four such withdrawal symptoms. ***[NCERT Exemplar]***

Ans. The withdrawal symptoms are:

(*a*) Anxiety (*b*) Shakiness

(*c*) Nausea (*d*) Sweating

Long Answer Questions–I [3 marks]

Q. 1. Name a human disease, its causal organism, symptoms (any three) and vector, spread by intake of water and food contaminated by human faecal matter. ***[CBSE (AI) 2017]***

Ans. Refer to Basic Concepts Point 3(*i*) or 5(*ii*) or 7(*ii*).

Q. 2. (*a*) Name the causative agent of typhoid in humans.

(*b*) Name the test administered to confirm the disease.

(*c*) How does the pathogen gain entry into the human body? Write the diagnostic symptoms and mention the body organ that gets affected in severe cases. ***[CBSE (AI) 2011]***

OR

Name the bacterium that causes typhoid. Mention two diagnostic symptoms. How is this disease transmitted to others? ***[CBSE (AI) 2012]***

Ans. Refer to Basic Concepts Point 3(*i*).

Q. 3. (*a*) Name the causative agents of pneumonia and common cold.

(*b*) How do these differ in their symptoms ?

(*c*) Mention two symptoms common to both. ***[CBSE 2019 (57/2/1)]***

Ans. (*a*) Pneumonia is caused by *Streptococcus pneumoniae*/*Haemophilus influenzae* and that of common cold is Rhinoviruses.

(*b*) Different symptoms:

S. No.	Pneumonia	Common cold
(*i*)	Infects alveoli of lungs	Infects nose & respiratory passage
(*ii*)	Symptoms: Chills, lips/fingers may turn grey to black	Symptoms: Sore throat, hoarseness

(*c*) Common symptoms:

(*i*) In both the cases the infected person is inflicted with cough.

(*ii*) In both the cases the patient suffers from headaches.

Q. 4. Mention the name of the causal organism, symptoms and the mode of transmission of the disease amoebiasis. ***[CBSE (AI) 2010]***

OR

(*a*) Name the protozoan parasite that causes amoebic dysentery in humans.

(*b*) Mention two diagnostic symptoms of the disease.

(*c*) How is this disease transmitted to others? ***[CBSE Delhi 2012]***

OR

(*a*) Name the agent that causes amoebiasis and the human body organ that it infects.

(*b*) Write the symptoms and the mode of transmission of the disease. ***[CBSE (AI) 2010; (F) 2013]***

Ans. Refer to Basic Concepts Point 5(*ii*).

Q. 5. Name any two organisms that are responsible for ringworms in humans. Mention two diagnostic symptoms. Name the specific parts of the human body where these organisms thrive and explain why. ***[CBSE (AI) 2012]***

Ans. *Microsporum*/*Trichophyton*/*Epideromophyton*. (*Any two*)

Symptoms: Dry/scaly lesion on skin/nails/scalp, intense itching.

These organisms thrive in body groin or between toes. They thrive better in heat/moisture/perspiration.

Q. 6. (*i*) Write the scientific names of the two species of filarial worms causing filariasis.
(*ii*) How do they affect the body of infected person(s)?
(*iii*) How does the disease spread? **[*CBSE (AI) 2011*]**

OR

Name the parasite that causes filariasis in human. Mention its two diagnostic symptoms. How is this disease transmitted to others? **[*CBSE Delhi 2012*]**

Ans. Refer to Basic Concepts Point 7(*ii*).

Q. 7. Trace the life-cycle of malarial parasite in the human body when bitten by an infected female *Anopheles*. **[*CBSE (AI) 2012; Delhi 2017*]**

Ans. *Plasmodium falciparum* is the malarial parasite.

Refer to Basic Concepts Point 5(*i*) (Life Cycle of *Plasmodium*).

Q. 8. (*a*) Name the respective forms in which the malarial parasite gains entry into (*i*) Human body and (*ii*) Body of female *Anopheles*.
(*b*) Name the hosts where the sexual and the asexual reproductions of malarial parasites occur respectively.
(*c*) Name the toxin responsible for the appearance of symptoms of malaria in humans. Why do these symptoms occur periodically?

Ans. (*a*) (*i*) Sporozoite
(*ii*) Gametocytes.

(*b*) Sexual reproduction occurs in mosquito and asexual reproduction takes place in human body.

(*c*) The name of the toxin is haemozoin. Parasites after entering the fresh RBCs take 48 to 72 hours to complete the erythrocytic cycle, rupturing the erythrocytes. They then burst to release toxic substance called haemozoin and the symptoms like chill and high fever occurs periodically.

Q. 9. (*a*) Name the stage of *Plasmodium* that gains entry into the human body.
(*b*) Trace the stages of *Plasmodium* in the body of female *Anopheles* after its entry.
(*c*) Explain the cause of periodic recurrence of chill and high fever during malarial attack in humans. **[*CBSE Delhi 2011*]**

Ans. (*a*) *Plasmodium* enters the human body as sporozoites.

(*b*) When a female *Anopheles* mosquito bites an infected person, the parasites enter the mosquito's body and undergo further development. The parasites multiply within them to form sporozoites that are stored in salivary glands until their transfer to human body.

(*c*) The rupture of RBCs release a toxic substance called haemozoin, which is responsible for the chill and high fever recur.

Q. 10. Explain the role of the following in providing defence against infection in human body:
(*i*) Histamines
(*ii*) Interferons
(*iii*) B-cells **[*CBSE (F) 2011*]**

Ans. **(*i*) Histamines:** These are chemicals which cause inflammatory responses.

(*ii*) Interferons: These are glycoproteins which protect non-infected cells from further viral infection.

(*iii*) B-cells: These produce proteins called antibodies in response to pathogens into the blood to fight with them.

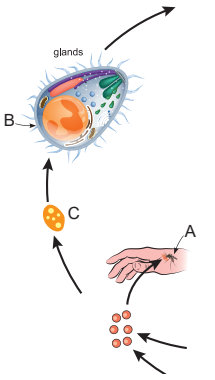
Q. 11. Study a part of the life cycle of malarial parasite given alongside. Answer the questions that follow:

(*a*) Mention the roles of 'A' in the life cycle of the malarial parasite.

(*b*) Name the event 'C' and the organ where this event occurs.

(*c*) Identify the organ 'B' and name the cells being released from it.

[*CBSE Delhi 2012*]



Ans. (*a*) A—Gametocytes of *Plasmodium* enter the mosquito when it bites a malarial patient and feed on blood.

(*b*) C—Fertilisation. It occurs in the intestine of mosquito.

(*c*) B—Salivary gland of the female *Anopheles* mosquito. These release sporozoites of *Plasmodium*.

Q. 12. Write the events that take place when a vaccine for any disease is introduced into the human body. **[*CBSE (AI) 2013*]**

Ans. The vaccine contains proteins of pathogen or inactivated/weakened pathogen. When a dose of vaccine is introduced into the human body, it behaves as an antigen and the body produces antibodies in response to the antigen. This response generates active immunity. The antibodies thus produced will neutralise the pathogenic agents during actual infection. The vaccines also generate memory B-cells and T-cells that recognise the pathogen quickly on subsequent exposure and overwhelm the invaders with a massive production of antibodies.

Q. 13. (*a*) It is generally observed that the children who had suffered from chicken-pox in their childhood may not contract the same disease in their adulthood. Explain giving reasons the basis of such an immunity in an individual. Name this kind of immunity.

(*b*) What are interferons? Mention their role. **[*CBSE (AI) 2016*]**

Ans. (*a*) The first infection of chicken pox produces a primary response and antibodies are generated against chicken pox virus, subsequent encounter with the same virus elicits a highly intensified secondary response, due to the memory cells formed during the first encounter. This kind of an immunity is active immunity.

(*b*) Proteins secreted by viral infected cells, which protects non-infected cells from viral infection are called interferous. When α-interferon is given to cancer patient it activates immune system and destroys tumour.

Q. 14. (*a*) How does the human body respond when vaccine is introduced into it ?

(*b*) It is said that vaccinations are a must for a healthy society. Justify. **[*CBSE 2019 (57/3/2)*]**

Ans. (*a*) B-cells assisted by T-cells produce antibodies against weakened antigens, which have been introduced as vaccine. These antibodies neutralise the pathogens (during actual infection) and also generate memory B-cells and T-cells.

(*b*) B and T memory cells recognise the pathogen in case of actual infection and produce antibodies to kill the pathogen. Thus the population will remain healthy if they are vaccinated prior to the infection.

Q. 15. Many microbial pathogens enter the gut of humans along with food. What are the preventive barriers to protect the body from such pathogens? What type of immunity do you observe in this case? **[*NCERT Exemplar*] [*HOTS*]**

Ans. Preventive barrier to protect body are:

(*i*) The mucus coating of the epithelium lining of the gut helps in trapping microbes entering the body.

(*ii*) Saliva in the mouth and hydrochloric acid in gastric juice secreted by stomach prevent microbial growth.

This type of immunity is innate immunity.

Q. 16. A person shows strong unusual hypersensitive reactions when exposed to certain substances present in the air, identify the condition. Name the cells responsible for such reactions. What precaution should be taken to avoid such reactions. **[*NCERT Exemplar*] [*HOTS*]**

Ans. The condition is called allergy. Mast cells are responsible for such reactions.

To avoid such reactions following precautions must be taken.

(*i*) Use of drugs like antihistamine, adrenaline and steroids quickly reduces the symptoms.

(*ii*) Avoid contact with substances to which a person is hypersensitive.

Q. 17. Your classmate complains of headache and cough. The doctor confirms that he is suffering from Pneumonia and not common cold, on the basis of certain symptoms. List these symptoms. Mention any two precautions to be followed to prevent the spread of this disease.

[*CBSE Sample Paper 2015, 2017*] [*HOTS*]

Ans. Doctor confirms pneumonia on the basis of the following symptoms—fever/chills/grey-blue lips and finger nails (*any two*).

It is not common cold as the following symptoms are not observed - Nasal congestion/sore throat/hoarseness (*any two*).

Precautions to be followed are:

(*i*) Cover the nose when near the patient.

(*ii*) Do not share glasses and utensils or articles used by the infected person.

Q. 18. (*a*) What precaution(s) would you recommend to a patient requiring repeated blood transfusion?

(*b*) If the advise is not followed by the patient, there is an apprehension that the patient might contract a disease that would destroy the immune system of his/her body. Explain with the help of schematic diagram only how the immune system would get affected and destroyed. **[*CBSE Delhi 2017*]**

Ans. (*a*) A patient requiring repeated blood transfusion must ensure that the donor's blood has been screened for HIV and other pathogens before transfusion.

(*b*) Refer to Fig. 8.4

Q. 19. During a school trip to 'Rohtang Pass', one of your classmate suddenly developed 'altitude sickness'. But, she recovered after sometime.

(*a*) Mention one symptom to diagnose the sickness.

(*b*) What caused the sickness?

(*c*) How could she recover by herself after sometime? **[*CBSE Delhi 2016*]**

Ans. (*a*) Nausea/fatigue/heart palpitation

(*b*) The sickness was caused due to low atmospheric pressure at high altitude because of which the body was deprived of oxygen.

(*c*) The body compensates low oxygen availability by increasing RBC production decreasing the binding capacity of haemoglobin and by increasing breathing rate.

Q. 20. A heavily bleeding bruised road accident victim was brought to a nursing home. The doctor immediately gave him an injection to protect him against a deadly disease.

(*a*) Write what did the doctor inject into the patient's body.

(*b*) How do you think this injection would protect the patient against the disease?

(*c*) Name the disease against which this injection was given and the kind of immunity it provides. **[*CBSE (AI) 2015*] [*HOTS*]**

Ans. (*a*) Tetanus antitoxins/Tetanus toxoid.

(*b*) The preformed antibody injected act on the pathogen immediately to provide protection.

(*c*) This injection was given against tetanus and it provides passive immunity.

Q. 21. To which category of cells do B-cells and T-cells belong? How do they differ from each other with reference to their formation and response to antigens?

Ans. B-cells and T-cells belong to the category of lymphocytes, *i.e.*, leucocytes (WBC).

Table 8.7: Differences between B-lymphocyte and T-lymphocyte

S. No.	B-lymphocytes	T-lymphocytes
(*i*)	They mature in bone marrow.	They mature in thymus gland.
(*ii*)	They produce antibody against antigen.	They directly attach the antigen or direct B-cells to produce antibody.
(*iii*)	They do not respond to organ transplantation.	They respond to organ transplantation.

Q. 22. What is the basic principle of vaccination? How do vaccines prevent microbial infections? Name the organism from which hepatitis B vaccine is produced. **[*NCERT Exemplar*]**

Ans. Principle of vaccination is based on the property of 'memory' of immune system. In vaccination, a preparation of antigenic proteins of pathogens or inactivated/live but weakened pathogens is introduced into the body. The antigens generate primary immune response by producing antibodies along with forming memory B-cells and T-cells. When the vaccinated person is attacked by the same pathogens, second time/subsequent time the existing memory B-cells and T-cells recognise the antigen and overwhelm the invaders with massive production of lymphocytes and antibodies. Hepatitis B vaccine is produced from yeast.

Q. 23. The immune system of a person is suppressed. In the ELISA test, he was found positive to a pathogen.

(*a*) Name the disease the patient is suffering from.

(*b*) What is the causative organism?

(*c*) Which cells of the body are affected by the pathogen? **[*NCERT Exemplar*]**

Ans. (*a*) The disease is AIDS.

(*b*) The causative organism is Human Immunodeficiency Virus.

(*c*) It affects or destroys helper T-cells.

Q. 24. On a visit to a Hill station, one of your friend suddenly become unwell and felt uneasy.

(*a*) List two symptoms you would look for the term it to be due to allergy.

(*b*) Explain the response of the body to an allergen.

(*c*) Name two drugs that can be recommended for immediate relief.

[*CBSE (F) 2016; 2019 (57/3/1)*]

Ans. (*a*) Sneezing, watery eyes, running nose and difficulty in breathing are symptoms of allergy. (*Any two*)

(*b*) In response to an allergen, the body releases antibodies of IgE type.

(*c*) Antihistamine, adrenalin, steroids. (*Any two*)

Q. 25. Name the cells HIV (Human Immunodeficiency Virus) gains entry into after infecting the human body. Explain the events that occur in these cells. **[*CBSE (AI) 2016*]**

Ans. HIV virus gains entry into Macrophages and (Helper) T-lymphocytes after getting into the human body.

Events that occur in the cells are:

(*i*) Viral RNA forms DNA by reverse transcription using the enzymes reverse transcriptase and directs the infected cells to produce viral particles.

(*ii*) Macrophages continue to produce viral particles and function as HIV factories.

(*iii*) The viral particles simultaneously enters into helper T-lymphocytes, replicates and produce viral progenies.

(*iv*) The number of T-lymphocytes progressively decreases in the body of the infected person.

(*v*) During this person suffers from bouts of fever, weight loss. Also decrease in the number of cells leads to weakening of immune system.

Q. 26. (*a*) All human beings have cellular oncogenes but only a few suffer from cancer disease. Give reasons.

(*b*) How is a malignant tumour different from a benign tumour? **[*CBSE (F) 2010*]**

Ans. (*a*) All humans have cellular oncogenes or proto-oncogenes, but only a few suffer from cancer because cancer only occurs on activation of oncogenes. This activation is induced by carcinogens which can be physical, chemical or biological. The chemical carcinogens present in tobacco and smoke have been identified as a major cause of lung cancer.

(*b*) Refer to Table 8.4.

Q. 27. Prior to a sports event, blood and urine samples of sports persons are collected for drug tests.

(*a*) Why is there a need to conduct such tests?

(*b*) Name the drugs the authorities usually look for.

(*c*) Write the genetic names of two plants from which these drugs are obtained.

[*CBSE Delhi 2016*]

Ans. (*a*) Such tests are conducted to detect drug abuse to ensure fair game.

(*b*) The authorities look for cannabinoids, cocaine, coca alkaloid, coke, crack, hashish, *charas*, *ganja* and hemp plant extract.

(*c*) These drugs are obtained from *Cannabis, Atropa, Erythroxylum, Datura.* (*Any two*)

Q. 28. (*a*) Name a drug used (*i*) as an effective sedative and pain killer (*ii*) for helping patients to cope with mental illnesses like depression, but often misused.

(*b*) How does the moderate and high dosage of cocaine affect the human body?

[*CBSE (F) 2011*]

Ans. (*a*) (*i*) Morphine

(*ii*) Lysergic acid diethyl amides (LSD).

(*b*) Cocaine has a potent simulating action on central nervous system producing a sense of euphoria and increased energy. Excessive dosage of cocaine causes hallucinations.

Q. 29. A team of students are preparing to participate in the interschool sports meet. During a practice session you find some vials with labels of certain cannabionoids.

(*a*) Will you report to the authorities? Why?

(*b*) Name a plant from which such chemicals are obtained.

(*c*) Write the effect of these chemicals on human body. **[*CBSE Delhi 2015*] [*HOTS*]**

Ans. (*a*) Yes. Because these may be abused by sports person.

(*b*) *Cannabis* (sativa)

(*c*) Cannabinoids effect cardiovascular system of the body.

Q. 30. A farmer while working on his farm was bitten by a poisonous snake. The workers in the farm immediately rushed him to the nearby health centre. The doctor right away gave him an injection to save his life. What did the doctor inject and why? Explain. **[*CBSE (F) 2017*]**

Ans. The doctor injected an antivenom. The antivenom contains preformed antibodies which when injected act on the pathogen immediately provide protection by providing passive immunity.

Q. 31. (*a*) Why is there a fear amongst the guardians that their adolescent wards may get trapped in drug/alcohol abuse?

(*b*) Explain 'addiction' and 'dependence' in respect of drugs/alcohol abuse in youth.

[*CBSE (AI) 2017*]

Ans. (*a*) Adolescents are easily affected by (or are vulnerable to) peer pressure. Curiosity, need for adventure and excitement, and experimentation constitute common causes for motivation. A child's natural curiosity motivates him/her to experiment. Television, movies, newspapers, internet also promote drug use.

(*b*) Addiction is the psychological attachment to certain effects such as euphoria or temporary feeling of well-being.

Dependence is the tendency of the body to show withdrawal syndrome or symptoms if regular doses of drug/alcohol is abruptly discontinued.

Q. 32. A group of youth were having a 'rave party' in an isolated area and was raided by police. Packets of 'smack' and syringes with needles were found littered around.

(*a*) Why is taking 'smack' considered an abuse?

(*b*) Write the chemical name of 'smack' and the name of its source plant.

(*c*) Syringes and needles used by the youth for taking the drug could prove to be very fatal. Why? **[*CBSE Delhi 2017*]**

Ans. (*a*) Taking smack is considered as abuse because it is highly addictive. It is a depressant and slows down body functions. It causes psychological and physical dependance.

(*b*) Its chemical name is diacetylmorphine and is obtained from poppy plant, *Papaver Somniferum.*

(*c*) Drugs taken intravenously (direct injection into the vein using a needle and syringe) are much likely to acquire serious infections like AIDS and hepatitis B. The viruses, which are responsible for these diseases are transferred from one person to another by sharing infected needles and syringes.

Q. 33. Write the source and the effect on the human body of the following drugs:

(*i*) Morphine (*ii*) Cocaine (*iii*) Marijuana **[*CBSE Delhi 2011*]**

Ans. **(*i*) Morphine:** It is obtained from poppy plant *Papaver somniferum*. It binds to specific opioid receptors present in central nervous system and gastrointestinal tract.

(*ii*) Cocaine: It is obtained from coca plant *Erythroxylum coca*. It interferes with the transport of the neurotransmitter dopamine.

(*iii*) Marijuana: It is obtained from *Cannabis sativa*. It affects the cardiovascular system of the body.

Q. 34. When someone buys packets of cigarettes, cannot miss the statutory warning that is present on the packing which warns against smoking and says how it is injurious to health. Yet, smoking is very prevalent in our society, both among young and old. Advise the adolescents about the importance of avoiding smoking. (Mention any six points.) **[*CBSE Sample Paper 2016*]**

Ans. (*i*) Tobacco in cigarettes contains a large number of chemical substances including nicotine, an alkaloid. Nicotine stimulates adrenal gland to release adrenaline and nor-adrenaline into blood circulation, both of which raise blood pressure and increase heart rate.

(*ii*) Smoking is associated with increased incidence of cancers of lung, urinary bladder, throat and oral cavity.

(*iii*) It is responsible for bronchitis and emphysema.

(*iv*) It is associated with increased risk of coronary heart disease, gastric ulcer, etc.

(*v*) Smoking increases carbon monoxide (CO) content in blood and reduces the concentration of haem-bound oxygen. This causes oxygen deficiency in the body.

Q. 35. A doctor prescribed morphine as a sedative and pain killer to your cousin who had undergone surgery. Even after recovery, he craved for the prescribed medicine. What do you conclude about his condition, had he continued with the same medication? After appraising yourself, what measures will you suggest to him to overcome this problem? Briefly explain any two. **[*CBSE Sample Paper 2015, 2017*] [*HOTS*]**

Ans. His condition is drug dependence. It is the tendency of the body to manifest a characteristic and unpleasant withdrawal syndrome if regular dose of drugs is abruptly discontinued. Because of perceived benefits, drugs are frequently used repeatedly from which the person may not be able to get out.

Following measures can be taken to overcome this problem:

(*i*) Education and counseling to face problems and stresses and to channelise the energy into healthy pursuits like reading, music, yoga and other extracurricular activities.

(*ii*) Seeking help from parents to guide the person appropriately and immediately.

(*iii*) Seeking professional and medical help to the person to get rid of the problem completely with sufficient efforts and will power (*any two*).

Long Answer Questions–II [5 marks]

Q. 1. Describe the asexual and sexual phases of life cycle of *Plasmodium* that causes malaria in humans. **[*CBSE Delhi 2013*]**

Ans. Refer to Basic Concepts Point 5(*i*) (Life cycle of *Plasmodium*).

Q. 2. Name the form of *Plasmodium* that gains entry into the human body. Explain the different stages of its life cycle in the human body. **[*CBSE (F) 2014*]**

Ans. ***Plasmodium vivax*** gains entry into the human body.

[Refer to Basic Concepts Point 5(*i*) (Life Cycle of *Plasmodium*)]

Q. 3. Malarial parasite '*Plasmodium*' completes its life cycle in two hosts. Draw its complete life cycle and explain various stages it follows throughout its life. **[*CBSE Sample Paper 2014*]**

Ans. Refer to Fig. 8.1.

Stages:

(*a*) The stage in which the parasite enters in the body of humans through saliva of mosquito—sporozoite stage.

(*b*) Asexual reproduction of sporozoites in liver cells, resulting into bursting of those cells and releasing outside into the blood.

(*c*) Sporozoites infect RBCs, cause them to get burst and represented by repeated cycles of fever. Released parasites also infect other RBCs.

(*d*) Parasites then follow sexual stage in RBCs which is called as ring signet stage and appears as a ring inside the RBCs under microscope. Usually presence of malarial parasite in humans is identified by pathologists by this stage.

(*e*) Female mosquito takes up gametocytes with the blood of host. Fertilisation and development takes place in the intestine of mosquito.

(*f*) From intestine, parasite comes to the salivary glands from where it reaches to human body and that is how the cycle continues.

Q. 4. Under polio prevention programme, infants in India were given polio vaccines on a large scale at regular intervals to eradicate polio from the country.

(*a*) What is a vaccine? Explain how does it impart immunity to the child against the disease.

(*b*) With the help of an example each, differentiate between active and passive immunity. **[*CBSE (F) 2015*]**

Ans. (*a*) Refer to Basic Concepts Point 11.

(*b*) Refer to Basic Concepts Point 9.

Q. 5. Explain the process of replication of a retrovirus after it gains entry into the human body. **[*CBSE (AI) 2014*]**

OR

(*a*) How does a Human Immunodeficiency Virus (HIV) replicate in a host?

(*b*) How does a HIV-infected patient lose immunity?

(*c*) List any two symptoms of this disease. **[*CBSE (F) 2016*]**

Ans. (*a*) Refer to Fig. 8.4.

(*b*) An HIV-infected patient loses immunity due to loss of T-lymphocytes.

(*c*) Symptoms are fever, diarrhoea, susceptibility to other diseases and prone to microbial infection. (*Any two*)

Q. 6. (*a*) Name and explain giving reasons, the type of immunity provided to the newborn by the colostrum and vaccinations.

(*b*) Name the type of antibody

(*i*) present in colostrum

(*ii*) produced in response to allergens in human body. **[*CBSE (F) 2014*]**

Ans. (*a*) Colostrum provides passive immunity, because the infant gets antibodies from the mother's body directly for protection.

Vaccinations provide active immunity because in this case microbes are injected into the body do develop immunity slowly.

(*b*) (*i*) IgA (*ii*) IgE

Q. 7. (*a*) Name and explain any four lymphoid organs present in humans.

(*b*) Categorise the named lymphoid organs as primary or secondary lymphoid organs, giving reasons. **[*CBSE (F) 2014*]**

Ans. Refer to Basic Concepts Point 14.

Q. 8. (*a*) Name the types of lymphoid organs, lymph nodes and thymus are. Explain the role played by them in causing immune response.

(*b*) Differentiate between innate immunity and acquired immunity. **[*CBSE (F) 2017*]**

Ans. (*a*) Thymus is primary lymphoid organ and lymph nodes are secondary lymphoid organs.

Thymus provides the microenvironment for immature lymphocytes to differentiate into antigen-sensitive lymphocytes.

Lymph nodes serve to trap the microorganisms or other antigens, which happen to get into the lymph and tissue fluid. Antigens trapped in the lymph nodes are responsible for the activation of lymphocytes present there and cause the immune response.

(*b*) Refer to Table 8.5.

Q. 9. (*a*) Cancer is one of the most dreaded diseases of humans. Explain 'Contact inhibition' and 'Metastasis' with respect to the disease.

(*b*) Name the group of genes which have been identified in normal cells that could lead to cancer and how they do so?

(*c*) Name any two techniques which are useful to detect cancers of internal organs.

(*d*) Why are cancer patients often given α-interferon as part of the treatment?

[*CBSE Delhi 2014*]

Ans. (*a*) Contact inhibition is the property of normal cells in which contact with other cells inhibits their uncontrolled growth.

Metastasis is the property in which tumour cells reach distant sites in the body, through blood.

(*b*) Proto oncogenes or Cellular oncogenes.

These genes when activated under certain condition could lead to oncogenic transformation of the cells.

(*c*) Biopsy/radiography/CT/MRI (*Any two*)

(*d*) α-interferon activates immune system and destroys the tumour.

Q. 10. Your school has been selected by the Department of Education to organise and host an interschool seminar on "Reproductive Health—Problems and Practices". However, many parents are reluctant to permit their wards to attend it. Their argument is that the topic is "too embarrassing."

Put forth four arguments with appropriate reasons and explanation to justify the topic to be very essential and timely. **[*CBSE (AI) 2015*]**

Ans. (*i*) The issue of puberty and adolescence need to be addressed effectively with the respective age group because many changes take place in the body during adolescence of which they are supposed to be aware of.

(*ii*) To bring in awareness about their reproductive health and its effect on their physical, emotional and social being.

(*iii*) To address the increase in sex abuse and sex crimes in our country.

(*iv*) Myths and misconceptions related to reproductive issues need to be cleared at the right time.

Q. 11. You have attended a birthday party hosted by one of your classmates. You found some guests at the party sitting in a corner making a lot of noise and consuming 'something'. After a while one of the boys from the group started screaming, behaving abnormally and sweating profusely. On enquiry you found that the group members were taking drugs.

(*a*) Would you inform your parents/school authorities? Yes/No. Give reasons is support of your answer.

(*b*) Prepare a note to be circulated amongst the schoolmates about the sources and dangers of any two drugs.

(*c*) Write any two ways that you will suggest to your school principal so as to promote awareness amongst the youth against the use of these drugs. **[*CBSE (F) 2015*]**

Ans. (*a*) Yes, so that it does not become a habit by repeated use. Consumption of drugs may cause harmful effects.

(*b*)

Drug	Source	Danger
Cocaine	*Erythroxylum coca*	Affects central nervous system and interferes with transport of dopamine.
Opioids/ Heroin/Smack	Latex of *Papaver somniferum* (poppy plant)	Slows down body functions.
Cannabinoids	*Cannabis sativa*	Affects cardiovascular system

(*c*) Awareness can be promoted by organising poster making competitions, street plays, talks by experts and interviews of experts.

Q. 12. What is cancer? How is a cancer cell different from normal cell? How do normal cells attain cancerous nature? **[*NCERT Exemplar*]**

Ans. An abnormal and uncontrolled division of cells is termed as cancer.

S.No.	Cancer cell	Normal cell
(*i*)	Cancer cells divide in an uncontrolled manner.	Normal cells divide in a controlled manner.
(*ii*)	These cells do not show contact inhibition.	These cells show contact inhibition.
(*iii*)	Lifespan is indefinite.	Lifespan is definite.

In our body, the growth and differentiation of cells is highly controlled and regulated. The normal cells show a property called contact inhibition. The surrounding cell inhibits uncontrolled growth and division of a cell. The normal cells when lose this property, become cancerous, giving rise to masses of cells called tumours. Transformation of normal cells into cancerous cells is induced by some physical, chemical or biological agents (carcinogens).

Q. 13. Explain the following in context of cancer:

(*a*) Benign tumour **(*b*) Malignant tumour**

(*c*) Oncogens/Carcinogens **(*d*) Oncogenes**

(*e*) Contact inhibition **[*CBSE Sample Paper 2014*]**

Ans. (*a*) Benign tumours are the masses of cells which remain confined to their original location and do not spread to other parts of the body and cause little damage.

(*b*) Malignant tumours are the masses of proliferating cells called neoplastic or tumour cells. These grow very rapidly, invading and damaging the surrounding normal tissues.

(*c*) Transformation of normal cells into cancerous, neoplastic cells may be induced by physical, chemical or biological agents. These agents are called carcinogens. For example X-rays, gamma rays, UV radiations and some chemicals like EtBr.

(*d*) The genes which may lead to oncogenic transformations of the cells are called oncogenes.

(*e*) Contact inhibition—Whenever normal cells come in contact with each other, after a definite time they inhibit each others' excess growth and multiplication. This property of normal cells is called contact inhibition which maintains the normal shape and size of the body. But cancer cells appear to have lost this property which results in their uncontrolled growth and multiplication.

Q. 14. Why do some adolescents start taking drugs? How can the situation be avoided?
[*NCERT Exemplar*]

Ans. Refer to Basic Concepts Point 18.
For measures to avoid taking drug, refer to Basic Concepts Point 20.

Self-Assessment Test

Time allowed: 1 Hour **Max. marks: 30**

1. Choose and write the correct option in the following questions. **(3×1 = 3)**

(i) AIDS is caused by HIV. Among the following, which one is not a mode of transmission of HIV?
(a) Transfusion of contaminated blood
(b) Sharing the infected needles
(c) Shaking hands with infected persons
(d) Sexual contact with infected persons

(ii) The target cell of HIV is
(a) B-cell (b) Macrophase
(c) Erythrocyte (d) helpher-T-cell

(iii) The interferons are
(a) antiviral proteins (b) antibacterial protein
(c) antifungal proteins (d) all of these

2. In the following questions a statement of assertion followed by a statement of reason is given. Choose the correct answer out of the following choices. **(3×1 = 3)**

(a) Assertion and reason both are correct statements and reason is correct explanation for assertion.
(b) Assertion and reason both are correct statements but reason is not correct explanation for assertion.
(c) Assertion is correct statement but reason is wrong statement.
(d) Assertion is wrong statement but reason is correct statement.

(i) Assertion : Acquired immunity supplements the protection provided by innate immunity.
Reason : An individual is born with innate immunity.
(ii) Assertion : T-helper cells are activated on stimulation by contact with antigens.
Reason : T-cells produce specialised proteins called antibodies.
(iii) Assertion : Allergens cause excessive immune response in human body.
Reason : Allergy involves IgA antibodies and interferons.

3. Name an allergen and write the response of the human body when exposed to it. **(1)**

4. What does LSD stand for? What is its source? **(1)**

5. Why is an antibody molecule represented as H_2L_2? **(2)**

6. The following table shows certain diseases, their causative organisms and symptoms. Fill the gaps.

S. No.	Name of the Disease	Causative organism	Symptoms
(i)	Typhoid	—	High fever, weakness, headache, stomach pain, constipation.
(ii)	Pneumonia	*Streptococcus pneumonia*	—
(iii)	—	Rhino viruses	Nasal congestion and discharge, sorethroat, cough, headache.
(iv)	Filariasis	—	Inflammation in lower limbs.

(2)

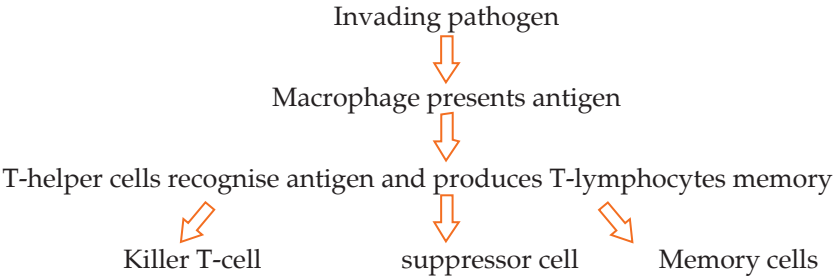
7. How does cell-mediated immune system work when our body is infected? **(2)**

8. (a) Why do the symptoms of malaria not appear immediately after the entry of sporozoites into the human body when bitten by female Anopheles? Explain.

   (b) Give the scientific name of the malarial parasite that causes malignant malaria in humans. **(2)**

9. List the specific symptoms of typhoid. Name its causative agent. **(3)**

10. Given below is the flow chart for cell mediated immune response.



Answer the following questions on the basis of the flow chart: **(3×1 = 3)**

(i) Name any two types of cells which act as 'Cellular Barriers' to provide Innate Immunity in humans.

(ii) Thymus of a new born child was degenerating right from birth due to a genetic disorder. Predict its two impacts on the health of the child.

(iii) How do cytokine barriers provide innate immunity in humans?

11. Explain metastasis. Why is it fatal? **(3)**

12. Explain the different measures for control and prevention of drug/alcohol abuse among adolescents. **(5)**

Answers

1. (*i*)—(*c*), (*ii*)—(*d*), (*iii*)—(*a*) **2.** (*i*)—(*b*), (*ii*)—(*c*), (*iii*)—(*c*)

Chapter–9

Strategies for Enhancement in Food Production

basic concepts

1. Animal Husbandry

- **Animal husbandry** is the agricultural practice of breeding and raising livestock useful to man.
- Animal husbandry deals with:
  - (*i*) breeding of livestock like buffaloes, cows, cattle, sheep, camels, etc., that are useful to humans.
  - (*ii*) rearing, catching, selling, etc., of fish, molluscs and crustaceans.
  - (*iii*) breeding of fowls for human use.
- India and China cover more than 70 per cent of the world's livestock population but contribute only 25 per cent to the world farm produce.

2. Dairy Farm Management

- It is the management of animals for milk and its products for human consumption.
- It deals with processes and systems to improve quality and quantity of milk.
- Milk yield primarily depends on the quality of breeds.
- The processes carried out for managing dairy farm are:
  - (*i*) Selection of good breeds having high yielding potential and resistance to diseases.
  - (*ii*) Cattle is well-housed with adequate water supply.
  - (*iii*) Cattle is fed in a scientific manner with good quality and quantity of fodder.
  - (*iv*) Hygiene is maintained while milking, storage and transport of milk and its products.
  - (*v*) Regular inspections along with keeping proper records.
  - (*vi*) Regular visits by a veterinary doctor.
  - (*vii*) Hygiene and cleanliness (both of cattle and handlers).
  - (*viii*) Identifying and rectifying problems as early as possible.

3. Poultry Farm Management

- The domesticated fowls (birds) used for food or for their eggs are called **poultry**.
- It includes chicken, duck, turkey and geese.
- The important parameters of poultry farm management are:
  - (*i*) selection of disease-free, suitable breeds.
  - (*ii*) proper and safe conditions of farm.
  - (*iii*) proper food and water.
  - (*iv*) hygiene and healthcare of the birds.

4. Bee-keeping (Apiculture)

- The maintenance of hives of honeybees for the production of honey is termed as **bee-keeping** or **apiculture**.
- Bee-keeping is practiced in any area where there is availability of sufficient bee pastures of some wild shrubs, fruit orchards and cultivated crops.
- Among several species of honeybees, one of the most common that can be reared is ***Apis indica***.
- A successful bee-keeping requires:
  - (*i*) Knowledge of the nature and habits of bees.
  - (*ii*) Selection of a suitable location for keeping the beehives.
  - (*iii*) Catching and hiving of swarms (groups of bees).
  - (*iv*) Management of beehives during different seasons.
  - (*v*) Handling and collection of honey and beeswax.

Ecological Importance of Bees

- Bees are the pollinators of many crop species like sunflower, *Brassica*, apple and pear. So, keeping beehives in crop fields during flowering period increases both crop yield and honey yield.

Commercial Importance of Bees

- (*i*) Honey is used as food of very high nutritive value.
- (*ii*) Honey is also used in the indigenous system of medicines.
- (*iii*) Beeswax produced by honeybees is used in industry to prepare cosmetics and polishes.

5. Fisheries

- It is an industry that includes catching, processing or selling of fish, shellfish (Mollusca, crustaceans, prawn, crabs) or other aquatic animals.
- Some common freshwater fishes are *Catla*, *Rohu* and common carp.
- Some edible marine fishes are *Hilsa*, sardines, mackerel and pomfrets.

Economic Importance

- (*i*) A large part of human population depends on fish and fish products for food.
- (*ii*) It provides income and employment to a large number of fishermen in coastal states.
- (*iii*) Fish liver oil is used in medicines.

Table 9.1: Differences between aquaculture and pisciculture

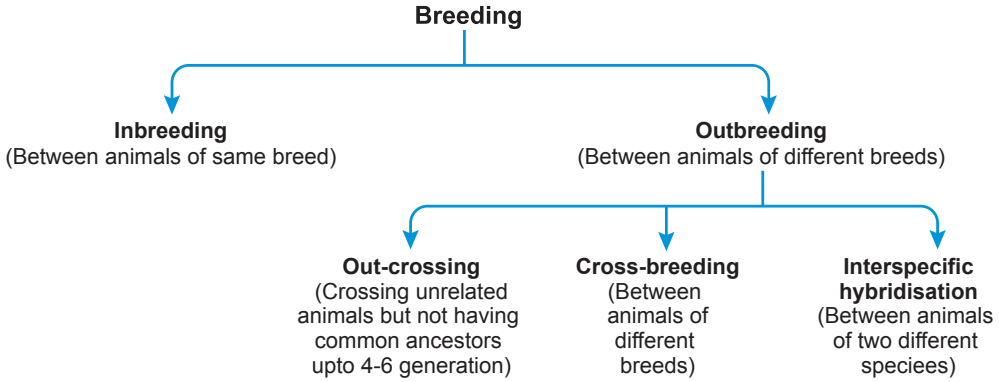
S. No.	Aquaculture	Pisciculture
(*i*)	It is also known as aquafarming and involves farming of all types of aquatic organisms in coastal and inland areas.	It is also known as fish farming and involves raising fish commercially in tanks for food.
(*ii*)	It involves production of all types of aquatic plants and animals – both fresh water and marine.	It involves culture of fish for food and related food animals in water bodies.
(*iii*)	There is little requirement of special feed from outside.	Fish feed has to be provided from outside.
(*iv*)	Number of economically important substances are obtained.	Yields only food items.

6. Animal Breeding

- A **breed** refers to a group of animals related by descent and are similar in most characters like general appearance, features, size and configuration.
- It can also be carried out artificially by artificial insemination and MOET.

- High yielding breed developed at NDRI (National Dairy Research Institute), Karnal is Karan Swiss.

Table 9.2: Classification of breeding



7. Inbreeding

- Inbreeding refers to the mating between closely related individuals within the same breed for 4–6 generations.

Strategy for Inbreeding

(*i*) Identify superior males and superior females of the same breed.
(*ii*) These are then mated in pairs.
(*iii*) Evaluate the progeny obtained from the mating to identify superior males and females.
(*iv*) In cattle, superior female is the cow or buffalo that produces more milk per lactation and superior male is the bull that gives rise to superior progenies.
(*v*) Superior progenies obtained are further mated.

Effects of Inbreeding

- **Advantages**

(*i*) Inbreeding increases and evolves a pure line.
(*ii*) Superior genes can be accumulated by inbreeding by eliminating undesirable genes.
(*iii*) By selection at every step, productivity of inbred population is increased.

- **Disadvantages**

(*i*) Close inbreeding usually results in reduction of fertility and productivity. This is called **inbreeding depression**. Fertility and yield can be restored by mating the selected animals with unrelated superior animal of same breed.
(*ii*) Recessive genes are exposed by inbreeding which are then eliminated by selection.

8. Outbreeding

- It refers to the breeding of unrelated animals which may be of the same breed but not having common ancestors (out-crossing) or of different breeds (cross-breeding) or even different species (interspecific hybridisation).

(i) Out-crossing

- It is a practice of mating animals of the same breed, that have no common ancestors on either side of their pedigree up to 4–6 generations.
- The offspring is known as an out-cross.
- **Advantages**

(*a*) It is done to increase milk production and growth rate in animals.
(*b*) A single out-cross overcomes inbreeding depression.

(ii) Cross-breeding

- Cross-breeding refers to the mating of superior males of one breed with superior females of another breed.
- A new sheep breed, *Hisardale*, was obtained in Punjab by crossing Bikaneri ewes and Marino rams.
- **Advantages**

(*a*) It helps to accumulate the desirable genes of the two breeds into a progeny.

(*b*) The progeny may be used for commercial production.

(iii) Interspecific hybridisation

- It refers to crossing between male and female animals of two different species.
- The progeny may or may not be of economic value.
- For example,

(*a*) a mule was obtained by crossing a male donkey and a female horse.

(*b*) Hinny was produced by crossing male horse and female donkey.

(*c*) Liger and Tigon are interspecific hybrid mammals of tiger and lion.

9. Artificial Insemination (AI)

- It is a method of controlled breeding in which semen from the selected male parent is injected into the reproductive tract of the selected female parent.

Advantages

(*i*) Helps in overcoming several problems of normal mating.

(*ii*) Semen collected can be frozen for later use.

(*iii*) Semen collected can be transported in frozen form.

(*iv*) Useful when desirable bull may not be available at time of heat period of female.

(*v*) Males have limited ability for mating 50–100 per year in case of bull.

(*vi*) It is healthier and cannot spread contagious diseases.

(*vii*) Males of exotic breeds require particular environment/climate.

10. Multiple Ovulation Embryo Transfer Technology (MOET)

- It is a programme for herd improvement in animals like cattle, sheep, rabbits, buffaloes, mares, etc.
- High milk-yielding breeds of female have been bred with high quality (lean meat with less lipid) meat-yielding bulls to increase herd size in lesser time.

Procedure

(*i*) A cow is administered hormones with FSH-like activity to induce follicular maturation and super-ovulation.

(*ii*) The cow produces 6–8 eggs instead of one egg produced normally.

(*iii*) It is now, either mated with an elite bull or artificial insemination is carried out.

(*iv*) When the fertilised eggs attain 8–32 cells stage, they are non-surgically removed and transferred to a surrogate mother.

(*v*) The genetic mother can now be again super-ovulated.

11. Plant Breeding

- Plant breeding is the purposeful manipulation of plant species in order to create plant types that are better suited for cultivation, give better yields and are disease resistant.

- The list of traits or characters that the breeders have tried to incorporate into desired crop plants are as follows:
  (*i*) increased tolerance to environmental stress (salinity, extreme temperature, drought).
  (*ii*) resistance to pathogens (viruses, fungi and bacteria).
  (*iii*) increased tolerance to insect pests.
  (*iv*) high-yielding and improved quality of crop plant.

12. Plant Breeding Programme

- Earlier methods of plant breeding involved crossing or hybridising pure lines, followed by artificial insemination to produce plants of desirable traits.
- The major steps in breeding a new genetic variety of a crop are as follows:

(i) Collection of variability

- Genetic variability is the root of any breeding programme.
- Pre-existing genetic variability is collected from wild varieties, species and relatives of the cultivated crop species.
- These are evaluated for their characteristics and preserved for effective exploitation of the natural genes.
- The entire collection of diverse alleles for all genes in a given crop is called **germplasm collection**.

(ii) Evaluation and selection of parents

- Evaluation of germplasm is carried out to identify plants with desirable combination of characters.
- The selected plants are multiplied and hybridised.
- By self-pollination, pure line is created whenever desired.

(iii) Cross-hybridisation among the selected parents

- The cross-hybridisation between the parents is done to produce hybrids that genetically combine to give desired characters in one plant.
- Cross-hybridisation is a time-consuming and tedious process because it involves emasculation and bagging techniques to transfer desired pollen grains to the desired plant.
- The chances of the desirable characters combining in the hybrid is also one in few thousand crosses.

(iv) Selection and testing of superior recombinants

- It involves the selection of plants among the progeny of the hybrids with desired combination of characters.
- The hybrid are superior to both the parents. This is called hybrid **vigour/heterosis**.
- They are self-pollinated for several generations till they reach a state of uniformity or homozygosity in order to avoid the segregation of characters in the future progeny.

(v) Testing, release and commercialisation of new cultivars

(a) Evaluation

- The newly selected lines are evaluated for their yield and other agronomic traits of quality, disease resistance, etc., by growing them in the research fields.
- Their performance is recorded under ideal fertiliser application, irrigation and other crop management practices.

(b) Testing

- After evaluation, the hybrid line is tested in farmer's fields.

- The crop is grown at different locations in the country with different agroclimatic zones for at least three growing seasons.
- The tested material is evaluated in comparison to the best available local crop cultivar (called check or reference cultivar) as a reference material for marketing of the material.

***(c)* Release**

- The material tested is then selected to be certified and released in bulk as a variety.

13. Green Revolution

- The development of several high yielding varieties of wheat and rice in the mid-1960s, as a result of various plant breeding techniques led to dramatic increase in food production in our country. This phase is often referred to as the **Green Revolution**.
- India is mainly an agricultural country. Agriculture accounts for approximately 33 per cent of Indian GDP and employs 62 per cent of the population.

(i) Wheat and rice

- Between 1960 and 2000, the production of wheat increased from 11 million tonnes to 75 million tonnes while the production of rice increased from 35 million tonnes to 89.5 million tonnes.
- The increase in production was due to introduction of **semi-dwarf varieties** of wheat and rice.
- Semi-dwarf wheat was developed by **Norman E. Borlaug**, at International Centre for Wheat and Maize Improvement in Mexico.
- Semi-dwarf varieties of rice were developed from **IR-8** (developed at International Rice Research Institute or IRRI, Philippines) and **Taichung Native-1** (developed in Taiwan).
- High-yielding and disease-resistant wheat varieties were introduced in India in 1963, *e.g.*, ***Sonalika*** and ***Kalyan sona***.
- Semi-dwarf rice varieties were introduced in India in 1966.
- India later developed better rice varieties like **Jaya** and **Ratna**.
- Indian hybrid variety of garden pea is P-1542.

(ii) Sugarcane

- ***Saccharum barberi*** and ***Saccharum officinarum*** were crossed to obtain sugarcane varieties having desirable qualities.
- *S. barberi* was grown in north India and had poor sugar content and yield.
- *S. officinarum* did not grow in north India but had thicker stem and higher sugar content.
- The new sugarcane varieties formed by crossing the two varieties had the following qualities:
  (*a*) high yield,
  (*b*) thick stem,
  (*c*) high sugar content,
  (*d*) ability to grow in north India.

(iii) Millets

- Hybrid breeding has led to the development of several high-yielding varieties resistant to water stress.
- Several high-yielding varieties of hybrid maize, jowar and bajra have been successfully developed in India.

14. Plant Breeding for Disease Resistance

- **Resistance** is defined as the genetic ability of a plant to prevent pathogen from causing disease.
  - **Advantages:**
    (*i*) Development of resistance in crops enhances production.
    (*ii*) Reduces the dependence on fungicides and bacteriocides.

Table 9.3: Few plant diseases caused by microbes

S. No.	Causative organism	Diseases caused
(*i*)	Fungi	Brown rust of wheat, red rot of sugarcane, late blight of potato.
(*ii*)	Bacteria	Black rot of crucifers, blight of rice, citrus canker.
(*iii*)	Virus	Tobacco mosaic, turnip mosaic.

Methods of Breeding for Disease Resistance

- There are two methods for carrying out breeding:
  (*i*) Conventional breeding techniques
  (*ii*) Mutation breeding

(i) Conventional breeding method

- It is carried out by the following steps:
  (*a*) Selection and screening of germplasm for disease resistance.
  (*b*) Hybridisation of selected plants.
  (*c*) Selection and evaluation of hybrids.
  (*d*) Testing and release of new varieties into the market.

Table 9.4: Few plant varieties developed by conventional breeding methods

Crop	Variety	Resistance to diseases
Wheat	*Himgiri*	Leaf and stripe rust, hill bunt
Brassica	*Pusa Swarnim* (*Karan rai*)	White rust
Cauliflower	*Pusa Shubhra, Pusa Snowball K-1*	Black rot, curl blight black rot
Cowpea	*Pusa Komal*	Bacterial blight
Chilli	*Pusa Sadabahar*	Chilly mosaic virus, tobacco mosaic virus, leaf curl

Disadvantages

(*a*) Limited number of disease resistance genes are present.
(*b*) Limited number of disease resistance genes have been identified in crop varieties or wild relatives.

(ii) Mutation breeding

- Mutation is a phenomenon by which genetic variation is achieved through changes in the base sequences within genes which creates a new character or trait absent in parental generation.
- **Mutation breeding** is defined as the process of breeding by artificially inducing mutations using chemicals (like aniline) or radiations (like gamma radiations).
- It is carried out by the following steps:
  (*a*) Inducing mutations in plants by various means.
  (*b*) Screening the plant for resistance.
  (*c*) Selecting the desirable plant for multiplication and breeding.
- In ***moong* bean**, resistance to yellow mosaic virus and powdery mildew were introduced by mutations.
- In *bhindi* (*Abelmoschus esculentus*), resistance to yellow mosaic virus was introduced from a wild species resulting a new variety called *Parbhani Kranti*.

15. Plant Breeding for Developing Resistance to Insect Pests

- The host crop plants may be resistant to insect pests due to the morphological, biochemical or physiological characteristics.
- Some characteristics that lead to pest resistance are:
  (*i*) Hairy leaves in plants., *e.g.*, resistance to jassids in cotton and cereal leaf beetle in wheat.
  (*ii*) Solid stem in wheat exhibits non-preference by stem sawfly.
  (*iii*) In cotton, smooth leaf and absence of nectar repel bollworms.
  (*iv*) In maize, high aspartic acid, low nitrogen and sugar content protects them from stem borers.
- The steps of breeding method is same as for the other agronomic traits.

Table 9.5: Some plant varieties developed by hybridisation and selection

Crop	Variety	Insect pests
Brassica (rapeseed mustard)	*Pusa Gaurav*	Aphids
Flat bean	*Pusa Sem* 2, *Pusa Sem* 3	Jassids, aphids and fruit borer
Okra (*Bhindi*)	*Pusa Sawani Pusa A*-4	Shoot and fruit borer

16. Plant Breeding for Improved Food Quality

- Need for breeding plants to improve food quality:
  (*i*) Lack of adequate food having adequate nutritional requirements in the world.
  (*ii*) Majority of people are unable to buy enough fruits, vegetables, legumes, fish and meat, and thus suffer from deficiencies or 'hidden hunger'.
  (*iii*) Essential micro-nutrients are absent from diet.
- **Biofortification** is the method for developing crops with higher levels of vitamins, minerals, proteins and healthier fats to improve public health.
- The objectives of biofortification is to improve
  (*i*) protein content and quality.
  (*ii*) oil content and quality.
  (*iii*) vitamin content.
  (*iv*) micronutrients and mineral content.

List of Crops with Improved Nutrient Content

- **Atlas 66** has been used as a donor for developing wheat varieties with improved protein content.
- Other varieties developed are:
  (*i*) maize hybrids: twice the amount of amino acids lysine and tryptophan than previous varieties.
  (*ii*) iron-fortified rice: increased iron content.

Table 9.6: List of fortified crop varieties released by Indian Agricultural Research Institute, New Delhi

Crop	Nutrient rich in
Carrot, spinach, pumpkin	Vitamin A
Bitter gourd, *bathua*, mustard, tomato	Vitamin C
Spinach, *bathua*	Iron and calcium
Broad bean, lablab, french bean, garden pea	Protein

17. Single Cell Protein (SCP)

- It is protein-rich cell biomass used as food or feed.
- It is an alternative protein source for animal and human nutrition from certain beneficial microorganisms like *Spirulina*.
- Microbes like *Spirulina*, *Methylophilus methylotrophus* can be grown on industrial scale as sources of good protein.
- It has been calculated that a 250 kg cow produces 200 g of protein per day. In the same period, 250 g of microbes like *Methylophilus methylotrophus* produce 25 tonnes of proteins because of its high rate of biomass production.
- Advantages of single cell proteins:
  - (*i*) **Easy to grow:** Microbes can be grown on materials like waste water from potato processing plants, straw, molasses, animal manure and sewage.
  - (*ii*) **Nutrient-rich:** Provide food rich in protein, minerals, fats, carbohydrates and vitamins.
  - (*iii*) Reduces environmental pollution.
  - (*iv*) **High yield:** Due to high rate of biomass production and growth, large amounts are produced in short time.
  - (*v*) They bridge the gap between requirement and supply of protein.
  - (*vi*) They reduce pressure on agriculture.
  - (*vii*) They can be easily genetically modified.

18. Tissue Culture

- **Tissue culture** is an *in vitro* technique of regeneration of a whole plant from any part of a plant by growing it on culture medium under aseptic conditions.
- The capacity of a cell explant to grow into a whole plant is called **totipotency**.
- The part of the plant taken for tissue culture is called **explant**.
- The method of growing or producing thousands of plants through tissue culture is called **micropropagation**.
- The nutrient medium for tissue culture should have following components:
  - (*i*) Carbon source — sucrose
  - (*ii*) Inorganic salts
  - (*iii*) Growth regulators — auxins, cytokinins, etc.
  - (*iv*) Vitamins
  - (*v*) Amino acids
- The plants produced from tissue culture are genetically identical to the original plant from which they are grown, so they are called **somaclones**.
- Advantages of tissue culture:
  - (*i*) A large number of plants can be grown in short time.
  - (*ii*) Disease-free plants can be developed from diseased plants.
  - (*iii*) Seedless plants can be multiplied.
  - (*iv*) The plants where sexual reproduction is absent may undergo somatic hybridisation.
  - (*v*) Healthy plants can be developed from diseased plants by meristem culture.

19. Somatic Hybridisation

- The process of fusion of protoplast of somatic cells obtained from different varieties or species of plant on a suitable nutrient medium *in vitro* to develop a somatic hybrid is called **somatic hybridisation**.

- It is carried out by the following steps:
  (*i*) Single cells from selected plants are isolated.
  (*ii*) The cell walls of cells are digested by enzymes like pectinase and cellulase, to expose the naked protoplasts.
  (*iii*) Naked protoplasts surrounded only by plasma membranes are isolated.
  (*iv*) The isolated protoplasts are fused with the help of PEG (polyethylene glycol) or sodium nitrate to obtain hybrid protoplasts under sterile conditions in special nutrient media.
  (*v*) The hybrid protoplasts are cultured in a suitable media to form new plant.
- **Pomato** is an example of a somatic hybrid produced by fusion of tomato and potato protoplasts.
- **Advantages:**
  (*i*) Interspecific and intergeneric hybrids are produced.
  (*ii*) Polyploids and fertile diploids are produced for sexually sterile hybrids.

20. Meristem Culture

- Healthy plants can be recovered from diseased plants by this method.
- **Meristem** (apical and axillary) is the only virus-free part of a virus-infected plant.
- By removing the meristem and growing it *in vitro*, virus-free plants can be obtained.
- Some plants developed by meristem culture are banana, sugarcane, potato, etc.

NCERT Textbook Questions

Q. 1. Explain in brief the role of animal husbandry in human welfare.

Ans. Animal husbandry is the practice of taking care and breeding domestic animals by applying scientific principles. It includes feeding, breeding and raising animal livestock whose primary purpose is to provide meat and milk. Milk is considered as an important article of regular diet. The animal protein is obtained from beef, cattle, sheep and meat of goats. Eggs and poultry meat also serve as sources of animal protein. Thus, animal husbandry plays an important role in human welfare by providing us milk, eggs, meat, wool, silk, honey, wax and many other products. Also, rearing of animals provide useful employment to many.

Q. 2. If your family owned a dairy farm, what measures would you undertake to improve the quality and quantity of milk production?

Ans. The following efforts need to be put in:
(*i*) The cattle in the dairy farm must be housed and fed properly.
(*ii*) Cleanliness should be maintained in the milking area.
(*iii*) The health of the dairy cattle should be of utmost importance and a veterinary doctor must visit regularly.
(*iv*) Regular inspections of the farm, maintaining records, identification and rectification of problems should be done along with maintaining precautionary measures.
(*v*) Milking should be done in a dirt-free area and all the sanitary conditions should be maintained.
(*vi*) High-yielding and disease-resistant breeds can be selected to maximise benefits.

Q. 3. What is meant by the term 'breed'? What are the objectives of animal breeding?

Ans. Breed refers to the group of animals having same ancestral characters, general appearance, size, etc.

Objectives of animal breeding:
(*i*) To increase the quantity of yield.
(*ii*) To improve the desirable qualities of the produce.

Q. 4. Name the methods employed in animal breeding. According to you which of the methods is best? Why?

Ans. The methods employed in animal breeding are:

(*i*) Natural methods: These can be carried out by inbreeding and outbreeding methods.

(*ii*) Artificial methods: These are carried out by artificial insemination and multiple ovulation embryo transfer (MOET).

The artificial method of animal breeding is best as it ensures good quality of progeny. It is also economic and time saving process to obtain the desirable progeny.

Q. 5. What is apiculture? How is it important in our lives?

Ans. Apiculture is the rearing, caring and management of honeybees for obtaining honey and wax.

Importance:

(*i*) It produces beeswax, used in the industry for making cosmetics, polishes, etc.

(*ii*) Honey has high nutritive value.

(*iii*) Bees act as pollinators of many crop species like sunflower, *Brassica*, etc, and thus increases crop yield.

Q. 6. Discuss the role of fishery in enhancement of food production.

Ans. Fishery is an industry related to the catching, processing and selling of fish, shellfish or other aquatic animals. Fishes are rich in proteins, vitamins and minerals, and are considered as complete food. Fish liver oil is used in medicine industry. A large part of human population depends on fish and fish products and other aquatic animals such as prawn, crab, lobster, edible oyster, etc., for food. Fishery provides income and employment to a large number of fishermen in coastal states.

Q. 7. Briefly describe various steps involved in plant breeding.

Ans. Refer to Basic Concepts Point 12.

Q. 8. Explain what is meant by biofortification.

Ans. Biofortification is a crop breeding programme that is aimed for developing crop with high levels of vitamins, minerals, proteins and fats to improve public health.

Q. 9. Which part of the plant is best suited for making virus-free plants and why?

Ans. The terminal bud having apical meristem are the best suited parts of plant for making virus-free plant because they are not infected by virus.

Q. 10. What are the major advantages of producing plants by micropropagation?

Ans. Major advantages of producing plants by micropropagation are:

(*i*) Large number of plants can be grown in short time.

(*ii*) Disease-free plants can be obtained.

(*iii*) Plants that have lost the capacity to produce seeds can be grown.

(*iv*) The plants where sexual reproduction is absent, may be hybridised by tissue culture.

(*v*) Plants produced are genetically similar to the parent and have all its characteristics.

Q. 11. Find out what the various components of the medium used for propagation of an explant *in vitro* are.

Ans. The major components of the medium for *in vitro* propagation are:

(*i*) Water (*ii*) Agar agar (*iii*) Sucrose

(*iv*) Inorganic salts (*v*) Vitamins (*vi*) Amino acids

(*vii*) Growth hormones like auxin, cytokinins.

Q. 12. Name any five hybrid varieties of crop plants which have been developed in India.

Ans. (*i*) Cauliflower varieties— *Pusa Shubhra* and *Pusa Snowball K-1*

(*ii*) Brassica varieties — *Pusa Swarnim* (*Karan rai*)

(*iii*) Wheat varieties — *Himgiri*

(*iv*) Rice varieties — *Jaya* and *Ratna*

(*v*) Chilli varieties — *Pusa Sadabahar*.

Multiple Choice Questions [1mark]

Choose and write the correct option in the following questions.

1. **Somaclones are obtained by**
   (*a*) plant breeding (*b*) irradiation
   (*c*) genetic engineering (*d*) tissue culture
2. **Breeding of crops with high levels of minerals, vitamins and proteins is called**
   (*a*) somatic hybridization (*b*) biofortification
   (*c*) biomagnification (*d*) micropropagation
3. **"Jaya" and "Ratna" developed for Green revolution in India are the varieties of**
   (*a*) maize (*b*) rice
   (*c*) wheat (*d*) bajra
4. **'Himgiri' developed by hybridization and selection for disease resistance against rust pathogens in a variety of**
   (*a*) chilli (*b*) maize
   (*c*) sugarcane (*d*) wheat
5. **In plant breeding programmes, the entire collection (of plants seeds) having all the diverse alleles for all genes in a given crop is called**
   (*a*) evaluation and selection of parents (*b*) germplasm collection
   (*c*) selection of superior recombinants (*d*) cross-hybridisation among the selected parents.
6. **A protoplast is a cell**
   (*a*) undergoing division (*b*) without cell wall
   (*c*) without plasma membrane (*d*) without nucleus.
7. **A group of animals which are related by descent and share many similarities are referred to as** *[NCERT Exemplar]*
   (*a*) breed (*b*) race
   (*c*) variety (*d*) species
8. **Inbreeding is carried out in animal husbandry because it** *[NCERT Exemplar]*
   (*a*) increases vigour (*b*) improves the breed
   (*c*) increases heterozygosity (*d*) increases homozygosity
9. **Bull semen for the purpose of artificial insemination is stored in**
   (*a*) ice (*b*) liquid oxygen
   (*c*) liquid nitrogen (*d*) liquid CO_2
10. **Which one of the following is not a fungal disease?** *[NCERT Exemplar]*
    (*a*) Rust of wheat (*b*) Smut of Bajra
    (*c*) Black rot of crucifers (*d*) Red rot of sugarcane
11. **In virus-infected plants the meristematic tissues in both apical and axillary buds are free of virus because** *[NCERT Exemplar]*
    (*a*) the dividing cells are virus resistant
    (*b*) meristems have anti viral compounds
    (*c*) the cell division of meristems are faster than the rate of viral multiplication
    (*d*) Viruses cannot multiply within meristem cell(s).
12. **Several South Indian states raise 2-3 crops of rice annually. The agronomic feature that makes this possible is because of** *[NCERT Exemplar]*
    (*a*) shorter rice plant (*b*) better irrigation facilities
    (*c*) early yielding rice variety (*d*) disease resistant rice variety.

13. Which one of the following combination would a sugarcane farmer look for in the sugarcane crop? [*NCERT Exemplar*]

(*a*) Thick stem, long internodes, high sugar content and disease resistant
(*b*) Thick stem, high sugar content and profuse flowering
(*c*) Thick stem, short internodes, high sugar content, disease resistant
(*d*) Thick stem, low sugar, content, disease resistant

14. Fungicides and antibiotics are chemicals that [*NCERT Exemplar*]

(*a*) enhance yield and disease resistance
(*b*) kill pathogenic fungi and bacteria, respectively
(*c*) kill all pathogenic microbes
(*d*) kill pathogenic bacteria and fungi respectively.

15. Superovulation is induced by

(*a*) artificial insemination
(*b*) more mating
(*c*) hormonal injection
(*d*) Any of these

16. The scientific process by which crop plants are enriched with certain desirable nutrients is called [*NCERT Exemplar*]

(*a*) crop protection
(*b*) breeding
(*c*) biofortification
(*d*) bioremediation.

17. Given below are a few statements regarding somatic hybridisation. [*NCERT Exemplar*]
Choose the correct statements.

(*i*) Protoplasts of different cells of the same plant are fused
(*ii*) Protoplasts from cells of different species can be fused
(*iii*) Treatment of cells with cellulase and pectinase is mandatory
(*iv*) The hybrid protoplast contains characters of only one parental protoplast.

(*a*) (*i*) and (*iii*)
(*b*) (*i*) and (*ii*)
(*c*) (*i*) and (*iv*)
(*d*) (*ii*) and (*iii*)

18. An explant is [*NCERT Exemplar*]

(*a*) dead plant
(*b*) part of the plant
(*c*) part of the plant used in tissue culture
(*d*) part of the plant that expresses a specific gene.

19. The biggest constraint of plant breeding is [*NCERT Exemplar*]

(*a*) availability of desirable gene in the crop and its wild relatives
(*b*) infrastructure
(*c*) trained manpower
(*d*) transfer of genes from unrelated sources.

20. Micro-propagation is [*NCERT Exemplar*]

(*a*) propagation of microbes *in vitro*
(*b*) propagation of plants *in vitro*
(*c*) propagation of cells *in vitro*
(*d*) growing plants on smaller scale.

21. Protoplast is [*NCERT Exemplar*]

(*a*) another name for protoplasm
(*b*) an animal cell
(*c*) a plant cell without a cell wall
(*d*) a plant cell.

22. To isolate protoplast, one needs [*NCERT Exemplar*]

(*a*) pectinase
(*b*) cellulase
(*c*) both pectinase and cellulase
(*d*) chitinase

23. Which one of the following is a marine fish? [*NCERT Exemplar*]

(*a*) *Rohu*
(*b*) *Hilsa*
(*c*) *Catla*
(*d*) Common Carp

24. Which one of the following products of apiculture is used in cosmetics and polishes [*NCERT Exemplar*]

(*a*) Honey
(*b*) Propolis
(*c*) Wax
(*d*) Royal jelly

25. 33 percent of India's Gross Domestic Product comes from [*NCERT Exemplar*]

(*a*) industry (*b*) agriculture

(*c*) export (*d*) small-scale cottage industries

26. A collection of all the alleles of all the genes of a crop plant is called [*NCERT Exemplar*]

(*a*) germplasm collection (*b*) protoplasm collection

(*c*) herbarium (*d*) somaclonal collection

Answers

1. (*d*)	**2.** (*b*)	**3.** (*b*)	**4.** (*d*)	**5.** (*b*)	**6.** (*b*)	**7.** (*a*)	**8.** (*d*)	**9.** (*c*)	**10.** (*c*)
11. (*c*)	**12.** (*c*)	**13.** (*a*)	**14.** (*b*)	**15.** (*c*)	**16.** (*c*)	**17.** (*d*)	**18.** (*c*)	**19.** (*a*)	**20.** (*b*)
21. (*c*)	**22.** (*c*)	**23.** (*b*)	**24.** (*c*)	**25.** (*b*)	**26.** (*a*)				

Assertion-Reason Questions

In the following questions a statement of assertion followed by a statement of reason is given. Choose the correct answer out of the following choices.

(a) Assertion and reason both are correct statements and reason is correct explanation for assertion.

(b) Assertion and reason both are correct statements but reason is not correct explanation for assertion.

(c) Assertion is correct statement but reason is wrong statement.

(d) Assertion is wrong statement but reason is correct statement.

1. Assertion : In plant tissue culture, somatic embryos can be induced from any plant cell.
Reason : Any viable plant cell can differentiate in to somatic embryos.

2. Assertion : Fish meal is a rich source of protein for cattle and poultry.
Reason : Fish meal is produced from non-edible parts of fishes like fins, tail.

3. Assertion : Micropropagation has been used to introduce variations in the offsprings.
Reason : Virus-free plants can be generated by the technique of micropropagation.

4. Assertion : Somatic embryos can be induced from any cell in plant tissue culture.
Reason : Any living plant cell is capable of differentiating into somatic embryos.

5. Assertion : A major advantage of tissue culture is protoplast fusion.
Reason : A hybrid is formed by the fusion of naked protoplasts of two plants.

6. Assertion : *Hisardale* is cross breed of sheep.
Reason : *Hisardale* is developed by crossing Bikaneri ewe and Merino ram.

7. Assertion : Beehives are kept in closed farms throughout the year.
Reason : Bees are pollinating agents.

8. Assertion : In emasculation male parts of the flower are removed.
Reason : There is no need to cover emasculated flowers.

9. Assertion : Inbreeding depression can be overcome by a single outcross.
Reason : Milk productivity can be increased by outcrossing method.

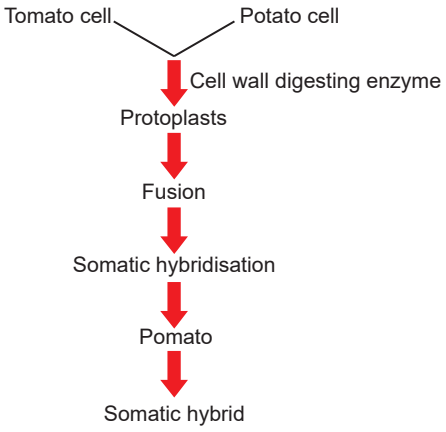
10. Assertion : Single cell proteins (SCP) can help to meet increasing demands of growing population.
Reason : SCP is produced using low cost substrates, in high amount commercially.

Answers

1. (*a*)	**2.** (*c*)	**3.** (*d*)	**4.** (*a*)	**5.** (*b*)	**6.** (*a*)	**7.** (*d*)	**8.** (*c*)	**9.** (*b*)	**10.** (*a*)

Case-based/Source-based Question

1. Given below is a flowchart for the formation of somatic hybrid, Pomato.



(*i*) A certain tissue, of a plant, infected with TMV was used to obtain a new plant using tissue culture technique. Identify the technique used and reason out the possibility of obtaining a new healthy plant.

(*ii*) How can pollen grains of wheat and rice which tend to lose viability within 30 minutes of their release be made available months later for breeding programmes?

(*iii*) What is protoplast fusion?

Ans. (*i*) The technique used is tissue culture using meristematic tissue as this method produces virus free plants.

(*ii*) The pollen grains can be stored in liquid nitrogen (–196°C). Such stored pollen grains do not lose their viability for years and can be used in breeding programmes.

(*iii*) The merging of protoplasts obtained from two different cells to form a hybrid protoplast is called protoplast fusion.

2. Study the table of varieties of crops shown resistance to certain diseases and answer the questions.

Crop disease	Disease resistant variety of crop
(*a*) White rust	*Pusa Swarnim*
(*b*) Leaf and stripe rust	*Himgiri*
(*c*) Black rot	*Pusa Shubhra*
(*d*) Jassids	*Pusa Sem 2*

(*i*) Genetic variability is the root of any breeding programme. How does this variation occur?

(*ii*) State the importance of biofortification.

(*iii*) How is it possible to recover healthy banana plants from a diseased but desirable quality banana plant? Explain.

Ans. (*i*) (*a*) All the wild varieties and relatives of the cultivated crops are collected and preserved.

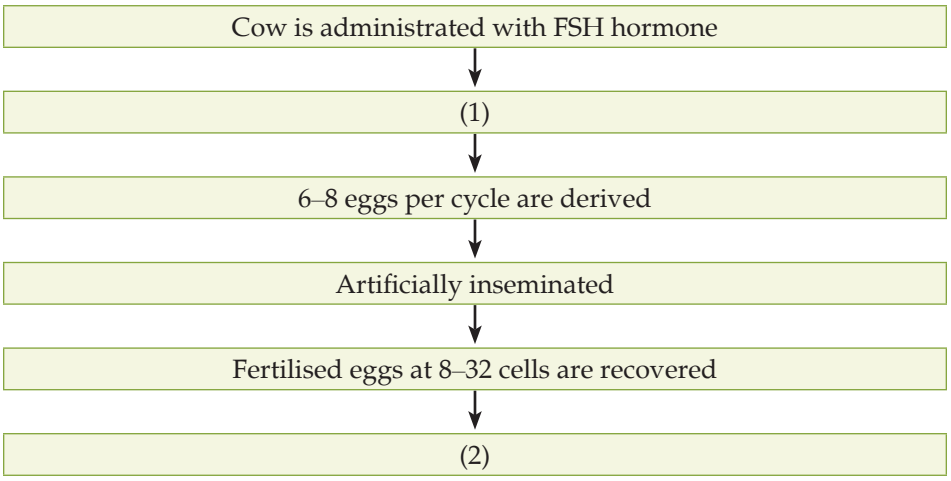
(*b*) For their characteristics, evaluation of these genetic collections are done.

(*ii*) (*a*) Breeding of crops for improvement of nutritional quality.

(*b*) Higher level of vitamins/proteins/minerals/healthier fats. (*Any one*)

(*iii*) Healthy bananas can be obtained by tissue culture technique. The meristem (apical and axillary) is free from virus. Hence, it is removed and grown *in vitro* to obtain healthy banana.

3.. Study the flow chart given below:



(*i*) Identify the events that take place at stages (1) and (2) respectively.

(*ii*) State the importance of the technology explained above.

(*iii*) Write one advantage of Artificial insemination.

Ans. (*i*) Events taking place at:

Stage (1) — Follicular maturation (super-ovulation)

Stage (2) —Transfer to surrogate mothers

(*ii*) Due to this technology, high milk-yielding breeds of cows and high quality meat yielding bulls have been bred successfully to increase herd size in a short time.

(*iii*) It is healthier and cannot spread contagious diseases.

Very Short Answer Questions [1 mark]

Q. 1. Write the name of the following:

(*a*) The most common species of bees suitable for apiculture.

(*b*) An improved breed of chicken. ***[CBSE (AI) 2012]***

Ans. (*a*) *Apis indica*/*Apis mellifera*/*Apis dorsata*

(*b*) Leghorn/Rhode island red/Minorca.

Q. 2. Mention the strategy used to increase homozygosity in cattle for desired traits.

Ans. Inbreeding

Q. 3. Write the importance of MOET. ***[CBSE Delhi 2013]***

Ans. MOET is used to increase the herd size in a short time. It also improves the chances of production of hybrids.

Q. 4. Write an alternate source of protein for animal and human nutrition. ***[CBSE (AI) 2014]***

Ans. Single cell protein/*Spirulina*

Q. 5. Name the following:

(*a*) The semi-dwarf variety of wheat which is high-yielding and disease-resistant.

(*b*) Any one inter-specific hybrid mammal. ***[CBSE Delhi 2012]***

Ans. (*a*) *Kalyan Sona*/*Sonalika*

(*b*) Mule/Hinny/Liger/Tigon

Q. 6. Select two disease resistant crop varieties from the list of crop varieties given below:

Himgiri, Pusa Gaurav, Pusa Komal, Pusa A-4 ***[CBSE 2019 (57/2/1)]***

Ans. *Himgiri*; *Pusa Komal*

Q. 7. Identify two correct statements from the following: [*CBSE (AI) 2014*]

(*i*) Apiculture means apical meristem culture.

(*ii*) Spinach is iron-enriched.

(*iii*) Green revolution has resulted in improved pulse-yield.

(*iv*) Aphids cannot infest rapeseed mustard.

Ans. (*ii*) and (*iv*) are correct.

Q. 8. A herd of cattle is showing reduced fertility and productivity. Provide one reason and one suggestion to overcome this problem. [*CBSE (AI) 2017*]

Ans. Inbreeding depression or continuous inbreeding may be the reason of reduced fertility and productivity. To overcome this, the cattle should be mated with unrelated superior cattle of the same breed.

Q. 9. Which of the following is the semi-dwarf wheat that is high yielding and disease resistant?

Pusa Shubra, Kalyan sona, Ratna [*HOTS*]

Ans. *Kalyan sona*

Q. 10. Write the names of two semi-dwarf and high yielding rice varieties developed in India after 1966. [*CBSE Delhi 2012*] [*HOTS*]

Ans. *Jaya*, *Ratna*.

Q. 11. Why is the South Indian sugarcane preferred by agriculturalists? [*CBSE (F) 2012*] [*HOTS*]

Ans. South Indian sugarcane has thicker stem and higher sugar content.

Q. 12. Name any two diseases the '*Himgiri*' variety of wheat is resistant to. [*CBSE (AI) 2013*] [*HOTS*]

Ans. Leaf and stripe rust; Hill bunt

Q. 13. What is meant by 'hidden hunger'? [*NCERT Exemplar*]

Ans. Consumption of food deficient in nutrients particularly, micronutrients, proteins and vitamins is called hidden hunger.

Q. 14. State any one significance of interspecific hybridisation in plants. [*HOTS*]

Ans. It is important for breeding disease-resistant plant varieties.

Q. 15. Why are apical and axillary meristems used for tissue culture? [*HOTS*]

Ans. Because these are free from virus.

Q. 16. Name the technology which in addition to tissue culture techniques play a pivotal role in enhancing food production. [*HOTS*]

Ans. Somatic hybridisation, Multiple Ovulation Embryo Transfer Technology

Q. 17. Why is mutation breeding necessary for producing disease resistance varieties? [*HOTS*]

Ans. Because there is limited availability of disease resistance genes in the crop plants and their wild relatives.

Q. 18. What can be used as the reference material for comparison of any new improved variety? [*HOTS*]

Ans. The best available local cultivar.

Short Answer Questions [2 marks]

Q. 1. What kind of areas are suitable for practicing apiculture? Write the scientific name of the variety commonly reared for the purpose. [*CBSE (F) 2016*]

Ans. Bee pastures of wild shrub, fruit orchards and cultivated crop are suitable for practicing apiculture. The commonly reared variety for this purpose is *Apis indica*.

Q. 2. Keeping beehives in crop fields has several advantages. List any two. [*CBSE Sample Paper 2016*]

Ans. (*i*) Pollination management

(*ii*) Versatile use of resources

(*iii*) Honey production at no cost

Q. 3. (*a*) List two advantages of keeping beehives in a crop field during flowering season.

(*b*) Name one annual and one perennial crop species favourable to beeswax collection.

[*CBSE Delhi 2014; (F) 2016, 2020*]

OR

Give the scientific name of the most common species of honey bee reared in India. Why is it advantageous to keep beehives in crop-fields during flowering periods? [*CBSE Delhi 2010*]

Ans. (*a*) The most common species of honey bee reared in India is *Apis indica*. Honeybees are good pollinators of almost all the plants. The flowers in turn offer floral rewards like nectar and pollen grains. So, when beehives are kept in crop-fields during the flowering season, honey collection increases and in turn the crop yield also increases.

(*b*) **Annual crop:** Sunflower/*Brassica*

Perennial crop: Apple/pear

Q. 4. State the disadvantage of inbreeding among cattle. How it can be overcome? [*CBSE Delhi 2014*]

Ans. Continuous inbreeding reduces fertility and productivity. This is called inbreeding depression.

This can be overcome by mating with animal of different breeds or individuals of the same breed with unrelated superior animals.

Q. 5. Describe the technology that has successfully increased the herd size of cattle in a short time to meet the increasing demands of growing human population. [*CBSE (AI) 2011*]

Ans. Multiple ovulation embryo transfer technology (MOET) has successfully increased the herd size of cattle. The cow is administered with FSH to induce follicular maturation and super-ovulation to produce 6 to 8 eggs per cycle. It is then mated or artificially inseminated. The fertilised eggs are recovered non-surgically and transferred to surrogate mother where they develop into an improved variety.

Q. 6. High yielding cattle is a good solution for food enhancement. How does the MOET technology help to increase the herd size? [*CBSE (AI) 2015*]

Ans. Refer to Basic Concepts Point 10.

Q. 7. In MOET technology, two 'mothers' are needed to produce one calf. Justify. [*CBSE (F) 2017*]

Ans. In MOET technology, one mother cow is administered hormones to induce follicular maturation and superovulation. These fertilised eggs are transferred to the second surrogate mothers for development.

Q. 8. What is inbreeding depression? Why do the self-pollinated crops not show the ill effects of inbreeding depression?

Ans. The continuous inbreeding may lead to reduced fertility and productivity called inbreeding depression. Self-pollinated crop does not show the ill effects of inbreeding depression because the deleterious allele becomes homozygous and exhibits their lethal effect so it is eliminated by selection.

Q. 9. Differentiate between inbreeding and heterosis. What is inbreeding depression?

Ans.

Table 9.7: Differences between inbreeding and heterosis

Inbreeding	Heterosis
The cross between two individuals of a species that are related by descent is called inbreeding.	The cross between two unrelated individuals or species or genus may develop an improved hybrid called heterosis.

The loss of vigour/fertility and productivity due to continuous inbreeding especially close inbreeding is called inbreeding depression.

Q. 10. Success rate of artificial insemination in cattle is fairly low. Identify any other mean to improve the successful production of hybrids. State the advantages of this technique.

[*CBSE Sample Paper 2015, 2017*]

Ans. Multiple Ovulation Embryo Transfer (MOET) technology can be used to improve production of hybrids. This technique produces 8-10 eggs at a time and the genetic mother is only available for superovulation. By this technique, herd size can be increased in a short time.

Q. 11. How is outcrossing different from cross breeding? ***[HOTS]***

Ans. Outcrossing is the practice of mating animals of the same breed that have no common ancestors on either side of their pedigree up to 4-6 generations whereas cross breeding is the cross of one with superior females of another breed.

Q. 12. "Artificial insemination helps overcome several problems of normal mating in cattle". Do you agree? Support your answer with any three reasons. ***[CBSE 2019 (57/4/1)]***

Ans. This statement is completely justified.

(*i*) It helps in selective breeding in animals.

(*ii*) Semen of a single bull can be used to impregnate several females.

(*iii*) Quality semen is available in preserved form all the time at all places.

(*iv*) Frozen semen can be exported or imported. It is the most reliable method.

(*v*) It does not spread contagious diseases.

Q. 13. How can we improve the success rate of fertilisation during artificial insemination in animal husbandry programmes? ***[NCERT Exemplar] [HOTS]***

Ans. The technology called MOET or Multiple Ovulation Embryo Transfer is used to increase the success rate. For details refer to Basic Concepts Point 10.

Q. 14. Explain the advantage of cross-breeding of the two species of sugarcane in India. ***[CBSE Delhi 2011] [HOTS]***

Ans. *Saccharum barberi*, grown in north India, had poor sugar content and yield, whereas *Saccharum officinarum*, grown in south India, had thicker stem and higher sugar content. The sugarcane species obtained after cross breeding these two species had thick stems, high sugar, high yield and ability to grow in north India.

Q. 15. What is outbreeding? Mention any two ways it can be carried out. ***[CBSE (F) 2017]***

Ans. Outbreeding refers to the breeding of unrelated animals either of the same breed but not having common ancestors or of different breeds or even different species.

It can be carried out by:

(*i*) Outcrossing

(*ii*) Cross-breeding

(*iii*) Interspecific hybridisation

Q. 16. Differentiate between outbreeding and outcrossing. ***[CBSE (F) 2015]***

Ans. Outbreeding is breeding of unrelated animals (having no ancestors for 4–6 generations) belonging to same breed or different breeds or different species.

Outcrossing is breeding within the animals of same breed having no common ancestors for 4–6 generation on either side of the pedigree.

Q. 17. Name any two common Indian millet crops. State one characteristic of millets that has been improved as a result of hybrid breeding so as to produce high yielding millet crops. ***[CBSE Delhi 2015]***

Ans. Maize, *jowar*, *bajra* (*Any two*)

Resistant to water stress has been improved.

Q. 18. Enumerate four objectives for improving the nutritional quality of different crops for the health benefits of the human population by the process of "Biofortification". ***[CBSE Delhi 2015]***

Ans. (*i*) Improving protein content and quality.

(*ii*) Improving oil content and quality.

(*iii*) Improving vitamin content and quality.

(*iv*) Improving micronutrient or mineral content.

Q. 19. List the two steps that are essential for carrying out artificial hybridisation in crop plants and why. ***[CBSE (F) 2014]***

Ans. **(*a*) Selection of parents:** Only those plants should be selected which have desired traits.

(*b*) Crossing over: Pollen grains from selected male plant is collected and transferred to the female plant after which it is bagged.

Q. 20. Scientists tried to develop a single plant exhibiting the characteristic of tomato and potato by using cells from tomato and potato plants respectively. Name the procedure and list the steps to achieve this. ***[CBSE 2019 (57/5/1)]***

Ans. The procedure followed by the scientists is somatic hybridisation.

It involves isolation of protoplast of tomato cell and potato cell having desirable character. These protoplasts fused to get hybrid protoplast which was further grown to form a new plant.

Q. 21. How is 'somatic hybridization' carried out ? Mention one example of a somatic hybrid. ***[CBSE 2019 (57/2/1)]***

Ans. Refer to the answer 21 above.

Q. 22. Identify A, B, C and D in the table given below. ***[CBSE (F) 2013]***

Crop	Variety	Resistance to disease
Wheat	A	Leaf and stripe rust
B	*Pusa Shubhra*	Black-rot
Cowpea	*Pusa Komal*	C
Brassica	*Karan Rai*	D

Ans. A : *Himgiri* B: Cauliflower

C : Bacterial blight D: White rust

Q. 23. How has mutation breeding helped in improving the production of mung bean crop? ***[CBSE Delhi 2015]***

Ans. Mutation breeding has helped in the production of disease resistant varieties of mung bean crops against yellow mosaic virus and powdery mildew.

Q. 24. Suggest four important steps to produce a disease resistant plant through conventional plant breeding technology. ***[CBSE (AI) 2016]***

Ans. Steps for producing disease resistant plants are:

(*i*) Screening of germplasm (for resistance sources)

(*ii*) Hybridisation of selected parents

(*iii*) Selection and evaluation of hybrids (for disease resistance and high yields)

(*iv*) Testing and release of new varieties

Q. 25. By taking two examples explain how has biofortification helped in improving food quality. ***[CBSE Delhi 2017]***

Ans. Biofortification has improved protein content and quality, oil content and quality, vitamin content, micronutrients and mineral content. For example, Atlas 66 has been used as a donor for developing wheat varieties with improved protein content. Maize hybrids have been developed with increased amount of amino acids, lysin and tryptophan.

Q. 26. How are biofortified maize and wheat considered nutritionally improved? ***[CBSE (F) 2012]***

Ans. Biofortified maize has twice the amount of amino acids, lysine and tryptophan, compared to existing hybrids and the wheat variety has increased protein content.

Q. 27. Plant breeding technique has helped sugar industry in North India. Explain how. ***[CBSE Delhi 2016]***

Ans. Refer to Basic Concepts Point 13(*ii*).

Q. 28. Write the importance of bagging of unisexual flowers in crop improvement programme.
[*CBSE (F) 2013*]

Ans. The emasculated flowers are covered with a bag of butter paper to prevent contamination of stigma with unwanted pollen. This process is called bagging. When this stigma attains receptivity, mature pollen grains are dusted on the stigma and the flowers are rebagged to allow the fruits to develop.

Q. 29. Identify 'A', 'B', 'C' and 'D' in the given table.

Crop	Variety	Resistance to disease
A	*Himgiri*	Leaf rust
Cauliflower	*Pusa Shubhra*	B
Brassica	*Pusa Swarnim*	C
Cowpea	D	Bacterial blight

[*CBSE Delhi 2016*]

Ans.

Crop	Variety	Resistance to disease
Wheat	*Himgiri*	Leaf rust
Cauliflower	*Pusa Shubhra*	Black rot/Curl blight black rot
Brassica	*Pusa Swarnim*	White rust
Cowpea	*Pusa Komal*	Bacterial blight

Q. 30. (*a*) Why are the plants raised through micropropagation termed as somaclones?
(*b*) Mention two advantages of this technique. [*CBSE (AI) 2015*]

Ans. (*a*) Plants raised through micropropagation are genetically identical, hence the name somaclones.
(*b*) (*i*) Large number of plants are produced in short duration.
(*ii*) Virus-free plants are produced.

Q. 31. (*i*) Mention the property that enables the explants to regenerate into a new plant.
(*ii*) A banana herb is virus-infected. Describe the method that will help in obtaining healthy banana plants from this diseased plant. [*CBSE (AI) 2010*]

OR

How is it possible to recover healthy banana plants from a diseased but desirable quality banana plant? Explain. [*CBSE (F) 2012*]

Ans. (*i*) Totipotency is the ability of a cell to grow or generate the whole plant.
(*ii*) Healthy banana plants can be obtained from diseased plants by meristem culture. Although the plant is virus infected, the apical and axillary meristem is free of virus. The meristem is removed from the plant and grown *in vitro* by micropropagation. The plants produced are virus-free.

Q. 32. How can healthy potato plants be obtained from a desired potato variety which is viral infected? Explain. [*CBSE Delhi 2014*]

Ans. Even though a plant is infected by a virus, the meristem (apical or axillary) is free of virus. So the meristem can be removed and grown *in vitro*, under sterile conditions and special nutrient/culture medium.

Q. 33. How does culturing *Spirulina* solve the food problems of the growing human population?

OR **[*CBSE (F) 2012*] [*HOTS*]**

"Large scale cultivation of *Spirulina* is highly advantageous for human population." Explain giving two reasons. [*CBSE (AI) 2016*] [*HOTS*]

Ans. Microbes are being grown on an industrial scale as source of good protein. Microbes like *Spirulina* can be grown easily on materials like waste water from potato processing plants (containing starch), straw, molasses, animal manure and even sewage, to produce large quantities and can serve as food rich in protein, minerals, fats carbohydrate and vitamins. Incidentally such utilisation also reduces environmental pollution and hence is environment friendly.

Q. 34. Identify two ways in which *Spirulina* is helpful to mankind.
[*CBSE (AI) 2011; CBSE Sample Paper 2016*]

Ans. *Spirulina* is a source of food rich in protein, minerals, fats, carbohydrates and vitamins. It can grow on waste water from potato processing plants, straw, molasses, animal manure and even sewage, so it also reduces water pollution.

Q. 35. Demand for mushroom as food has led to its culturing on a large scale. Similarly, it is perceived that microbes too would become acceptable as food. Identify a microbe which can be cultured as a food source and give the applicability of its culture in the given context.
[*CBSE Sample Paper 2015*] [*HOTS*]

OR

To reduce the percentage of population suffering from hunger and malnutrition, microbes are grown on a large scale to act as food supplements. Mention any two microbes used as food supplement and suggest their role. **[*CBSE Sample Paper 2017*]**

Ans. The two microbes used as food supplements are:

(*i*) *Spirulina*: Produces large quantities of food rich in protein, minerals, fats, carbohydrates and vitamins.

(*ii*) *Methylophilus methylotrophus*: 250 gm of this microorganism produces 25 tonnes of protein per day.

Q. 36. Lifestyle diseases are increasing alarmingly in India. We are also dealing with large scale malnutrition in the population. Is there any method by which we can address both these problems? **[*NCERT Exemplar*] [*HOTS*]**

Ans. The answer to address both these problems is biofortification. This looks at improving food quality with respect to protein, oil, vitamin, micro-nutrient and mineral content. The oils need to be rich in omega-3 fatty acids which are good for heart. Similarly, proteins should have more of lysine and tryptophan (essential amino acids). Many varieties of maize, carrots and spinach have been released with increased content of vitamin A, vitamin C, iron and calcium which fulfill the above criteria.

Q. 37. "Growing *Spirulina* on a large scale is beneficial both environmentally and nutritionally for humans." Justify. **[*CBSE Delhi 2017*]**

Ans. *Spirulina* can be grown easily on materials like waste water from potato processing plants, straw, molasses, animal manure, sewage. This way it reduces environmental pollution and hence is environmentally beneficial. It serves as food rich in protein, carbohydrate, fats, vitamins and minerals. Thus, it is nutritionally beneficial too.

Q. 38. How are somaclones cultured from explants in *in vitro* conditions? Why are somaclones so called? **[*CBSE (F) 2010*] [*HOTS*]**

Ans. A part of the plant called explant is taken for tissue culture. The explant is grown in aseptic condition in synthetic/cultural media which is rich in inorganic nutrients, vitamins, amino acids and growth regulators like cytokinin and auxin. The method of growing or producing thousands of plants through tissue culture is called micropropagation.

The plants produced from tissue culture are genetically identical to the original plant from which they are grown, so they are called somaclones.

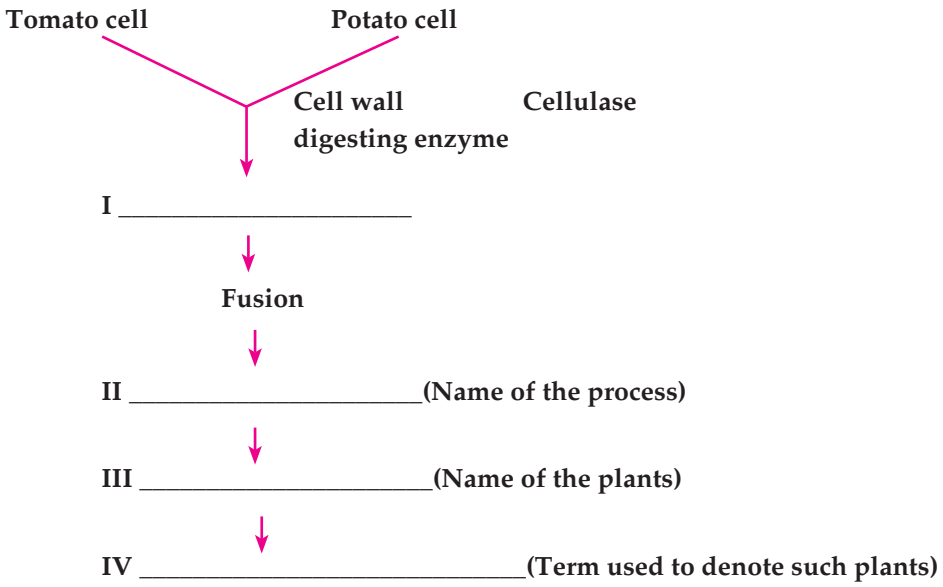
Q. 39. Suggest two features of plants that will prevent insect and pest infestation. **[*NCERT Exemplar*]**

Ans. (*i*) Increasing hair growth on aerial parts of plants.

(*ii*) Rendering the flowers nectar less.

(*iii*) Enabling plants to secrete insect killing chemicals (toxins).

Q. 40. Fill in the blanks. [*NCERT Exemplar*]



Ans. I— Protoplasts; II— Somatic hybridisation; III— Pomato; IV— Somatic hybrid

Q. 41. Give two examples of biofortified crops. What benefits do they offer to the society? [*NCERT Exemplar*] [*HOTS*]

Ans. Maize, wheat, rice, bathua, spinach, pulses have biofortified varieties. Maize hybrids have twice the amount of amino acids, fortified wheat variety has high protein content, fortified rice has high quantity of iron. Consumption of such biofortified foods will enrich the nutritive value of our common foods and will vastly improve public health. It may even help overcome several nutrient deficiency disorders latent in our country.

Q. 42. Name the improved characteristics of wheat that helped India achieve green revolution. [*NCERT Exemplar*] [*HOTS*]

Ans. (*i*) Semi-dwarf nature
(*ii*) Quick yielding feature
(*iii*) High yielding feature
(*iv*) Disease resistant feature

Q. 43. Suryakant had banana plantation in his field. Quality of the fruit was excellent but the yield suffered due to infection of the plants by a virus. Suggest a fast and efficient method to get healthy and a large number of plants in the next generation without compromising on the existing quality. Justify the selection of your method. [*CBSE Sample Paper 2016*] [*HOTS*]

Ans. He can grow thousands of plants through tissue culture of meristem by micro-propagation. He can remove the meristem and grow it *in vitro* using tissue culture technique. Although the plant is infected with a virus, the meristem (apical and axillary) is free of viruses.

Long Answer Questions–I [3 marks]

Q. 1. (*a*) Name any two fowls other than chicken reared in a poultry farm.
(*b*) Enlist four important components of poultry farm management. [*CBSE Delhi 2016*]

Ans. (*a*) Ducks and geese.
(*b*) Refer to NCERT Textbook Questions, Q. 2.

Q. 2. Enumerate any six essentials of good, effective dairy farm management practices. [*CBSE (AI) 2015*]

OR

Explain the efforts which must be put in to improve health, hygiene and milk yield of cattle in a dairy farm. ***[CBSE Delhi 2010]***

Ans. Refer to NCERT Textbook Questions, Q. 2.

Q. 3. What is inbreeding depression and how is it caused in organisms? Write any two advantages of inbreeding. ***[CBSE Delhi 2011]***

Ans. Animal inbreeding has the following advantages:

(*i*) It helps in evolving the pure lines of animals.

(*ii*) It helps in accumulation of superior genes and elimination of less desirable genes.

(*iii*) There is an increase in productivity in the inbred population.

Inbreeding depression stands for the inability of an organism to reproduce. It occurs due to continued inbreeding especially close inbreeding. There is reduction in fertility and productivity of the population that is inbred continuously.

Q. 4. (*a*) Explain how to overcome inbreeding depression in cattle. ***[CBSE Delhi 2013; (AI) 2014]***

(*b*) List three advantages of inbreeding in cattle.

(*c*) Name an improved breed of cattle.

Ans. (*a*) In order to overcome the cattle from inbreeding depression, selected animals of the breeding population should be mated with unrelated superior animals of the same breed or different breed. This helps in restoring the fertility and yield in the cattle.

(*b*) (*i*) Pure lines can be obtained.

(*ii*) Harmful recessive genes are exposed that are eliminated by selection.

(*iii*) Superior genes can be accumulated by inbreeding by eliminating undesirable genes.

(*c*) Jersey cow.

Q. 5. Mention the cause and effect of inbreeding depression in cattle. How can it be overcome? Explain. ***[CBSE (F) 2010]***

Ans. Inbreeding which refers to the mating between closely related individuals with the same breed for 4–6 generations causes inbreeding depression. Continued inbreeding, especially close inbreeding usually reduces the fertility and even productivity of the organism, this is called as inbreeding depression.

It can be overcome by mating the selected animals of breeding population with unrelated superior animals of same breed or different breed to restore fertility and yield.

Q. 6. Explain the importance of "selection" during inbreeding in cattle. ***[CBSE Delhi 2017]***

Ans. Selection during inbreeding helps in accumulation of superior genes and elimination of less desirable genes. It increases homozygosity, pure lines, true breeding and helps to restore fertility. It also helps to increase yield or productivity. The cattle produces more milk per lactation, produces superior progeny and produces disease resistant breeds.

Q. 7. Expand MOET. Explain the procedure of this technology in cattle improvement.

Ans. MOET stands for Multiple Ovulation Embryo Transfer Technology.

Procedure: Refer to Basic Concepts Point 10.

Q. 8. (*a*) What is the programme called that is involved in improving success rate of production of desired hybrid and herd size of cattle?

(*b*) Explain the method used for carrying this programme for cows. ***[CBSE (AI) 2012]***

Ans. (*a*) Multiple ovulation embryo transfer method/MOET.

(*b*) Refer to Basic Concepts Point 10 (Procedure).

Q. 9. (*a*) Name the Indian scientist whose efforts brought 'green revolution' in India.

(*b*) Mention the steps that are essentially carried out in developing a new genetic variety of crop under plant breeding programme. ***[CBSE (F) 2012]***

Ans. (*a*) M.S. Swaminathan brought green revolution in India.

(*b*) The steps are:

(*i*) Collection of variability.

(*ii*) Evaluation and selection of parents.

(*iii*) Cross hybridisation among the selected parents.

(*iv*) Selection and testing of superior recombinants.

(*v*) Testing, release and commercialisation of new cultivars.

Q. 10. Name the technique and the property of plant cells that can help to grow somaclones of certain desired variety of apple. Explain how somaclones of apple can be obtained in the lab so as to get the desired variety on a large scale. ***[CBSE 2019 (57/4/1)]***

Ans. Tissue Culture or micropropagation can help grow somaclones because of the property of totipotency in plant cells.

Explants of apple plant (any small part) is taken and grown in a test tube under sterile conditions in (special) nutrient media. The nutrient media contains sucrose, inorganic salts, amino acids and vitamins, with growth regulators.

Q. 11. (*a*) What is micropropagation? Why are the plants produced by micropropagation called somaclones?

(*b*) Name the technique by which healthy plants can be recovered from the diseased plants.

Ans. (*a*) Micropropagation is the method of growing a number of plants through tissue culture. Since tissue culture involves only mitotic divisions, the plantlets formed are genetically identical and hence are called somaclones.

(*b*) Meristem culture.

Q. 12. Explain the process of artificial hybridisation to get improved crop variety in (*i*) plants bearing bisexual flowers (*ii*) female parent producing unisexual flowers. ***[CBSE (AI) 2010]***

Ans. (*i*) In plants bearing bisexual flowers, the anthers are removed from the flower before they dehisce. This is called emasculation. The emasculated flowers are covered with a bag of butter paper to prevent contamination of stigma with unwanted pollen. This process is called bagging. When this stigma attains receptivity, mature pollen grains are dusted on the stigma and the flowers are rebagged to allow the fruits to develop.

(*ii*) If the female parent produces unisexual flowers, there is no need of emasculation. The flower buds are bagged before the flowers open. When the stigma becomes receptive, pollen is dusted on stigma and the flower is rebagged.

Q. 13. IARI has released several varieties of crop plants that are biofortified. Give three examples of such crops and their biofortifications. ***[CBSE (F) 2011]***

Ans. (*i*) Bittergourd enriched with vitamin C.

(*ii*) Carrots enriched with vitamin A.

(*iii*) Spinach enriched with iron and calcium.

Q. 14. (*a*) Write the desirable characters a farmer looks for in his sugarcane crop.

(*b*) How did plant breeding techniques help north Indian farmers to develop cane with desired characters? ***[CBSE (AI) 2017]***

Ans. (*a*) The desirable characters for a sugarcane crop are high yield, thick stem, high sugar content and ability to grow in their areas.

(*b*) *Saccharum barberi* had poor sugar content and yield but *Saccharum officinarum* had thicker stems and higher sugar content but it could not be grown in northern India. By crossing *Saccharum officinarum,* the south Indian variety with *Saccharum barberi,* the north Indian low yield variety, the farmers developed cane having desired characteristics.

Q. 15. Differentiate between somaclones and somatic hybrids. Give one example of each.
[*CBSE Delhi 2016*]

Ans.

Table 9.7: Differences between somaclones and somatic hybrids

S. No.	Somaclones	Somatic hybrids
(*i*)	These are genetically identical to the original plant from which they are grown.	These are formed by fusion of somatic protoplasts obtained from different varieties or species of plant.
(*ii*)	These are produced by tissue culture or micropropagation.	These are produced by somatic hybridisation.
(*iii*)	**Example:** Tomato, banana, etc.	**Example:** Pomato formed by fusion of tomato and potato.

Q. 16. Differentiate between inbreeding and outbreeeding in cattle. State one advantage and one disadvantage for each one of them. **[*CBSE Delhi 2013, 2019 (57/2/1)*]**

Ans.

Table 9.8: Differences between inbreeding and outbreeding

S. No.	Inbreeding	Outbreeding
(*i*)	It is breeding between animals belonging to same breeds.	It is breeding between different breeds of animals.
(*ii*)	**Advantage:** Helps in accumulation of superior genes.	**Advantage:** Helps overcoming inbreeding depression.
(*iii*)	**Disadvantage:** Reduces fertility/productivity.	**Disadvantage:** There is a possibility of introduction of undesirable characters.

Q. 17. Why is it necessary to emasculate a bisexual flower in a plant breeding programme? Mention the condition under which emasculation is not necessary. **[*CBSE (F) 2013*]**

Ans. Emasculation is necessary to ensure that only the desired pollen grains are used for pollination and the stigma is protected from contamination, from unwanted self pollen. The anthers are removed followed by bagging so the plant now behaves as a female plant. The pollen grains from the anthers of the desired male plant can be dusted on the stigma of flower of the female plant to obtain desired results.

Emasculation is not required if the plant produces unisexual flowers.

Q. 18. (*a*) Write the two limitations of traditional breeding technique that led to promotion of micro-propagation.
(*b*) Mention two advantages of micropropagation.
(*c*) Give two examples where it is commercially adopted. **[*CBSE (AI) 2016*]**

Ans. (*a*) (*i*) Failed to keep pace with demand.
(*ii*) Failed to provide fast and efficient system of crop improvement.
(*b*) (*i*) Large number of plants can be developed in a short duration.
(*ii*) Production of genetically identical plants or somaclones.
(*iii*) Healthy plants can be recovered from diseased plants. (*Any two*)
(*c*) Tomato, banana, apple. (*Any two*)

Q. 19. Mention the property of plant cells that has helped them to grow into a new plant in *in vitro* conditions. Explain the advantages of micropropagation. **[*CBSE Delhi 2011*]**

Ans. The property of plant cells that helped them to grow into a new plant is totipotency.

The advantages of micropropagation are:

(*i*) It is possible to achieve propagation of a large number of plants in very short durations. Plants like tomato, banana, apple, etc., have been produced on commercial scale.

(*ii*) Healthy plants can be recovered from diseased plants by micropropagation. This is done by removing the meristem, which is disease-free and growing it *in vitro*. This has been done in banana, sugar cane, potato, etc.

Q. 20. How can crop varieties be made disease-resistant to overcome food crisis in India? Explain. Name one disease-resistant variety in India of:

(*a*) Wheat to leaf and stripe rust.

(*b*) *Brassica* to white rust. **[*CBSE Delhi 2011*] [*HOTS*]**

Ans. Crop varieties can be made disease-resistant by conventional breeding methods or by mutation breeding. The germplasm is screened for resistance sources or mutations are introduced, followed by hybridisation of selected parents. The resulting hybrids are evaluated and tested. Finally, disease-resistant varieties are released.

Disease-resistant variety of:

(*a*) Wheat to leaf and stripe rust—*Himgiri*.

(*b*) *Brassica* to white rust—*Pusa swarnim*.

Q. 21. (*a*) "Fortification of crops is the need of the hour." Give two reasons.

(*b*) Select one fresh water and one marine fish from the following:

Prawn; Catla; Mackerel; Lobster **[*CBSE (F) 2016*] [*HOTS*]**

Ans. Fortification of crops is needed for following reasons:

(*a*) (*i*) To improve the nutritional quality,

(*ii*) to improve public health,

(*iii*) to prevent malnutrition, (*Any two*)

(*b*) Fresh water : Catla

Marine fish : Mackerel.

Q. 22. According to Global Hunger Index, 2014, two billion people suffer from hidden hunger. Apply your knowledge of plant breeding techniques to suggest a programme to improve public health. Specify four objectives of the programme. Also, mention one example of such a produce. **[*CBSE Sample Paper 2016*] [*HOTS*]**

Ans. Biofortification can improve public health. It involves breeding crops with higher levels of vitamins and minerals, or higher protein and healthier fats.

Breeding for improved nutritional quality is improving:

(*i*) Protein content and quality;

(*ii*) Oil content and quality;

(*iii*) Vitamin content; and

(*iv*) Micronutrient and mineral content.

In the year 2000, maize hybrids that had twice the amount of the amino acids, lysine and tryptophan, compared to existing maize hybrids were developed. Another example is the wheat variety, Atlas 66, having a high protein content which has been used as a donor for improving cultivated wheat.

Long Answer Questions–II [5 marks]

Q. 1. (*a*) State the objective of animal breeding.

(*b*) List the importance and limitations of inbreeding. How can the limitations be overcome?

(*c*) Give an example of a new breed each of cattle and poultry. **[*CBSE (AI) 2014*]**

Ans. (*a*) Objective of animal breeding is to increase the yield of animal and improve the desirable qualities of the produce.

(*b*) **Importance:**

(*i*) Increases homozygosity

(*ii*) Evolves pure line

(*iii*) Expose harmful recessive genes

(*iv*) Help in accumulation of superior genes

(*v*) Eliminate less desirable genes.

Limitations:

Inbreeding reduces fertility and productivity (inbreeding depression).

The limitations can be overcome by outbreeding or out-crossing or interspecific hybridisation. Selected animals may be bred with unrelated superior animals of the same breed.

(*c*) *Hisardale* is a new breed developed by crossing Bikaneri ewes and Mirano rams (sheep) and Leghorn is the new breed of chicken and Jersey is improved breed of cattle..

Q. 2. (*i*) Name the tropical sugarcane variety grown in South India. How has it helped in improving the sugar cane quality grown in North India?

(*ii*) Identify '*a*', '*b*' and '*c*' in the following table:

No.	Crop	Variety	Insect Pests
1.	*Brassica*	***Pusa Gaurav***	(*a*)
2.	Flat Bean	***Pusa Sem 2***	(*b*)
		Pusa Sem 3	
3.	(*c*)	***Pusa Sawani***	Shoot and Fruit borer
		Pusa A-4	

[*CBSE Delhi 2014*]

Ans. (*i*) *Saccharum officinarum* is grown in South India. It was crossed with North Indian variety (*Saccharum barberi*) to combine the desirable qualities of high **yield**, thick stems high sugar and ability to grow in North India.

(*ii*) (*a*) Aphids

(*b*) Jassids/aphids/fruit borer

(*c*) Okra (*Bhindi*).

Q. 3. (*a*) Name the technology that has helped the scientists to propagate on large scale the desired crops in short duration. List the steps carried out to propagate the crops by the said technique.

(*b*) How are somatic hybrids obtained? **[*CBSE Delhi 2014*]**

Ans. (*a*) The technology that has helped the scientists to propagate on large scale the desired crops is tissue culture or micropropagation.

The steps to propagate crops are:

(*i*) Obtaining an explant from a plant.

(*ii*) Growing the explant in a test tube under sterile conditions.

(*iii*) A special nutrient or culture medium is provided for growth.

(*b*) Isolated single cells are isolated from plants. Their cell walls are digested to obtain protoplasts. Isolated protoplasts from two different plant varieties are fused to get hybrid protoplasts.

Q. 4. With advancements in genetics, molecular biology and tissue culture, new traits have been incorporated into crop plants.

Explain the main steps in breeding a new genetic variety of a crop. **[*CBSE (AI) 2014*]**

Ans. (*i*) Collection of variability on germplasm collection. All different wild varieties, species and relatives of cultivated species are collected and preserved.

(*ii*) Evaluation and selection of parents to identify plant with desirable combination of character. Pure lines are created.

(*iii*) Cross hybridisation among selected parents to produce hybrids.

(*iv*) Selection and testing of superior recombinants. Selection among the progeny of the hybrids that have desired character combinations, superior to both the parents are self pollinated for several generations.

(*v*) Testing, release and commercialisation of new cultivars. Newly selected lines are evaluated for yield and other agronomic traits of quality or disease resistance in research fields followed by testing the material in farmers fields for three seasons in different agroclimatic zones.

Q. 5. Differentiate between an inbred line and a hybrid variety of crop. Explain the steps involved in the production of the hybrid variety.

Ans. **Table 9.9: Differences between inbred line and hybrid variety**

Inbred line	Hybrid variety
The continuous inbreeding in a cross-pollinated crop develops a homozygous line called inbred line.	A hybrid variety is produced by crossing two different species where progeny obtained is used for raising the next seasonal crop.

Steps involved in hybrid variety production:

Refer to Basic Concepts Point 12.

Self-Assessment Test

Time allowed: 1 Hour **Max. marks: 30**

1. Choose and write the correct option in the following questions. **(3×1 = 3)**

(i) When cross is made between two species of the same genus, then the cross is known as

(a) Intraspecific hybridisation (b) Interspecific hybridisation

(c) Inbreeding (d) Outcrossing

(ii) Out breeding means

(a) Breeding in non-breeding season

(b) Breeding in laboratory conditions and not in natural environments

(c) Breeding between two different species

(d) None of these

(iii) Which of the following can be used as single cell protein ?

(a) *Amoeba* (b) *Streptococus*

(c) *Spirulina* (d) None of these

2. In the following questions a statement of assertion followed by a statement of reason is given. Choose the correct answer out of the following choices. **(3×1 = 3)**

(a) Assertion and reason both are correct statements and reason is correct explanation for assertion.

(b) Assertion and reason both are correct statements but reason is not correct explanation for assertion.

(c) Assertion is correct statement but reason is wrong statement.

(d) Assertion is wrong statement but reason is correct statement.

(i) Assertion : In interbreeding the individual having common ancestors are mated.

Reason : Breeding increases the yield and qualities of individuals.

(ii) Assertion : Mutation causes change in the base sequences of genes.

Reason : Mutation can be induced artificially for breeding.

(iii) Assertion : SCP helps to reduce environmental pollution.

Reason : SCP uses common pollutants as its substrate.

3. Define inbreeding depression. **(1)**

4. What is an explant? **(1)**

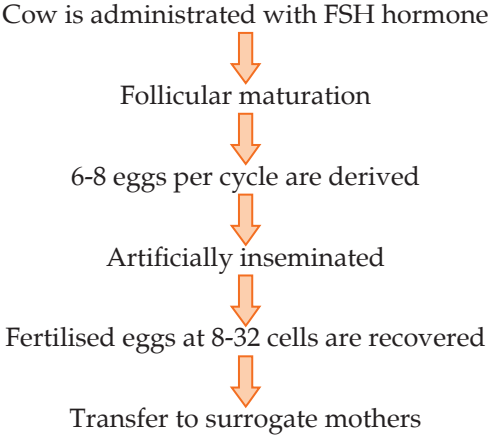
5. Suggest two features of plants that will prevent insect and pest infestation. **(2)**

6. Enumerate in sequential order, the four steps that a plant breeder should follow to obtain a disease-resistant crop. **(2)**

7. Why are beehives kept in crop field during flowering period? Name any two crop fields where this is practiced. **(2)**

8. What is meant by germplasm collection? What are its benefits? **(2)**

9. Multiple Ovulation Embryo Transfer (MOET) technology is used for herd improvement in cattles. **(3×1 = 3)**



(i) Mention the role of 'genetic mother' in MOET.

(ii) Suggest the breeding method most suitable for animals that are below average in milk productivity.

(iii) In animal husbandry, if two closely related animals are mated for a few generations, it results in loss of fertility and vigour. Why is this so?

10. Name the prominent South Indian and North Indian species of sugarcane used for cross breeding. List the desired qualities of the hybrid cane obtained from this cross. **(3)**

11. A potato plant is infected with a virus. Name and explain a method to obtain virus-free potato plants from it. **(3)**

12. (i) What is plant breeding? List the two steps the classical plant breeding involves.

(ii) How has the mutation breeding helped in improving crop varieties? Give one example where this technique has helped.

(iii) How has the breeding programme helped in improving the public nutritional health? State two examples in support of your answer. **(5)**

Answers

1. (*i*)—(*b*), (*ii*)—(*c*), (*iii*)—(*c*) **2.** (*i*)—(*d*), (*ii*)—(*b*), (*iii*)—(*a*)

Chapter–10

Microbes in Human Welfare

basic concepts

1. Microorganisms or Microbes

- Microbes are organisms which cannot be seen by naked eyes.
- **Occurrence:** These can be found everywhere, *i.e.*, in soil, water, air and inside the bodies of living organisms. They can be found in thermal vents, deep in soil, under snow as well as in acidic environment.
- **Diversity:** Microbes are of various varieties—protozoa, bacteria, fungi, plant viruses, viroids and prions.

2. Microbes in Household Products

(i) Curd

- Curd is formed by adding a small amount of curd to milk, which acts as a starter or **inoculum**.
- *Lactobacillus*/lactic acid bacteria (LAB) present in starter, multiply at suitable temperature and convert milk into curd.
- Acids released by LAB during the growth, coagulates and partially digest milk protein, casein.
- **Benefits of LAB:**
  (*a*) Increases vitamin B_{12} amount thus increasing nutrient quality of milk.
  (*b*) Checks disease-causing microbes in stomach.

(ii) Dough

- Dough is formed by fermentation by bacteria.
- Bread is made by fermentation by *Saccharomyces cerevisiae* or commonly called baker's yeast.
- CO_2 released during the process of fermentation gives the puffy appearance to dough.
- It is used to make foods like *idli*, *dosa*, bread, etc.

(iii) Toddy

- It is a traditional drink of Southern India.
- It is made by fermentation of sap from palm trees by bacteria.

(iv) Cheese

- Cheese is formed by partial degradation of milk by different microorganisms.
- Swiss cheese is formed by the bacterium *Propionibacterium sharmanii*. Its characteristic feature is formation of large holes due to production of large amount of CO_2.
- Roquefort cheese is formed by ripening with the fungi *Penicillium roqueforti* for a particular flavour.

3. Microbes in Industrial Products

- Large-scale production of various compounds in industries is done in very large vessels called **fermentors**.

(i) Fermented beverages

- Beverages are formed by fermenting malted cereals and fruit juices with *Saccharomyces cerevisiae* or brewer's yeast to produce ethanol.
- Formation of different types of alcoholic drinks depends on raw material and type of processing.
- Wine and beer are produced without distillation.
- Whisky, brandy and rum are formed by distillation.

(ii) Antibiotics

- Antibiotics are chemical substances produced by some microorganisms which can kill or retard the growth of other disease-causing microorganisms.
- **Penicillin**, discovered by **Alexander Fleming**, was the first antibiotic to be discovered.
- **Discovery of penicillin:** While working on *Staphylococcus* bacteria, Fleming observed the growth of mould around which the bacteria did not grow. It was found to be a chemical, penicillin, produced by *Penicillium notatum*.
- The function of penicillin as an antibiotic was established by **Ernest Chain** and **Howard Florey**.It was used to treat American soldiers wounded in World War II. Fleming, Chain and Florey were awarded Nobel prize in 1945 for their discovery.
- Diseases cured by antibiotics include plague, whooping cough (*kali khansi*), diphtheria (*gal ghotu*) and leprosy (*kusht rog*).

Table 10.1: Organic acids and alcohol produced by microbial metabolic actions

S. No.	Organic acid	Microbe	Type of microbe
(*i*)	Citric acid	*Aspergillus niger*	Fungi
(*ii*)	Acetic acid (Vinegar)	*Acetobacter aceti*	Bacteria
(*iii*)	Butyric acid	*Clostridium butylicum*	Bacteria
(*iv*)	Lactic acid	*Lactobacillus* sps.	Bacteria
(*v*)	Ethanol	*Saccharomyces cerevisiae*	Yeast (fungi)

Table 10.2: Some important enzymes commercially produced

S. No.	Enzyme	Uses
(*i*)	Lipase	(*a*) Used in detergent formulations. (*b*) Helps in removing oily stains from laundry.
(*ii*)	Pectinase and protease	Used for clarifying bottled juices.
(*iii*)	Streptokinase (produced by *Streptococcus* and modified by genetic engineering)	Used as 'clot-buster' for removing clots from blood vessels of patients who have undergone myocardial infarction.
(*iv*)	Invertase produced by yeast	To invert sugar for ice creams and confectioneries.

Table 10.3: Some important bioactive molecules

S. No.	Molecule	Source organism	Use
(*i*)	Cyclosporin A	*Trichoderma polysporum* (fungus)	Used as immunosuppressive agent in organ transplant patients.
(*ii*)	Statin	*Monascus purpureus* (fungus)	Used as blood-cholesterol lowering agent. It competitively inhibits enzymes for cholesterol synthesis.

4. Microbes in Sewage Treatment

- **Sewage** is the municipal waste water, containing large quantities of human excreta.
- **Need for sewage treatment:** Sewage contains large amounts of organic matter and pathogenic microbes. Before discharging into natural bodies, sewage is made less polluting.
- Sewage is treated in sewage treatment plants (STPs).
- **Ganga Action Plan** and **Yamuna Action Plan** have been initiated by Ministry of Environment and Forests, under which large number of STPs will be build to treat sewage before their discharge in rivers to reduce their pollution.
- Sewage treatment is carried out in two stages:

(i) Primary treatment or physical treatment

- It is the physical removal of large and small particles from sewage.
- First, the floating debris is removed by sequential filtration by passing through wire mesh screens.
- Then, the grit (soil and small pebbles) are removed by sedimentation in settling tanks. The sediment is called **primary sludge** and the supernatant is the **effluent**.
- The effluent is taken for secondary treatment.

(ii) Secondary treatment or biological treatment

- Primary effluent is passed into large **aeration tanks** with constant mechanical agitation and air supply.
- Useful aerobic microbes grow rapidly and form **flocs**.
- **Flocs** are masses of bacteria associated with fungal filaments to form mesh-like structures.
- The growing microbes consume organic matter and thus reduce the **biochemical oxygen demand (BOD).**
- When BOD of sewage has reduced, the effluent is passed into **settling tank**.
- Here, the bacterial flocs settle and the sediment is called **activated sludge**.
- A small part of the sludge is used as an **inoculum** in the aeration tank and the remaining part is passed into large tanks called **anaerobic sludge digesters**.
- In the digesters, **heterotrophic microbes** anaerobically digest bacteria and fungi in sludge producing mixture of gases such as methane, hydrogen sulphide (H_2S) and CO_2, which form the biogas.
- Effluent is now released into rivers and streams.

Biological Oxygen Demand (BOD)

- BOD refers to the amount of oxygen consumed if all the organic matter in one litre of water is oxidised by bacteria.
- BOD measures the amount of organic matter in water by measuring the rate of oxygen uptake by microbes, thus it is measure of organic matter present in water.
- Higher BOD indicates higher polluting potential.

5. Microbes in Production of Biogas

- **Biogas** is a mixture of inflammable gases (methane, CO_2, etc) produced by microbial activity that can be used as fuel (mainly methane, CH_4)
- **Methanogens,** particularly ***Methanobacterium***, anaerobically breaks down cellulosic material to produce CO_2 and H_2 in
  - (*i*) Anaerobic sludge in sewage treatment plants.
  - (*ii*) Rumen (a part of stomach) of cattle, thus providing nutrition to cattle.
- Indian Agricultural Research Institute (IARI) and Khadi and Village Industries Commission (KVIC) developed the technology of biogas in India.

Mechanism of Biogas or Gobar Gas Production

- The raw material for biogas production is excreta (dung) of cattle called ***Gobar*** which is rich in these bacteria.
- The biogas plant has a concrete tank (10–15 feet deep) in which bio-wastes and slurry of dung is collected.

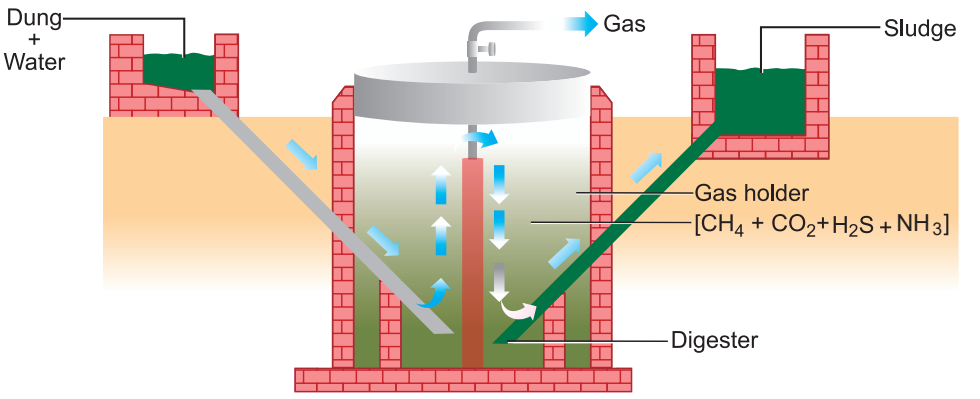


Fig. 10.1. A typical biogas plant

- The tank has a floating cover which rises on production of gas in the tank.
- *Methanobacterium* in the dung act on the bio-wastes to produce biogas.
- The gas produced is supplied to nearby houses by an outlet.
- Through another outlet, the spent slurry is removed to be used as fertiliser.
- Biogas is used as fuel for cooking and lighting.

6. Microbes as Biocontrol Agents

- **Biocontrol** is defined as controlling plant diseases and pests using biological methods.
- Earlier, chemicals like insecticides and pesticides were used for biocontrol.
- Disadvantages of chemical agents:
  - (*i*) Chemicals are toxic and harmful to human beings and animals.
  - (*ii*) Chemicals pollute the environment and plants.
  - (*iii*) Weedicides used to remove weeds also pollute the soil.
- **Organic farmers** use a holistic approach for following reasons:
  - (*i*) Keeping pests at manageable levels by a complex system of checks and balances, within the ecosystem, instead of their complete eradication.
  - (*ii*) Complete eradication of pests is undesirable, as without them the beneficial predatory and parasitic insects which depend on them as food or act as host will not be survive. This will disturb the balance of the ecosystem.

(*iii*) Biocontrol agents reduce dependency on toxic chemicals and fertilizers.

- Following are some of the approaches for biological farming:
  (*i*) Familiarity with various life-forms inhabiting the field.
  (*ii*) Gain knowledge about the life cycles, patterns of feeding and habitat of predators and pests.

Some Examples of Biocontrol

(*a*) Ladybirds and Dragonflies are used to get rid of aphids and mosquitoes respectively.

(*b*) The bacteria *Bacillus thuringiensis* (Bt) are used to control butterfly caterpillars.
- Dried spores of Bt are mixed with water and sprayed on plants such as brassicas and fruit trees.
- Insect larvae, after eating these are killed by the toxin released in their gut.
- *B. thuringiensis* toxin genes have been introduced into plants to provide resistance to pests. For example, **Bt cotton**.

(*c*) *Trichoderma* sps., free-living fungi, are present in root ecosystems where they act against several plant pathogens.

(*d*) **Baculoviruses** are pathogens that attack insects and other arthropods.
- Most of these biocontrol agents belong to the genus *Nucleopolyhedrovirus*. These are species-specific, narrow spectrum insecticides.
- They do not harm plants, mammals, birds, fish and other non-target insects.
- Baculoviruses are helpful in **integrated pest management** (IPM) programme, in which beneficial insects are conserved and there is no negative impact on plant mammals, birds, fish or nontarget insects.

7. Microbes as Biofertilisers

- Biofertilisers are the microorganisms which enrich the nutrient (nitrogen, phosphorus, etc.) quality of the soil.
- Bacteria, fungi and cyanobacteria are the three main sources of biofertilisers.

(i) Bacteria as biofertilisers

- ***Rhizobium*** is a symbiotic bacterium that lives in the root nodules of legumes and fixes atmospheric nitrogen into organic compounds.
- ***Azospirillum*** and ***Azotobacter*** are free-living bacteria which absorb free nitrogen from soil, air and convert it into salts of nitrogen and enrich soil nutrients.

(ii) Fungi as biofertilisers

- Fungi form symbiotic association with the roots of higher plants called **mycorrhiza**, *e.g.*, *Glomus*.
- The fungal hyphae absorb phosphorus from soil and passes it to the plant.
- Mycorrhiza shows the following benefits to plant:
  (*a*) resistance to root-borne pathogens.
  (*b*) tolerance to salinity and drought.
  (*c*) overall increase in plant growth and development.

(iii) Cyanobacteria as biofertilisers

- They fix atmospheric nitrogen and increase the organic matter of the soil through their photosynthetic activity, *e.g.*, *Nostoc, Anabaena, Oscillatoria*, etc.
- Blue-green algae increase the soil fertility by adding organic matter to the soil.
- Cyanobacteria are important biofertilisers in paddy fields.

Advantages of biofertilisers

(*a*) Increase fertility of soil.

(*b*) Reduce dependency on chemical fertilizers.

NCERT Textbook Questions

Q. 1. Bacteria cannot be seen with the naked eyes, but these can be seen with the help of a microscope. If you have to carry a sample from your home to your biology laboratory to demonstrate the presence of microbes under a microscope, which sample would you carry and why? [*HOTS*]

Ans. The most common household product that we would like to carry is curd which contains lactic acid bacteria (*Lactobacillus* sps.).

Q. 2. Give examples to prove that microbes release gases during metabolism.

Ans. Puffed-up appearance of dough which is used for making '*dosa*', '*idli*' and bread is due to gas production. Methanogens (bacteria) in the biogas plant produce methane and carbon dioxide. Also large holes in the 'Swiss cheese' are due to production of a large amount of CO_2 during its production.

Q. 3. In which food would you find lactic acid bacteria? Mention some of their useful applications.

Ans. The lactic acid bacteria (LAB) are found in curd. LAB convert the lactose sugar of milk into lactic acid. Lactic acid coagulates the milk protein called casein. It also increases the nutritional quality of curd as the curd contains vitamin B_{12} along with other vitamins. They also check the growth of other harmful microbes.

Q. 4. Name some traditional Indian foods made of wheat, rice and Bengal gram (or their products) which involve use of microbes.

Ans. '*Dosa*' and '*idli*' (from rice), bread (from wheat) and '*dhokla*' (from Bengal gram) are the traditional Indian foods which involve use of microbes.

Q. 5. In which way have microbes played a major role in controlling diseases caused by harmful bacteria?

Ans. The major role of microbes in controlling the diseases is the 'antibiotic production'. Antibiotics have been used against pathogenic bacteria, *e.g.*, penicillin from *Penicillium notatum*, streptomycin from *Streptomyces griseus*, etc.

Q. 6. Name any two species of fungus, which are used in the production of the antibiotics.

Ans. Two species of fungus, used in the production of the antibiotics:

(*i*) *Penicillium notatum* (for penicillin production).

(*ii*) *Aspergillus fumigatus* (for fumagillin production).

Q. 7. What is sewage? In which way can sewage be harmful to us?

Ans. Sewage is the municipal waste water containing large quantities of human excreta and other organic wastes. Sewage could be harmful to us as it contains many pathogenic microbes and produces foul smell. It is the cause of many water-borne diseases. It is also the cause of eutrophication of water bodies thereby killing many aquatic organisms.

Q. 8. What is the key difference between primary and secondary sewage treatment?

Ans. The key difference between primary and secondary treatment of sewage is that primary treatment is the physical process of removing grit and floating debris while secondary treatment is a biological process that involves digestion of organic matter by microbes.

Q. 9. Do you think microbes can also be used as source of energy? If yes, how? [*HOTS*]

Ans. Yes, microbes can be used to produce energy indirectly. Methanogens (bacteria) like *Methanobacterium* are involved in the production of biogas which is used as source of energy.

Q. 10. Microbes can be used to decrease the use of chemical fertilisers and pesticides. Explain how this can be accomplished.

Ans. Microbes can be used both as fertilisers and pesticides called biofertilisers and biopesticides, respectively. Microbes are used as biofertilisers to enrich the soil nutrients, *e.g., Rhizobium, Azotobacter, Azospirillum*, etc., which can fix atmospheric nitrogen in the soil. *Bacillus thuringiensis* bacteria act as biopesticide to control the growth of insect pests. *Trichoderma*, fungal species, is an effective bicontrol agent of several plant pathogens. Baculoviruses used as biological

control agents in genus *Nucleopolyhedrovirus* are excellent for species-specific, narrow spectrum insecticidal applications.

Q. 11. Three water samples namely river water, untreated sewage water and secondary effluent discharged from a sewage treatment plant were subjected to BOD test. The samples were labelled A, B and C; but the laboratory attendant did not note which was which. The BOD values of the three samples A, B and C were recorded as 20 mg/L, 8 mg/L and 400 mg/L, respectively. Which sample of the water is most polluted? Can you assign the correct label to each assuming the river water is relatively clean? [*HOTS*]

Ans. Sample C is most polluted (Highest BOD).

Sample A — River water

Sample B — Secondary effluent (Least BOD)

Sample C — Untreated sewage (Highest BOD)

Q. 12. Find out the name of the microbes from which cyclosporin A (an immuno-suppressive drug) and statins (blood cholesterol lowering agents) are obtained.

Ans. (*a*) Cyclosporin A is obtained from *Trichoderma polysporum*.

(*b*) Statins are obtained from the yeast *Monascus purpureus*.

Q. 13. Find out the role of microbes in the following and discuss it with your teacher.

(*a*) Single cell protein (SCP)

(*b*) Soil

Ans. **(*a*) Single cell protein (SCP):** It is a protein-rich microbial biomass which can be used as food. SCP contains essential amino acids and low fat. Bacteria, filamentous fungi, algae, yeast, etc., are used as "single cell proteins" (SCPs). *Spirulina* is taken as a tablet having 60 per cent proteins, all minerals, vitamins, etc.

(*b*) Soil: Soil is the habitat of numerous microbes. Microbes in the soil increase the fertility of soil by decomposing organic matter. Some microbes convert nitrates into free nitrogen that escapes into atmosphere for replenishment.

Q. 14. Arrange the following in the decreasing order (most important first) of their importance, for the welfare of human society. Give reasons for your answer. [*HOTS*]

Biogas, Citric acid, Penicillin and Curd.

Ans. **(*i*) Penicillin:** It is an antibiotic used in curing numerous bacterial diseases.

(*ii*) Biogas: It is a source of energy in rural areas, produced by anaerobic degradation of organic matter.

(*iii*) Curd: It is vitamin-rich milk preparation which is easily digested.

(*iv*) Citric acid: It is an organic acid used as preservative in juices, jams and jellies, etc.

Q. 15. How do biofertilisers enrich the fertility of the soil?

Ans. Biofertilisers are microorganisms which bring about nutrient enrichment of soil by enhancing the availability of nutrients to crops. They are of following types:

(*i*) Nitrogen fixing bacteria and cyanobacteria: They form symbiotic association with plants. They get food and shelter from plants and on the other hand, plants get nitrogen fixed by these bacteria. For example, *Rhizobium*.

(*ii*) Mycorrhiza: It is an association between a fungus and roots of higher plants. It takes part in the solubilisation and absorption of nutrients from organic matter. Many members of the genus *Glomus* form mycorrhiza.

(*iii*) Manures: They are semi-decayed organic remains of various types—manure, green manure, compost and vermicompost.

Multiple Choice Questions [1mark]

Choose and write the correct option in the following questions.

1. Select the correct statement from the following

(*a*) Biogas is produced by the activity of aerobic bacteria on animal waste

(*b*) *Methanobacterium* is an aerobic bacterium found in rumen of cattle

(*c*) Biogas, commonly called gobar gas, is pure methane

(*d*) Activated sludge-sediment in settlement tanks of sewage treatment plant is a rich source of aerobic bacteria.

2. A common biocontrol agent for the control of plant diseases is

(*a*) baculovirus (*b*) *Bacillus thuringiensis*

(*c*) *Glomus* (*d*) *Trichoderma*

3. Secondary sewage treatment is mainly a

(*a*) physical process (*b*) mechanical process

(*c*) chemical process (*d*) biological process

4. An organism used as a biofertilizer for raising soyabean crop is

(*a*) *Azotobacter* (*b*) *Azospirillum*

(*c*) *Rhizobium* (*d*) *Nostoc*

5. *Monascus purpureus* is a yeast used commercially in the production of

(*a*) ethanol

(*b*) streptokinase for removing clots from the blood vessels

(*c*) citric acid

(*d*) blood cholesterol lowering statins.

6. A good producer of citric acid is

(*a*) *Clostridium* (*b*) *Sacchaaromyces*

(*c*) *Aspergillus* (*d*) *Pseudomonas.*

7. The vitamin whose content increases following the conversion of milk into curd by lactic acid bacteria is [*NCERT Exemplar*]

(*a*) vitamin C (*b*) vitamin D

(*c*) vitamin B12 (*d*) vitamin E.

8. Wastewater treatment generates a large quantity of sludge, which can be treated by [*NCERT Exemplar*]

(*a*) anaerobic digesters (*b*) floc

(*c*) chemicals (*d*) oxidation pond

9. Methanogenic bacteria are not found in [*NCERT Exemplar*]

(*a*) rumen of cattle (*b*) gobar gas plant

(*c*) bottom of water-logged paddy fields (*d*) activated sludge.

10. Match the following list of bacteria and their commercially important products [*NCERT Exemplar*]

Bacterium	Product
A. *Aspergillus niger*	(*i*) Lactic acid
B. *Acetobacter aceti*	(*ii*) Butyric acid
C. *Clostridium butylicum*	(*iii*) Acetic acid
D. *Lactobacillus*	(*iv*) Citric acid

Choose the correct match.

(*a*) A-(*ii*), B-(*iii*), C-(*iv*), D-(*i*) (*b*) A-(*ii*), B-(*iv*), C-(*iii*), D-(*i*)

(*c*) A-(*iv*), B-(*iii*), C-(*ii*), D-(*i*) (*d*) A-(*iv*), B-(*i*), C-(*iii*), D-(*ii*)

11. Bottled fruit juices from market are clearer than that at home because of

(*a*) antibiotics (*b*) hormones (*c*) enzymes (*d*) filtration

12. Match the following list of bioactive substances and their roles [*NCERT Exemplar*]

Bioactive	Substance Role
A. Statin	(*i*) Removal of oil stains]
B. Cyclosporin A	(*ii*) Removal of clots from blood vessels
C. Streptokinase	(*iii*) Lowering of blood cholesterol
D. Lipase	(*iv*) Immuno-suppressive agent

Choose the correct match.

(*a*) A-(*ii*), B-(*iii*), C-(*i*), D-(*iv*) (*b*) A-(*iv*), B-(*ii*), C-(*i*), D-(*iii*)

(*c*) A-(*iv*), B-(*i*), C-(*ii*), D-(*iii*) (*d*) A-(*iii*), B-(*iv*), C-(*ii*), D-(*i*)

13. The primary treatment of waste water involves the removal of [*NCERT Exemplar*]

(*a*) dissolved impurities (*b*) stable particles

(*c*) toxic substances (*d*) harmful bacteria.

14. BOD of waste water is estimated by measuring the amount of [*NCERT Exemplar*]

(*a*) total organic matter (*b*) biodegradable organic matter

(*c*) oxygen evolution (*d*) oxygen consumption

15. Which one of the following alcoholic drinks is produced without distillation? [*NCERT Exemplar*]

(*a*) Wine (*b*) Whisky

(*c*) Rum (*d*) Brandy

16. The technology of biogas production from cow dung was developed in India largely due to the efforts of [*NCERT Exemplar*]

(*a*) Gas Authority of India

(*b*) Oil and Natural Gas Commission

(*c*) Indian Agricultural Research Institute and Khadi & Village Industries Commission

(*d*) Indian Oil Corporation.

17. Which of these is/are symbiotic N_2 fixing organisms?

(*a*) *Rhizobium* (*b*) *Clostridium*

(*c*) *Azotobacter* (*d*) All of these

18. The free-living fungus *Trichoderma* can be used for [*NCERT Exemplar*]

(*a*) insects (*b*) biological control of plant diseases

(*c*) controlling butterfly caterpillars (*d*) producing antibiotics

19. What would happen if oxygen availability to activated sludge flocs is reduced? [*NCERT Exemplar*]

(*a*) It will slow down the rate of degradation of organic matter

(*b*) The center of flocs will become anoxic, which would cause death of bacteria and eventually breakage of flocs.

(*c*) Flocs would increase in size as anaerobic bacteria would grow around flocs.

(*d*) Protozoa would grow in large numbers.

20. Mycorrhiza does not help the host plant in [*NCERT Exemplar*]

(*a*) enhancing its phosphorus uptake capacity (*b*) increasing its tolerance to drought

(*c*) enhancing its resistance to root pathogens (*d*) increasing its resistance to insects.

21. Big holes in Swiss cheese are made by [*NCERT Exemplar*]

(*a*) a machine

(*b*) a bacterium that produces methane gas

(*c*) a bacterium producing a large amount of carbon dioxide

(*d*) a fungus that releases a lot of gases during its metabolic activities.

22. The residue left after methane production from cattle dung is [*NCERT Exemplar*]

(*a*) burnt (*b*) burried in land fills

(*c*) used as manure (*d*) used in civil construction.

23. Methanogens do not produce [*NCERT Exemplar*]

(*a*) oxygen (*b*) methane

(*c*) hydrogen sulfide (*d*) carbon dioxide.

24. Primary treatment of sewage waste involves which processes ?

(*a*) Filtration and incubation (*b*) Sedimentation and decantation

(*c*) Filtration and sedimentation (*d*) Sedimentation and microbial proliferation

25. Activated sludge should have the ability to settle quickly so that it can [*NCERT Exemplar*]

(*a*) be rapidly pumped back from sedimentation tank to aeration tank

(*b*) absorb pathogenic bacteria present in waste water while sinking to the bottom of the settling tank

(*c*) be discarded and anaerobically digested

(*d*) absorb colloidal organic matter.

26. Match the items in Column 'A' and Column 'B' and choose correct answer. [*NCERT Exemplar*]

Column I	Column II
A. Lady bird	(*i*) Methanobacterium
B. Mycorrhiza	(*ii*) Trichoderma
C. Biological control	(*iii*) Aphids
D. Biogas	(*iv*) Glomus

The correct answer is:

(*a*) A-(*ii*), B-(*iv*), C-(*iii*), D-(*i*) (*b*) A-(*iii*), B-(*iv*), C-(*ii*), D-(*i*)

(*c*) A-(*iv*), B-(*i*), C-(*ii*), D-(*iii*) (*d*) A-(*iii*), B-(*ii*), C-(*i*), D-(*iv*)

Answers

1. (*d*)	**2.** (*a*)	**3.** (*d*)	**4.** (*c*)	**5.** (*d*)	**6.** (*c*)	**7.** (*c*)	**8.** (*a*)	**9.** (*d*)	**10.** (*c*)
11. (*c*)	**12.** (*d*)	**13.** (*b*)	**14.** (*d*)	**15.** (*a*)	**16.** (*c*)	**17.** (*a*)	**18.** (*b*)	**19.** (*b*)	**20.** (*d*)
21. (*c*)	**22.** (*c*)	**23.** (*a*)	**24.** (*c*)	**25.** (*a*)	**26.** (*b*)				

Assertion-Reason Questions

In the following questions a statement of assertion followed by a statement of reason is given. Choose the correct answer out of the following choices.

(a) Assertion and reason both are correct statements and reason is correct explanation for assertion.

(b) Assertion and reason both are correct statements but reason is not correct explanation for assertion.

(c) Assertion is correct statement but reason is wrong statement.

(d) Assertion is wrong statement but reason is correct statement.

1. Assertion : Chemical fertilisers are more preferable than biofertilizers.
Reason : Chemical fertilisers are expensive and hazardous to the environment.

2. Assertion : A small part of activated sludge is pumped back into aeration tank.
Reason : It serves as inoculum.

3. Assertion : *Streptococcus thermophilus* increases nutritional value of milk.
Reason : Curd and yoghurt have higher vitamin content than milk.

4. Assertion : For organ transplantation Cyclosporin A needs to be injected to the patient.
Reason : Cyclosporin A inhibits activation of T-cells and interferons.

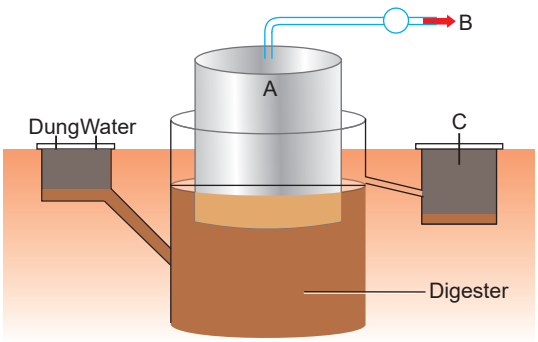
5. **Assertion :** Primary treatment of sewage is also called bilogical treatment.
   Reason : Primary sewage treatment depends only on density of materials in sewage.
6. **Assertion :** Acetic acid production involves both aerobic and anaerobic processes.
   Reason : First alcohol is produced from glucose by aerobic process which is followed by production of acetic by anaerobic process.
7. **Assertion :** Baculoviruses control growth of many insects and arthropods.
   Reason : Lady bird and *Trichoderma* are used as biocontrol agents.
8. **Assertion :** Integrated Pest Management (IPM) uses different pest control methods which are ecofriendly.
   Reason : *Bacillus thuringiensis* kill larvae of certain insects.
9. **Assertion :** Biogas is produced by anaerobic digestion of biomass by methanogenic bacteria.
   Reason : Biogas is made up of methane entirely and is the most ecofriendly fuel.
10. **Assertion :** In mycorrhiza the fungus symbiont absorbs phosphorus for the plant.
    Reason : Mycorrhiza is a symbiotic association of fungus with roots of higher plants.

Answers

1. (*d*) **2.** (*a*) **3.** (*a*) **4.** (*a*) **5.** (*d*) **6.** (*c*) **7.** (*b*) **8.** (*b*) **9.** (*c*) **10.** (*b*)

Case-based/Source-based Question

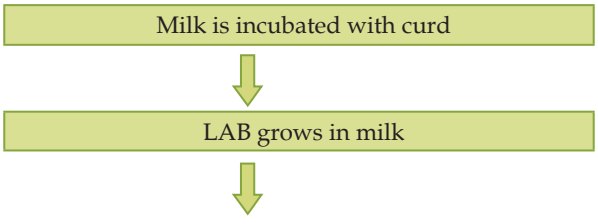
1. Given below is a figure of a biogas plant.

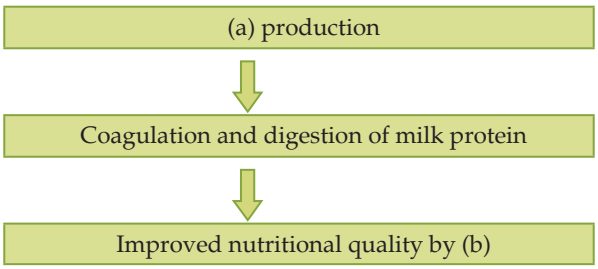


(*i*) Name the group of organisms and the substrate they act on to produce biogas.
(*ii*) Identify the products A and B and discuss their significance.
(*iii*) What are methanogens? How do they generate biogas?

Ans. (*i*) The organisms are methanogens which act on cellulosic materials like cow dung and agricultural waste.
(*ii*) A is the biogas which is a mixture of gases consisting of methane, hydrogen sulphide and carbon dioxide. It can be used as a source of energy to nearby houses as it is inflammable.
B is the spent slurry or sludge which is removed through another outlet and may be used as fertiliser.
(*iii*) Methanogens are anerobic methane producing bacteria which grow anaerobically on cellulosic material in cow dung to decompose it to produce large amount of methane, CO_2 and H_2. This mixture of gases is biogas.

2. Following is the process of curd formation from milk.





(*i*) What does (*a*) and (*b*) signify in the flow chart.

(*ii*) Expand the word LAB.

(*iii*) Milk starts to coagulate when LAB is added to warm milk as a starter. Mention any other two benefits that LAB provides.

Ans. (*i*) (*a*) Lactic acid;

(*b*) increased vitamin B_{12}

(*ii*) Lactic Acid Bacteria

(*iii*) (*a*) It increases nutritional quality of curd by increasing vitamin B_{12} content.

(*b*) It checks the growth of disease-causing organisms in the gut.

Very Short Answer Questions [1 mark]

Q. 1. Give an example of a rod-shaped virus. *[NCERT Exemplar]*

Ans. Tobacco mosaic virus.

Q. 2. What causes doughing of wheat flour? *[HOTS]*

Ans. Production of CO_2 gas during yeast fermentation of bacteria.

Q. 3. Write the scientific name of the microbe used for fermenting malted cereals and fruit juices. *[CBSE Delhi 2011]*

Ans. *Saccharomyces cerevisiae.*

Q. 4. Why is distillation required for producing certain alcoholic drinks? *[NCERT Exemplar]* *[HOTS]*

Ans. Distillation increases the alcohol content in alcoholic drinks.

Q. 5. Why are drinks like Whisky and Rum more intoxicating than wine? *[HOTS]*

Ans. This is because wine is produced without distillation whereas whisky and rum are produced by distillation of the fermented broth.

Q. 6. What would have happened if antibiotics were not discovered? *[HOTS]*

Ans. If antibiotics were not discovered, bacterial diseases would not have been controllable.

Q. 7. Why are antibiotics always sold in combination with *Lactobacillus*? *[HOTS]*

Ans. Antibiotics may kill even the useful bacteria present in the digestive tract. LAB is given, which will protect some microbes in the digestive tract and enhance the production and absorption of vitamin B_{12}.

Q. 8. Give the scientific name of the source organism from which the first antibiotic was produced. *[CBSE (F) 2014]*

Ans. *Penicillium notatum*

Q. 9. Mention the information that the health workers derive by measuring BOD of a water body. *[CBSE (AI) 2010]*

Ans. (*i*) By measuring BOD of a water body, health workers find the amount of dissolved oxygen in water. The lesser the amount of dissolved oxygen, the more polluted the water body will be.

(*ii*) It is also measure of organic matter present in water and uptake of O_2 by microbes.

Q. 10. The excreta of cattle does not contain any cellulose but human excreta may contain cellulose. Why? [*HOTS*]

Ans. The rumen of cattle contains methanogens which help in the digestion of cellulose but these bacteria are not present in human stomach so cellulose is not digested.

Q. 11. Name the pests that ladybird, beetle and dragonflies help to get rid of.

Ans. Ladybird, beetle and dragonflies control aphids and mosquitoes respectively.

Q. 12. What for *Nucleopolyhedroviruses* are being used nowadays? [*NCERT Exemplar*] [*HOTS*]

Ans. *Nucleopolyhedroviruses* are used for the biological control of insect pests.

Q. 13. How is the presence of cyanobacteria in the paddy fields beneficial to rice crop? [*NCERT Exemplar*] [*HOTS*]

Ans. Cyanobacteria can fix atmospheric nitrogen. In paddy fields, the cyanobacteria act as an important biofertiliser. They also add organic matter to soil and increase its fertility.

Q. 14. Mention the role of cyanobacteria as a biofertiliser. [*CBSE (AI) 2012*]

Ans. It is a biological organism that fixes atmospheric nitrogen.

Q. 15. What are biofertilisers? Give two examples. [*NCERT Exemplar*]

Ans. Biofertilisers are organisms that enrich the nutrients in the soil. *e.g. Rhizobium*, *Azotobacter*.

Short Answer Questions [2 marks]

Q. 1. Mention the importance of Lactic acid bacteria to humans other than setting milk into curd. [*CBSE Delhi 2012*]

Ans. Lactic acid bacteria increase vitamin B_{12} absorption and also checks disease-causing microbes.

Q. 2. Mention a product of human welfare obtained with the help of each one of the following microbes:

(*a*) LAB **(*b*) *Saccharomyces cerevisiae***

(*c*) *Propionibacterium sharmanii* **(*d*) *Aspergillus niger*** [*CBSE Delhi 2015*]

Ans. (*a*) Convert milk to curd (*b*) Bread/alcoholic drinks

(*c*) Swiss cheese (*d*) Citric acid

Q. 3. Name the bacterium responsible for the large holes seen in "Swiss Cheese". What are these holes due to? [*CBSE (AI) 2013*]

Ans. *Propionibacterium sharmanii.*

The holes are because of production of large amount of CO_2.

Q. 4. Name the microbes that help production of the following products commercially:

(*a*) Statin **(*b*) Citric acid**

(*c*) Penicillin **(*d*) Butyric acid** [*CBSE (AI) 2017*]

Ans. (*a*) *Monascus purpureus* (*b*) *Aspergillus niger*

(*c*) *Penicillium notatum* (*d*) *Clostridium butylicum*

Q. 5. To reduce the percentage of population suffering from hunger and malnutrition, microbes are grown on a large scale to act as food supplements. Mention any two microbes used as food supplement and suggest their role. [*CBSE Sample Paper 2018*]

Ans. *Spirulina* and *Methylophilus methylotrophus* are used as food supplements.

Spirulina produces large quantities of food rich in protein, minerals, fats, carbohydrates and vitamins.

250 gm of *Methylophilus methylotrophus* produces 25 tonnes of protein per day.

Q. 6. Name the blank spaces *a*, *b*, *c* and *d* given in the following table:

Type of microbe	Name	Commercial product
Bacterium	*a*	Clot buster enzyme
b	*Aspergillus niger*	Citric acid
Fungus	*Trichoderma polysporum*	*c*
Bacterium	*d*	Butyric acid

Ans. (*a*) *Streptococcus* (*b*) Fungus
(*c*) Cyclosporin A (*d*) *Clostridium butylicum*

Q. 7. Write the binomials of two fungi and mention the products/bioactive molecules they help to produce. **[*CBSE (AI) 2017*]**

Ans.

Fungi	Products/Bioactive molecules produced
Trichoderma polysporum	Cyclosporin A
Aspergillus niger	Citric Acid
Monascus purpureus	Statin
Saccharomyces cerevisiae	Ethanol/alcohol
Penicillium notatum	Penicillin

(*Any two*)

Q. 8. Name the blank spaces *a*, *b*, *c* and *d* given in the following table:

Type of microbe	Name	Commercial product
Bacterium	*a*	Lactic acid
Fungus	*b*	Cyclosporin A
c	*Monascus purpureus*	Statins
Fungus	*Penicillium notatum*	*d*

Ans. (*a*) *Lactobacillus* (*b*) *Trichoderma polysporum*
(*c*) Fungus (*d*) Penicillin

Q. 9. Why are some molecules called bioactive molecules? Give two examples of such molecules. **[*CBSE (AI) 2011*]**

Ans. Some molecules are called bioactive molecules, because microbes like bacteria or fungi are used in their production.

e.g., Citric acid produced by *Aspergillus niger*
Butyric acid produced by *Clostridium butylicum*
Ethanol produced by *Saccharomyces cerevisiae*
Streptokinase produced by *Streptococcus* (*Any two*)

Q. 10. Give the binomials of two types of yeast and the commercial bioactive products they help to produce. **[*CBSE (AI) 2017*]**

Ans.

Yeast	Their bioactive products
Saccharomyces cerevisiae	Ethanol/alcohol
Monascus purpureus	Statin

Q. 11. Name the source of statin and state its action on the human body. **[*CBSE (F) 2012*]**

OR

Name a microbe used for statin production. How do statin lower blood cholesterol level? **[*NCERT Exemplar*]**

Ans. Statin is produced by the yeast *Monascus purpureus*. It acts as a blood-cholesterol lowering agent, by competitively inhibiting the enzyme responsible for synthesis of cholesterol.

Q. 12. Name a bioactive molecule, its source organism and the purpose for which it is given to organ transplant patients. **[*CBSE (F) 2017*]**

Ans. Cyclosporin A is a bioactive molecules given to organ transplant patients. It is obtained from a fungus *Trichoderma polysporum*. It is used as an immunosuppressive agent.

Q. 13. (*a*) Patients who have undergone myocardial infarction are given clot buster. Mention the clot buster administered and its microbial source.

(*b*) A person recuperating from illness is advised to have curd regularly. Why? **[*CBSE Sample Paper 2015, 2017*]**

Ans. (*a*) *Streptokinase* is the clot buster and its microbial source is *Streptococcus.*

(*b*) Curd contains Lactic Acid Bacteria, which play beneficial role in checking disease-causing microbes. It is also a source of vitamin B_{12}.

Q. 14. What is a broad spectrum antibiotic? Name one such antibiotic. **[*NCERT Exemplar*]**

Ans. A broad spectrum antibiotic is one which can inhibit the growth of both gram positive and gram negative bacteria. For example, tetracycline, which is obtained from *Streptomyces aureofaciens*.

Q. 15. How was penicillin discovered? **[*NCERT Exemplar*]**

Ans. Penicillin was an accidental discovery. Sir Alexander Fleming observed that in unwanted culture plates of *Staphylococcus* a mould of *Penicillium* was growing This mould inhibited the growth of *Staphylococcus* around it. Later the antibiotic penicillin was isolated from this fungus.

Q. 16. Name the source of streptokinase. How does this bioactive molecule function in our body? **[*CBSE Delhi 2012*]**

Ans. Source: *Streptococcus*.

Streptokinase is a clot buster, *i.e.,* it removes clot from the blood vessels of patients who had a heart attack.

Q. 17. Name the enzyme produced by *Streptococcus* bacterium. Explain its importance in medical sciences. **[*CBSE (AI) 2011*]**

Ans. *Streptococcus* bacterium produces streptokinase.

It is used for removing clots from the blood vessels in a patient suffering from myocardial infarction/or in a heart patient.

Q. 18. Give the scientific name of the microbes from which cyclosporin A and statin are obtained. Write one medical use of each one of these drugs. **[*CBSE (F) 2011*]**

Ans. Cyclosporin A that is used as an immuno-suppressive agent during organ transplantation in patients is produced by the fungus *Trichoderma polysporum*. Statins produced by yeast *Monascus purpureus* have been commercialised as blood cholesterol lowering agents.

Q. 19. Name the source of cyclosporin-A. How does this bioactive molecule function in our body? **[*CBSE (AI) 2012*]**

Ans. *Trichoderma polysporum*.

It acts as an immuno-suppresant and is used in organ transplant patient.

Q. 20. (*a*) A patient who had an organ transplant was given cyclosporin A. Mention the microbial source and state the reason for administration of this bioactive molecule.

(*b*) Bottled fruit juices bought from the market are clearer as compared to those made at home. Give reason. **[*CBSE Sample Paper 2019*]**

Ans. (*a*) **Source:** *Trichoderma polysporum*

Reason: It is an Immunosuppressive agent.

(*b*) Bottled fruit juices are clarified by pectinases and proteases which makes them clearer.

Q. 21. Describe how biogas is generated from activated sludge. List the components of biogas. ***[CBSE (F) 2010; (AI) 2013]***

Ans. The activated sludge is pumped into large tanks called anaerobic sludge digesters. Here, bacteria which grow anaerobically digest the bacteria and the fungi in the sludge. During this digestion, bacteria produce a mixture of gases which form biogas. Biogas is made up of methane, hydrogen sulphide and carbon dioxide.

Q. 22. What are methanogens? Name the animals they are present in and the role they play there. ***[CBSE Delhi 2014]***

Ans. Methanogens are bacteria which grow anaerobically on cellulosic material.

They are present in the rumen of cattles.

These bacteria are responsible for the breakdown of cellulose, thus help in nutrition of animal.

Q. 23. What is the chemical nature of biogas? Name an organism which is known to be employed in biogas. ***[NCERT Exemplar]***

Ans. The biogas contains methane, CO_2 and H_2. *Methanobacterium*, a type of methanogen is employed for biogas production.

Q. 24. What is BOD? What does it mean if a water sample has more BOD?

Ans. BOD stands for biochemical oxygen demand which represents the amount of dissolved oxygen that would be consumed if all the organic matter in one litre of water were oxidised by microorganisms. More BOD value means the water sample is polluted by organic matter.

Q. 25. What is *Chakravarthy* bug? Give its scientific name and its application? ***[HOTS]***

Ans. *Chakravarthy* bug is a super bug of *Pseudomonas* with multiple plasmids. They are helpful in removing oil spills.

Q. 26. What does the Ganga Action Plan tend to achieve? ***[HOTS]***

Ans. Ganga Action Plan tends to save the major rivers from pollution like Ganga. Under these plans, a large number of sewage treatment plants were built so that only treated sewage is discharged in the rivers.

Q. 27. Name the two different categories of microbes naturally occurring in sewage water. Explain their role in cleaning sewage water into usable water. ***[CBSE Delhi 2012]***

Ans. Aerobic and anaerobic bacteria or fungi exist in sewage water.

After the primary treatment of water, aerobic bacteria are added in aeration tanks. Growth of these bacteria reduces BOD as they consume organic matter. Anaerobic bacteria are added in anaerobic sludge digesters, where these digest the sludge and form biogas, etc.

Q. 28. List the events that lead to biogas production from waste water whose BOD has been reduced significantly. ***[CBSE Delhi 2016]***

Ans. The effluent is passed into a settling tank where the bacterial 'flocs' are allowed to sediment. This is called activated sludge. The sludge is pumped into anaerobic sludge digesters where they are anaerobically digested. During this digestion, bacteria produce biogas.

Q. 29. List the events that reduce the Biological Oxygen Demand (BOD) of a primary effluent during sewage treatment. ***[CBSE Delhi 2016]***

OR

Explain the process of secondary treatment given to the primary effluent up to the point it shows significant change in the level of biological oxygen demand (BOD) in it. ***[CBSE (AI) 2015]***

Ans. During secondary treatment of primary effluents, vigorous growth of useful aerobic microbes into flocs occur when it is agitated mechanically and air is pumped into it in a large aeration tank. These microbes while growing consume major part of the organic matter in the effluent. This significantly reduces BOD.

Q. 30. Distinguish between the roles of flocs and anaerobic sludge digesters in sewage treatments. ***[CBSE Delhi 2016]***

Ans. Flocs are masses of bacteria associated with fungal filaments to form mesh-like structures. These consume the major part of the organic matter in the effluent, significantly reducing the BOD. The effluent is then passed into a settling tank where the flocs sediment. A part of this sediment

(activated sludge) is pumped into anaerobic sludge digestors where anaerobic digestion of sludge takes place, producing biogas in the process.

Q. 31. Name a free-living and a symbiotic bacterium that serve as biofertiliser. Why are they so called? **[*CBSE (AI) 2016*]**

Ans. *Azospirillium / Azotobacter* and *Rhizobium* act as biofertilisers.

They are so called because they enrich soil nutrients by nitrogen fixation.

Q. 32. Why is *Rhizobium* categorised as a 'symbiotic bacterium'? How does it act as a biofertiliser? **[*CBSE Delhi 2012*]**

Ans. *Rhizobium* is present in the root nodules of leguminous plants. Theirs is a symbiotic relationship in which the bacterium obtains food and shelter from the plant and the plant gets fixed nitrogen in return. These bacteria fix atmospheric nitrogen into organic forms, which is used by the plant as nutrient.

Q. 33. Your advice is sought to improve the nitrogen content of the soil to be used for cultivation of a non-leguminous terrestrial crop.

(*a*) Recommend two microbes that can enrich the soil with nitrogen.

(*b*) Why do leguminous crops not require such enrichment of the soil? **[*CBSE 2018*]**

Ans. (*a*) *Azospirillum/Azotobacter/Anabaena/Nostoc/Oscillatoria/Frankia*. (*Any two*)

(*b*) Leguminous crops do not need nitrogen from soil because the nitrogen fixing bacteria (*Rhizobium*) are present in their root nodules, which can fix atmospheric nitrogen for the crops.

Q. 34. How do mycorrhizae act as biofertilisers? Explain. Name a genus of fungi that forms a mycorrhizal association with plants. **[*CBSE Delhi 2012*]**

Ans. Mycorrhizae is a symbiotic association of a fungus with roots of higher plants. The fungus absorbs phosphate from soil and passes it to the plant. It also provides resistance to root-borne pathogen and increase the tolerance of plant to salinity and drought. This way they act as biofertilisers.

Genus of fungi — *Glomus*.

Q. 35. How does the application of the fungal genus, *Glomus*, to the agricultural farm increase the farm output? **[*CBSE Delhi 2017*]**

Ans. *Glomus* is a fungus which is found in symbiotic relationship with roots of seed plants. It absorbs phosphorus from the soil and passes it on to the plant, and in turn gets sugars from the plant. Due to increased availability of phosphorus there is an increase in farm output.

Q. 36. How does the application of cyanobacteria help to improve agriculture output? **[*CBSE Delhi 2017*]**

Ans. Cyanobacteria are autotrophic, free-living or symbiotic microbes. They can fix atmospheric nitrogen. Blue-green algae also add organic matter to the soil and increases its fertility. They replenish soil nutrients and reduce dependence on chemical fertilisers.

Q. 37. How do mycorrhizae help the plants to grow better? **[*CBSE Delhi 2017*]**

Ans. Mycorrhizae absorb phosphorus, provide resistance to root-borne pathogens and enhance the tolerance of the plants towards salinity and drought. (*Any two*)

Q. 38. Describe the main ideas behind the biological control of pests and diseases. **[*NCERT Exemplar*] [*HOTS*]**

Ans. Biological control means life against life. It is a natural and ecofriendly concept. It employs natural organisms to control the population of pathogens and pests in an ecosystem. Classical examples are *Trichoderma* which is antagonist against many soil-borne plant pathogens. Similarly, *Penicillium* inhibits the growth of *Staphylococcus* and therefore has been successfully used in the production of penicillin antibiotic to control many human bacterial pathogens.

Ladybirds used to control aphids and dragonflies used to control mosquitoes.

Q. 39. How do mycorrhizal fungi help the plants harbouring them? **[*NCERT Exemplar*]**

Ans. The mycorrhizal fungi absorb phosphorus from the soil and transfer them to the host cells. They also impart resistance to host plants against root pathogens. They also help plants to tolerate salinity and drought.

Long Answer Questions–I [3 marks]

Q. 1. Identify *a, b, c, d, e* and *f* in the table given below: ***[CBSE Delhi 2010]***

S. No.	Organism	Bioactive molecule	Use
(*i*)	*Monascus purpureus* (yeast)	*a*	*b*
(*ii*)	*c*	*d*	Antibiotic
(*iii*)	*e*	Cyclosporin A	*f*

Ans. (*a*) Statins (*b*) Blood cholesterol lowering agent
(*c*) *Penicillium notatum* (*d*) Penicillin
(*e*) *Trichoderma polysporum* (*f*) Immunosuppressant

Q. 2. State the medicinal value and the bioactive molecules produced by *Streptococcus, Monascus* and *Trichoderma*. ***[CBSE (AI) 2015]***

Ans.

		Bioactive Molecule Produced	Medicinal Value
(*i*)	*Streptococcus*	Streptokinase	Removes clot from the blood vessels
(*ii*)	*Monascus purpureus*	Statin	Inhibits enzymes responsible for synthesis of cholesterol. So is used as cholesterol lowering agent.
(*iii*)	*Trichoderma polysporum*	Cyclosporin A	Immunosuppressive agents used in organ transplantation.

Q. 3. (*a*) Why are the fruit juices bought from market clearer as compared to those made at home?
(*b*) Name the bioactive molecules produced by *Trichoderma polysporum* and *Monascus purpureus*. ***[CBSE Delhi 2013]***

Ans. (*a*) The fruit juices bought from market are clearer because they have been clarified by pectinases and proteases.
(*b*) *Trichoderma polysporum*: Cyclosporin A
Monascus purpureus: Statins

Q. 4. Explain the function of "anaerobic sludge digester" in a sewage treatment plant. ***[CBSE (AI) 2015]***

Ans. Anaerobic sludge digester has anaerobic bacteria that digests the aerobic bacteria and fungi present in the sludge. During the digestion these bacteria produce mixture of gases such as methane, H_2S and CO_2 (biogas).

Q. 5. Explain the different steps involved during primary treatment phase of sewage. ***[CBSE (AI) 2015]***

Ans. Refer to Basic Concepts Point 4(*i*).

Q. 6. Describe the steps that are followed during secondary treatment of sewage. ***[CBSE 2019(57/3/1)]***

OR

Effluent from the primary treatment of the sewage is passed through large aeration tanks for biological treatment. Explain the complete process that follows till the water is ready to be released into the natural water bodies. ***[CBSE 2019(57/4/2)]***

Ans. Refer to Basic Concepts Point 4(*ii*).

Q. 7. Describe how do 'flocs' and 'activated sludge' help in sewage treatment. ***[CBSE Delhi 2017]***

Ans. Flocs are masses of aerobic bacteria associated with fungal filaments to form mesh like structures. These aerobic microbes consume the major part of the organic matter in the effluent. This significantly reduces Biological oxygen demand (BOD) of the effluent.

A small part of the activated sludge is used as inoculum and pumped back to aeration tank. The remaining major part of the sludge is pumped into anaerobic sludge digesters where microbes or bacteria grow anaerobically to produce CH_4 or H_2S or CO_2 or biogas.

Q. 8. (*i*) List the components of biogas.
(*ii*) What makes methanogens suitable for biogas production? [*CBSE (F) 2017*]

Ans. (*i*) Biogas is a mixture of inflammable gases like methane, carbon dioxide and hydrogen.

(*ii*) Methanogens grow anaerobically and help in breakdown of cellulosic material to produce large amount of methane, carbon dioxide and hydrogen and so it is suitable for biogas production.

Q. 9. How can sewage be used to generate biogas? Explain. [*CBSE (F) 2015*]

Ans. When biochemical oxygen demand (BOD) of sewage is reduced, effluent is passed into a settling tank for bacterial flocs to settle down. The sediment is called activated sludge. Activated sludge is pumped into anaerobic sludge digesters. In the digesters, heterotrophic microbes anaerobically digest bacteria and fungi in the sludge producing a mixture of gases which form the biogas.

Q. 10. Secondary treatment of the sewage is also called Biological treatment. Justify this statement and explain the process. [*CBSE (AI) 2017*]

Ans. Secondary treatment of sewage involves biological organism such as aerobic and anaerobic microbes or bacteria and fungi to digest or consume organic waste. Therefore, it is also called biological treatment.

Q. 11. (*a*) How is activated sludge produced during sewage treatment?
(*b*) Explain how this sludge is used in biogas production.

Ans. (*a*) Once the BOD of sewage or waste water is reduced significantly, the effluent is passed into a settling tank where the bacterial flocs undergo sedimentation and the sediment is thus called activated sludge.

(*b*) A small part of the activated sludge is pumped back into the aeration tank to serve as the inoculum. The remaining major part of the activated sludge is pumped into large tanks called anaerobic sludge digesters. The anaerobic bacteria digest the bacteria and fungi in the sludge and produce mixture of gases like methane, hydrogen sulphide and CO_2 which constitute biogas.

Q. 12. Cow dung and water is mixed and this slurry is fed into the biogas plant for digestion by microbes. The person performing the process shares that there is no need to provide inoculum for it, why? What is the role of microbes at the source? Under which condition will they be most active and effective? [*CBSE (AI) 2015; CBSE Sample Paper 2015, 2017, 2018*]

Ans. There is no need to provide inoculum for it because the bacteria, methanogens are present in cow dung. The role of these microbes is breakdown of cellulose. These are most active in an anaerobic condition.

Q. 13. Name the genus to which baculoviruses belong. Describe their role in the integrated pest management programmes. [*CBSE (AI) 2011; (F) 2011*]

Ans. Baculovirus belongs to the genus *Nucleopolyhedrovirus*. Baculoviruses are pathogens that attack insects and other arthopods. These viruses are very useful for species-specific, narrow spectrum insecticidal applications. Also, as they show no negative impacts on plants, mammals, birds, fish or even on non-target insects, they are beneficial in integrated pest management (IPM) programme in which beneficial insects are conserved.

Q. 14. Given below is a list of six microorganisms. State their usefulness to humans.

(*a*) *Nucleopolyhedrovirus* **(*b*) *Saccharomyces cerevisiae***
(*c*) *Monascus purpureus* **(*d*) *Trichoderma polysporum***
(*e*) *Penicillium notatum* **(*f*) *Propionibacterium sharmanii***

[*CBSE Delhi 2016*]

Ans. (*a*) *Nucleopolyhedrovirus*: Used as bio-control agents.

(*b*) *Saccharomyces cerevisiae*: Used in bread making and in brewing industry.

(*c*) *Monascus purpureus*: Cholesterol lowering agent.

(*d*) *Trichoderma polysporum*: Produces Cyclosporin-A, used as immunosuppressive agent.

(*e*) *Penicillium notatum*: Produces antibiotic penicillin.

(*f*) *Propionibacterium sharmanii*: Produces large amount of CO_2 in Swiss cheese.

Q. 15. Explain the role of the following in increasing the soil fertility and crop yield:

(*a*) Leguminous plants

(*b*) Cyanobacteria

(*c*) Mycorrhizae **[*CBSE (F) 2013*]**

Ans. (*a*) Leguminous plants possess root nodules where nitrogen is fixed by symbiotic nitrogen fixing bacteria *Rhizobium* and fertilise the soil.

(*b*) Refer to Basic Concepts Point 7 (*iii*).

(*c*) Refer to Basic Concepts Point 7 (*ii*).

Q. 16. Choose any three microbes, from the following which are suited for organic farming, which is in great demand these days for various reasons. Mention one application of each one chosen.

Mycorrhiza; Monascus; Anabaena; Rhizobium; Methanobacterium; Trichoderma.

[*CBSE Delhi 2015*] [*HOTS*]

Ans. ***Mycorrhiza*:** (Fungal symbiont of the association) Absorbs phosphorus from soil.

***Anabaena*:** Fix atmospheric nitrogen and adds organic matter to the soil.

***Rhizobium*:** Fix atmospheric nitrogen (in leguminous plants).

***Methanobacterium*:** They digest cellulosic material and their product/spent slurry can be used as a fertiliser.

***Trichoderma*:** Biocontrol agent for several plant pathogens. (*Any three*)

Q. 17. What are the harmful effects of chemical pesticides?

Ans. The harmful effects of chemical pesticides are:

(*i*) They pollute the soil and water.

(*ii*) They kill many useful organisms in the soil.

(*iii*) They enter the food chain and cause disease at various trophic levels (Biological magnification).

(*iv*) They affect the salinity of the soil.

Q. 18. What are the advantages of using biofertilisers in agriculture?

Ans. Following are the advantages of using biofertilisers in agriculture:

(*i*) Biofertilisers do not cause any pollution.

(*ii*) These are cheap and economical.

(*iii*) Some of them act as biopesticides also.

(*iv*) In ill-irrigated conditions few biofertilisers can enhance the crop yield.

(*v*) They improve soil structure and function.

(*vi*) They make available vitamins and other growth promoting biochemicals.

Q. 19. An organic farmer relies on natural predation for controlling plant pests and diseases. Justify giving reasons why this is considered to be a holistic approach. **[*CBSE (F) 2010*]**

Ans. Besides acting as 'conduits' for energy transfer across trophic levels, predators are used in biological control of plant pests. This ability of the predator is based on its regulating the prey population.

The natural predators reduce interspecific competition and does not harm the crop plants. For example, in an area the invasive cactus can be brought under control by cactus-feeding predator (a moth).

Using natural predation, the ecosystem is kept stable without harming any of the trophic levels.

Long Answer Questions–II [5 marks]

Q. 1. Identify 'a', 'b', 'c', 'd', 'e' and 'f' in the table given below:

Scientific name of the organism	Product produced	Use in human welfare
Streptococcus	Streptokinase that was later modified	*a*
b	Cyclosporin A	*c*
Monascus purpureus	*d*	*e*
Lactobacillus	*f*	Sets milk into curd

[CBSE (F) 2014]

Ans. (*a*) Bioactive molecule used to remove blood clot
(*b*) *Trichoderma polysporum*
(*c*) Immunosuppressant
(*d*) Statin
(*e*) Blood cholesterol lowering agent
(*f*) Lactic acid

Q. 2. Complete the given table.

Name of the organism	Product/Enzyme/Bioactive male cule
Aspergillus niger	(*i*)
(*ii*)	Ethanol
(*iii*)	Cyclosporin-A
(*iv*)	Acetic acid
Monascus purpureus	(*v*)
Streptococcus	(*vi*)

Ans. (*i*) Citric acid
(*ii*) *Saccharomyces cerevisiae*
(*iii*) *Trichoderma polysporum*
(*iv*) *Acetobacter aceti*
(*v*) Statin
(*vi*) Streptokinase

Q. 3. Explain the different steps involved in sewage treatment before it can be released into natural water bodies. **[CBSE (F) 2011]**

OR

Describe the process of waste-water treatment under the following heads:

(*a*) Primary treatment

(*b*) Secondary treatment **[CBSE (F) 2016]**

OR

Explain the process of sewage water treatment before it can be discharged into natural water bodies. Why is this treatment essential? **[CBSE (AI) 2014; 2019 (57/2/1)]**

Ans. Refer to Basic Concepts Point 4 (*i*) and (*ii*).

The sewage treatment is essential before being released into water bodies so as to check water borne diseases or pathogenic organisms due to water pollution.

Q. 4. (*a*) Name the category of microbes occurring naturally in sewage and making it less polluted during the treatment.

(*b*) Explain the different steps involved in the secondary treatment of sewage. **[CBSE (F) 2014]**

Ans. (*a*) Aerobic microbes

(*b*) Refer to Basic Concepts Point 4(*ii*).

Q. 5. "Microbes play a dual role when used for sewage treatment as they not only help to retrieve usable water but also generate fuel". Explain. **[CBSE Sample Paper 2014]**

Ans. ● Microbes naturally present in the sewage are employed in the secondary treatment of the sewage.

- The effluent from the primary treatment is passed into large aeration tanks.
- This allows the rapid growth of aerobic microbes into flocs which consume the organic matter of the sewage and reduces the BOD.
- Then the effluent is passed into a settling tank, where the flocs are allowed to sediment forming the activated sludge.
- Major parts of this activated sludge is pumped into anaerobic sludge digesters, where the anaerobic bacteria digest microbes in the activated sludge.
- During this digestion bacteria produce a mixture of gases like methane, hydrogen sulphide and carbon dioxide, which form the biogas and can be used as a source of energy. The effluent is generally released into rivers and streams.

Q. 6. Why should biological control of pests and pathogens be preferred to the conventional use of chemical pesticides? Explain how the following microbes act as biocontrol agents:

(*a*) *Bacillus thuringiensis*

(*b*) *Nucleopolyhedrovirus*

Ans. Biological control of pests and pathogens is preferred because:

(*i*) The chemicals cause pollution of water bodies as well as ground water, besides getting stored in the plants.

(*ii*) The chemicals are toxic thus extremely harmful to human beings and other animals.

(*a*) *Bacillus thuringiensis*: *Bacillus thuringiensis* is available in sachets as dried spores, which are mixed with water and sprayed onto vulnerable plants. When they are eaten by the insect larvae, the toxin is released in the gut where it becomes active and kills the larvae.

B. thuringiensis toxin genes when introduced into plant, develop resistance to attack by insect pests. Specific Bt toxin genes obtained from *B. thuringiensis* are used in several crop plants which make them resistant to insect pest.

(*b*) *Nucleopolyhedrovirus*: These viruses are excellent candidates for species-specific, narrow spectrum insecticidal applications. This is especially desirable when beneficial insects are being conserved to aid in an overall integrated pest management (IPM) programme.

Q. 7. Explain the significant role of the genus *Nucleopolyhedrovirus* in an ecological sensitive area. **[*CBSE (AI) 2014*]**

Ans. Baculoviruses are pathogens that attack insects and other arthropods. Baculoviruses of genus *Nucleopolyhedrovirus* are used as biological control agents. They are excellent candidates for species-specific, narrow spectrum insecticidal applications. They do not show negative impact on plants, mammals, birds, non-target insects. Therefore, they are used as biological control agents.

Importance in organic farming: It is desirable when beneficial insects are being conserved to aid in an overall Integrated Pest Management (IPM) programme. In organic farming, it is used to conserve beneficial insects and kills harmful ones.

Q. 8. What are biofertilisers? Describe their role in agriculture. Why are they preferred to chemical fertilisers? **[*CBSE (F) 2015*]**

Ans. Refer to Basic Concepts Point 7.

These are preferred to chemical fertilisers because:

(*i*) They do not pollute soil, air and water.

(*ii*) They do not spoil the soil texture or pH of the soil.

(*iii*) They are economical.

Self-Assessment Test

Time allowed: 1 Hour **Max. marks: 30**

1. Choose and write the correct option in the following questions. **(3×1 = 3)**

(i) Which of the following is used as a "clot buster" (removing clots inside blood vessels)?

(a) *Streptococcus* (b) *Staphylococcus*

(c) *Lactobacillus* (d) *Acetobacter*

(ii) To prevent curd from getting sour, which parameter should be essentially controlled?

(a) Quantity of milk (b) Amount of LAB added initially

(c) Temperature of the surrounding (d) Amount of O_2 in surrounding air

(iii) 'Swiss cheese' bears large holes due to the production of CO_2 by which microbe ?

(a) Lactobacillus (b) *Sachharomyces cerevisiae*

(c) Propionibacterium shermanii (d) *Aspergillus niger*

2. In the following questions a statement of assertion followed by a statement of reason is given. Choose the correct answer out of the following choices. **(3×1 = 3)**

(a) Assertion and reason both are correct statements and reason is correct explanation for assertion.

(b) Assertion and reason both are correct statements but reason is not correct explanation for assertion.

(c) Assertion is correct statement but reason is wrong statement.

(d) Assertion is wrong statement but reason is correct statement.

(i) Assertion : Acetic acid is used for the preparation of vinegar.
Reason : It is prepared from fermented alcohols with the help of *Aspergillus niger*.

(ii) Assertion : Sewage is made less polluting by passing it through sewage treatment plants.
Reason : Sewage not only contains excreta and other organic wastes but pathogenic microbes too.

(iii) Assertion : Cyanobacteria can fix atmospheric nitrogen.
Reason : Blue green algae add organic matter to the soil.

3. What are antibiotics? **(1)**

4. How do biofertilisers enrich the fertility of the soil? **(1)**

5. Bottled fruit juices are clearer as compared to those made at home. Explain. **(2)**

6. State the use of the following enzymes/acids produced by the microbes:

(i) Lipase (ii) Lactic acid

(iii) Streptokinase (iv) Pectinase (2)

7. Why is 'starter' added to set the milk into curd? Explain **(2)**

8. Explain the change that fresh milk undergoes when a small amount of curd as starter is added to it and kept at suitable temperature. **(2)**

9. Explain the process of sewage water treatment. **(3)**

10. Explain the role of baculoviruses as biological control agents. Mention their importance in organic farming. **(3)**

11. Large quantities of waste water are generated everyday. It is treated in sewage plants before releasing into water bodies. **(3×1 = 3)**

(i) What is BOD?

(ii) What does it mean if a water sample has more BOD?

(iii) Distinguish between the roles of flocs and anaerobic sludge digesters in sewage treatments.

12. (i) What are biopesticides? Give any two examples of their application.

(ii) What are mycorrhiza? How does it act as a biofertiliser? **(5)**

Answers

1. (*i*)—(*a*), (*ii*)—(*a*), (*iii*)—(*b*) **2.** (*i*)—(*c*), (*ii*)—(*a*), (*iii*)—(*b*)

Chapter–11

Biotechnology: Principles and Processes

basic concepts

1. Biotechnology

- **Biotechnology** deals with microorganisms, plant or animal cells or their enzymes to produce products and processes useful to humans.
- The term "Biotechnology" was given by **Karl Ereky (1919)**.
- According to **European Federation of Biotechnology** (EFB), biotechnology is the integration of natural science and organisms, cells, parts thereof, and molecular analogues for products and services.

2. Principles of Biotechnology

- The two core techniques that developed modern biotechnology are:
  - (*i*) **Genetic engineering** which is modification of chemical nature of DNA/RNA and their introduction into another host organism, to change the phenotypic characters of the host.
  - (*ii*) **Sterilisation methods** to maintain growth and manipulation of only the desired microbes or cells in large quantities, for the manufacture of biotechnological products like antibiotics, vaccines, enzymes, etc.
- The basic steps in genetic engineering include:
  - (*i*) identification of DNA with desirable genes.
  - (*ii*) introduction of the DNA into host to form recombinant DNA (*r*DNA).
  - (*iii*) maintenance of DNA in host and gene cloning.
  - (*iv*) gene transfer.
- In 1972, **Stanley Cohen** and **Herbert Boyer** constructed the first recombinant DNA.
- **Herbert Boyer** worked on restriction enzymes of *E. coli* which cut DNA in particular fashion and produce sticky ends on both the strands. These restricted ends were ligated with desired pieces of DNA.
- **Stanley Cohen** studied plasmid DNA floating freely in cytoplasm of bacterial cells.. He also developed a method of removing plasmids from the cell and reinserting them in other cells.
- They isolated antibiotic resistant gene from plasmid of bacteria and then linked the gene with plasmid and incorporated into *E coli*, where it could replicate using the new host's DNA polymerase enzyme and make multiple copies.
- Steps carried out in constructing first recombinant DNA:
  - (*i*) A gene encoding antibiotic resistance in the native plasmid of *Salmonella typhimurium V*. was identified. **Plasmid** is an autonomously replicating circular extra-chromosomal DNA.

(*ii*) The desired DNA was cut at specific locations by restriction enzymes.

(*iii*) The cut DNA was linked to plasmid DNA and transferred to *E. coli* for gene multiplication.

3. Tools of Recombinant DNA Technology

- The key tools required for the recombinant DNA technology are:
  (*i*) Restriction enzymes
  (*ii*) Polymerase enzymes
  (*iii*) Ligases
  (*iv*) Vectors
  (*v*) Host organism/cell.

4. Restriction Enzymes

- The restriction enzymes are called **"molecular scissors"** and are responsible for cutting DNA.
- They are present in bacteria to provide a type of defence mechanism called the **"restriction–modification system"**.
- The first restriction endonuclease, ***Hin*dII**, was isolated by **Smith**, **Wilcox** and **Kelley** (1968) from *Haemophilus influenzae* bacterium. It was used to cut DNA molecules at a particular point by recognising a specific sequence of six base pairs, known as the **recognition sequence**.

Naming of Restriction Enzymes

- The first letter is derived from the genus name and the next two letters from the species name of the prokaryotic cell from where the enzymes are extracted. The roman numbers, following the name, show the order in which the enzymes were isolated from the bacterial strain.
- For example, *Eco*RI is derived from *Escherichia coli* RY13, *Hin*dII from *Haemophilus influenzae* Rd, *Bam*HI from *Bacillus amyloliquefaciens* H, *Eco*RII from *E. coli* R245, etc.
- Restriction enzymes belong to a class of enzymes called **nucleases** and are of two types:
  (*i*) Exonucleases—cut DNA at the ends.
  (*ii*) Endonucleases—cut at specific positions within the DNA.
- The recognition sequences of endonucleases are **palindromic**, *i.e.*, the sequence of base pairs read the same on both the DNA strands, when orientation of reading is kept same, *e.g.*,

5′ ——— G A A T T C ——— 3′
3′ ——— C T T A A G ——— 5′

Mechanism of Action of Endonucleases

- Every endonuclease inspects the entire DNA sequence for the palindromic recognition sequence.
- On finding the palindrome, the endonuclease binds to the DNA.
- It cuts the opposite strands of DNA in the sugar–phosphate backbone; a little away from the centre of the palindrome sites but between the same bases on both strands.
- This results in the formation of single stranded overhanging stretches at the end of each strand called **sticky ends**.
- The sticky ends facilitate the action of the enzyme DNA ligase by readily forming hydrogen bonds with complementary strands.
- In **genetic engineering**, DNA from different sources are cut with the same restriction enzymes so that both DNA fragments have same kind of sticky ends.
- These sticky ends are complementary to each other and thus can be joined by DNA ligase (end-to-end).

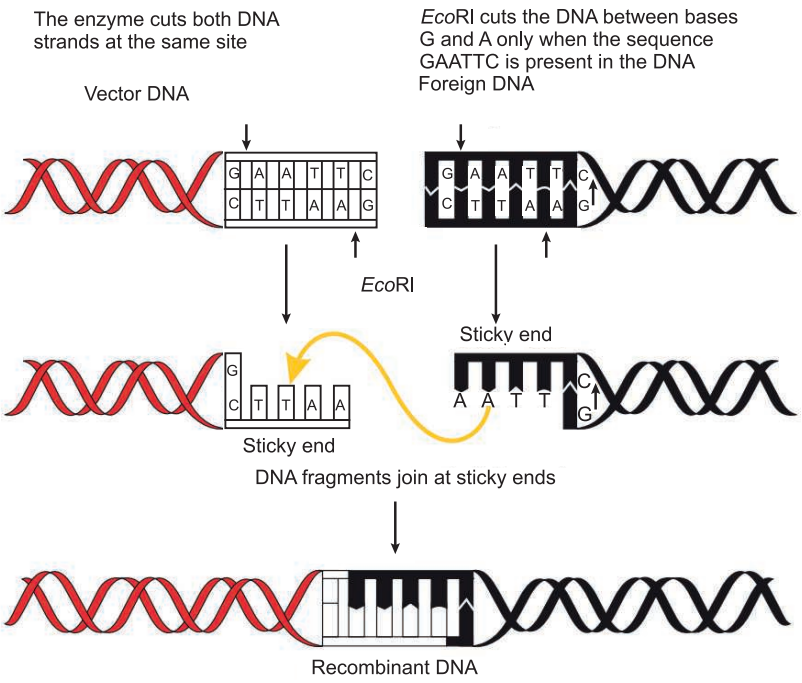


Fig. 11.1 Steps in formation of recombinant DNA by action of restriction endonuclease enzyme *Eco*RI

5. Separation and Isolation of DNA Fragments (Gel Electrophoresis)

- **Gel electrophoresis** is a technique for separating DNA fragments based on their size.
- Firstly, the sample DNA is cut into fragments by restriction endonucleases.

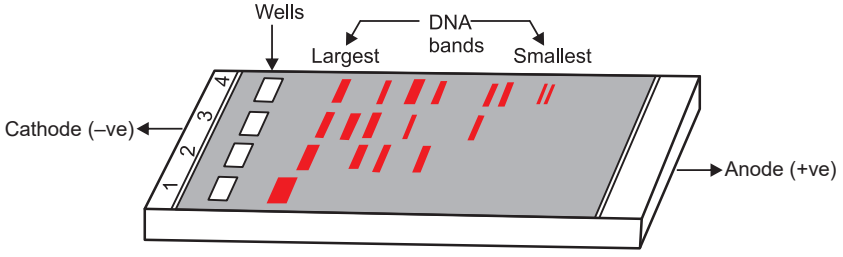


Fig. 11.2 A typical agarose gel electrophoresis showing migration of undigested (lane 1) and digested set of DNA fragments (lane 2 to 4)

- The DNA fragments being negatively charged can be separated by forcing them to move towards the anode under an electric field through a medium/matrix.
- Commonly used matrix is **agarose**, which is a natural linear polymer of D-galactose and 3, 6-anhydro-L-galactose which is extracted from sea weeds.
- The DNA fragments separate-out (resolve) according to their size because of the sieving property of agarose gel. Hence, smaller the fragment size, the farther it will move.
- The separated DNA fragments are visualised after staining the DNA with **ethidium bromide** followed by exposure to **UV radiation**.
- The DNA fragments are seen as orange coloured bands.
- The separated bands of DNA are cut out and extracted from the gel piece. This step is called **elution**.
- The purified DNA fragments are used to form recombinant DNA which can be joined with cloning vectors.

6. Cloning Vectors

- The **vectors** are the DNA molecules that can carry a foreign DNA segment into the host cell.
- **Vectors may be:**
  - **(*a*) Plasmids:** These are autonomously replicating circular extra-chromosomal DNA.
  - **(*b*) Bacteriophages:** These are viruses that infect bacteria. Bacteriophages because of their high number per cell have very high copy number within bacterial cells.
- **Copy number:** It is defined as the number of copies of vectors present in a cell. It varies from 1–100 copies per cell.
- The best known vector is the plasmid vector.
- **pBR322** is the first artificial cloning vector developed in 1977 by **Boliver** and **Rodriguez** from *E. coli* plasmid.
- The following features are required to facilitate cloning into a vector:

(i) Origin of replication (*ori*)

- This is a DNA sequence that is responsible for initiating replication. Any piece of DNA when linked to this sequence can replicate within the host cells.
- *ori* also controls the copy numbers of the linked DNA. For many copies of target DNA, it should be cloned in a vector whose origin supports high copy number.

(ii) Selectable marker

- It helps to select the host cells which contain the vector (**transformants**) and eliminate the non-transformants.
- **Transformation** is defined as the procedure by which a piece of DNA is introduced into a bacterial cell.
- Genes encoding resistance to antibiotics like ampicillin, chloramphenicol, tetracycline or kanamycin, are useful selectable markers for *E. coli*.

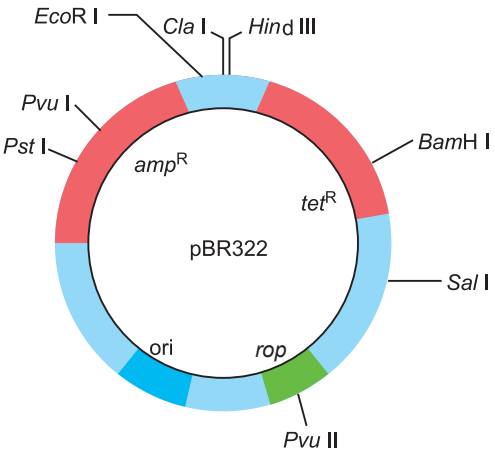


Fig. 11.3. *E. coli* cloning vector pBR322 showing restriction sites (*Hin*dIII, *Eco*RI, *Bam*HI, *Sal*I, *Pvu*II, *Pst*I, *Cla*I), ori and antibiotic resistance genes (amp^R and tet^R). *rop* codes for the proteins involved in the replication of the plasmid.

- The normal *E. coli* cells do not carry resistance against any of these antibiotics.

(iii) Cloning sites

- To link the alien DNA, the vectors require very few (mostly single) **recognition sites** for the restriction enzymes.
- More than one recognition sites within the vector, can complicate the gene cloning as it will generate several fragments.
- Ligation of alien DNA can be carried out at a restriction site present in one of the two antibiotic resistance genes.

(iv) Vectors for cloning genes in plants and animals

- There are several vectors which are used for cloning genes in plants and animals.
- In plants, the tumour inducing plasmid (Ti) of *Agrobacterium tumefaciens* is used as a cloning vector.
- *A. tumefaciens* is a pathogen of several dicot plants.
- It delivers a piece of DNA known as **'T-DNA'** in the Ti plasmid which transforms normal plant cells into tumor cells to produce chemicals against pathogens.

- Retrovirus, adenovirus, papillomavirus are also now used as cloning vectors in animals because of their ability to transform normal cells into cancerous cells. They are first disarmed and then used to transfer desirable genes to animal cells.

- Selection of recombinants formed can be done by one of the following methods:

(a) Inactivation of antibiotics

- If a foreign DNA ligates at the *Bam*HI site of tetracycline resistance gene in the vector pBR322, the recombinant plasmid loses the tetracycline resistance due to insertion of foreign DNA.
- It can still be selected out from non-recombinant ones by plating the transformants on ampicillin containing medium.
- The transformants growing on ampicillin containing medium are then transferred on to a medium containing tetracycline.
- The recombinants can grow in ampicillin containing medium but not on that containing tetracycline whereas non-recombinants can grow on the medium containing both the antibiotics and thus recombinants are selected.

(b) Alternative Selectable Marker (Insertional inactivation)

- On the basis of colour production in the presence of chromogenic substrate, the recombinants and non-recombinants can also be differentiated.
- Here, a recombinant DNA is inserted within the coding sequence of an enzyme β-galactosidase, which results into inactivation of the enzyme and hence there is no conversion of substrate to products.
- Hence, the bacterial colonies having transformed plasmid, shows no colouration while those without inserted plasmid form blue colour colonies.

7. Competent Host (For Transformation with Recombinant DNA)

- DNA being a hydrophilic molecule, cannot pass through cell membranes.
- Therefore, the bacteria should be made competent to accept the DNA molecules.
- **Competency** is the ability of a cell to take up foreign DNA.
- The cell is made competent by the following methods:

(*i*) Chemical method (*ii*) Physical method

(i) Chemical method

- The cell is treated with specific concentration of a divalent cation such as calcium to increase pore size in cell wall.
- The cells are incubated with recombinant DNA on ice, followed by placing them briefly at 42°C and then putting it back on ice. This is called **heat shock** treatment.
- The bacteria now take up the recombinant DNA.

(ii) Physical methods

The physical methods include

- **Micro-injection method:** Recombinant DNA is directly injected into the nucleus of an animal cell of micro-pipettes.
- **Biolistic or gene gun method:** Cells are bombarded with high velocity micro-particles of gold or tungsten coated with DNA in plants.

- Disarmed pathogen vectors are also used to transfer *r*DNA like *Agrobacterium tumefaciens*.

8. Process of Recombinant DNA Technology

- Recombinant DNA technology involves the following steps:
  - (*i*) Isolation of DNA
  - (*ii*) Fragmentation of DNA by restriction endonucleases
  - (*iii*) Isolation of a desired DNA fragment
  - (*iv*) Amplification of the gene of interest
  - (*v*) Ligation of the DNA fragment into a vector
  - (*vi*) Insertion of recombinant DNA into the host
  - (*vii*) Culturing the host cells on a suitable medium at a large scale
  - (*viii*) Extraction of the desired gene product
  - (*ix*) Downstream processing of the products as finished product, ready for marketing

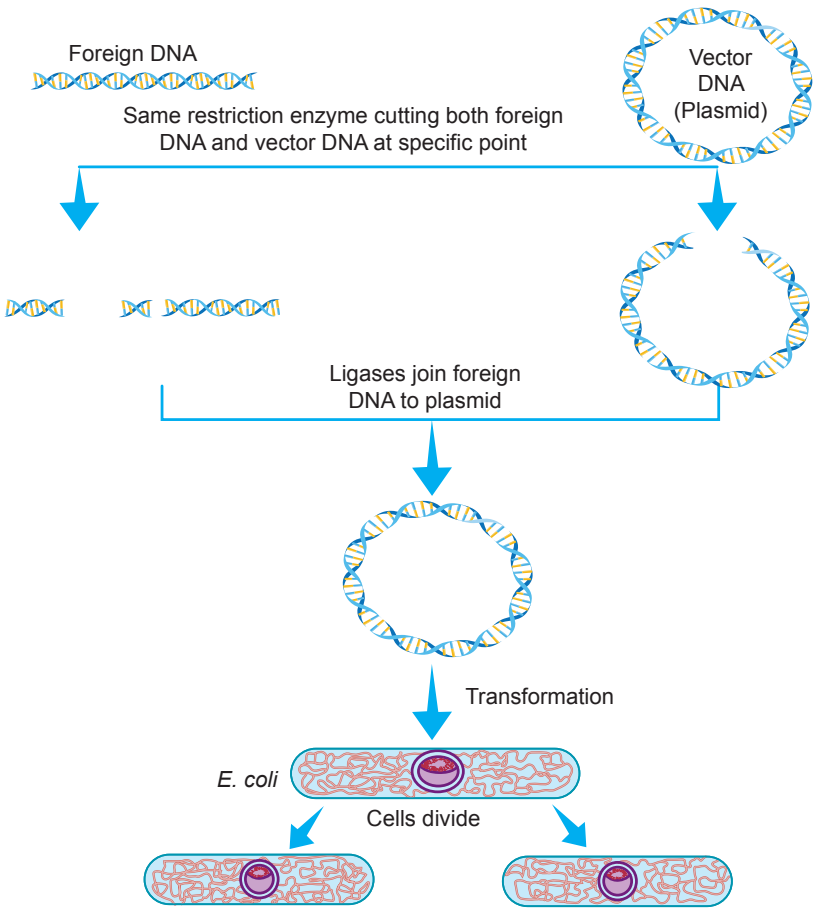


Fig. 11.4 Diagrammatic representation of recombinant DNA technology

(i) Isolation of the genetic material (DNA)

- To cut DNA with restriction enzymes DNA should be purified, free from other macromolecules.
- The bacterial/plant/animal cell is broken down by enzymes to release DNA, along with RNA, proteins, polysaccharides and lipids.
- Bacterial cell is treated with enzyme **lysozyme**.
- Plant cell is treated with enzyme **cellulase**.
- Fungal cell is treated with **chitinase**.

- RNA is removed by treatment with **ribonuclease** and proteins are removed by treatment with **protease**.
- After several treatments, the purified DNA is precipitated by adding chilled **ethanol**.

(ii) Cutting of DNA at specific locations

- The DNA is cut using restriction enzymes.
- The purified DNA is incubated, with the specific restriction enzyme at conditions optimum for the enzyme to act.
- Process is repeated with vector DNA also.

(iii) Isolation of desired DNA fragment

- Using agarose gel electrophoresis, the activity of the restriction enzymes can be checked.
- Since the DNA is negatively charged, it moves towards the positive electrode or anode and in the process, DNA fragments separate out based on their sizes.
- The desired DNA fragment is eluted out.

(iv) Amplification of gene of interest using PCR

- The Polymerase Chain Reaction (PCR) is a reaction in which amplification of specific DNA sequences is carried out *in vitro*.
- This technique was developed by **Kary Mullis** in 1985, and for this, he received Nobel Prize for Chemistry in 1993.

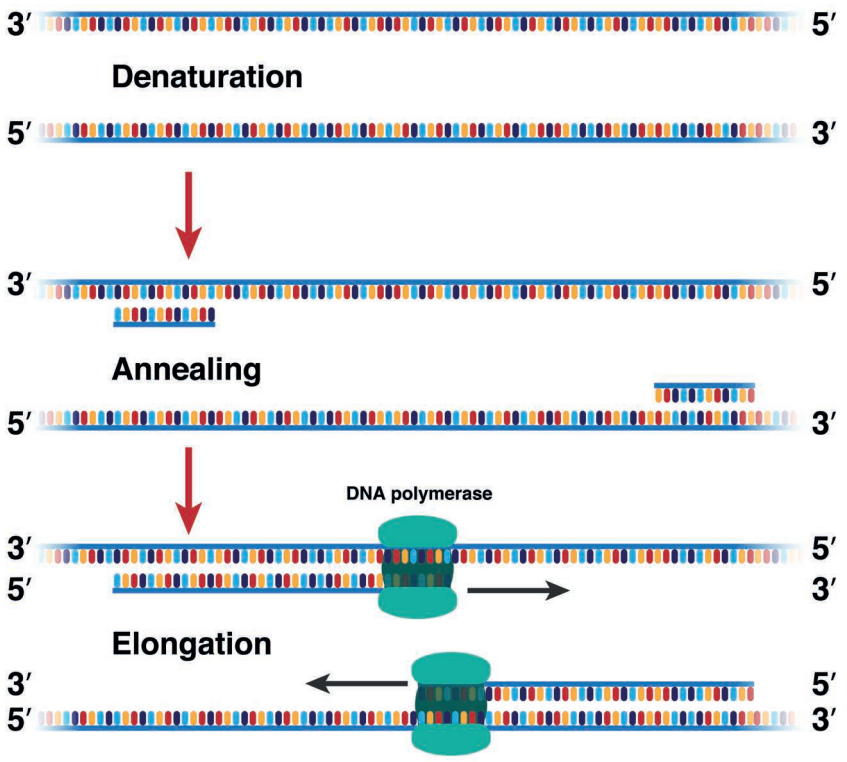


Fig. 11.5. Polymerase chain reaction (PCR)

- **Requirements for PCR:**
  - **(*a*) DNA template:** The double-stranded DNA that needs to be amplified.
  - **(*b*) Primers:** Small chemically synthesised oligonucleotides of about 10–18 nucleotides that are complementary to a region of template DNA.
  - **(*c*) Enzyme:** Two commonly used enzymes are ***Taq* polymerase** (isolated from thermophilic bacterium, *Thermus aquaticus*) and **Vent polymerase** (isolated from *Thermococcus litoralis*).
- PCR is carried out in the following three steps:

(*a*) Denaturation

— The double-stranded DNA is denatured by subjecting it to high temperature of 94°C for 15 seconds. Each separated single stranded strand now acts as template for DNA synthesis.

(*b*) Annealing

— Two sets of primers are added which anneal to the 3′ end of each separated strand.

— Primers act as initiators of replication.

(*c*) Extension

— DNA polymerase extends the primers by adding nucleotides complementary to the template provided in the reaction.

— A thermostable DNA polymerase (*Taq* polymerase) is used in the reaction which can tolerate the high temperature of the reaction.

— All these steps are repeated many times to obtain several copies of desired DNA.

(v) Ligation of DNA fragment into a vector

- The vector DNA and source DNA are cut with the same endonuclease to obtain sticky ends.
- These are then ligated by mixing vector DNA, gene of interest and enzyme DNA ligase to form a recombinant DNA.

(vi) Insertion of recombinant DNA into the host cell/organism

- Introduction of ligated DNA into recipient cells occurs by several methods, before which the recipient cells are made competent to receive the DNA.
- If recombinant DNA carrying antibiotic resistance (*e.g.*, ampicillin) is transferred into *E. coli* cells, the host cell is transformed into ampicillin-resistant cells.
- The ampicillin resistant gene in this case is called a selectable marker.
- On growing transformed cells on agar plates containing ampicillin, only transformants will grow and others will die.

(vii) Culturing the host cells

- The transformed host cells are grown in appropriate nutrient medium at optimal conditions.
- The DNA gets multiplied and expresses itself to form desired product.

(viii) Extraction of desired gene product

- When a protein encoding gene is expressed in a heterologous host, it is called a **recombinant protein**.
- The cells having genes of interest can be grown on a small scale or on a large scale.
- **On small scale,** the cells are grown on cultures in laboratory and then the expressed protein is extracted and purified by different separation techniques.
- **On large scale,** the cells are grown in a continuous culture system in which fresh medium is added from one side, to maintain cells in exponential growth phase and the desired protein is collected from the other side.
- In large scale method, larger biomass is produced which leads to high yield.

(ix) Downstream processing

- All the processes to which a product is subjected to before being marketed as a finished product are called **downstream processing**.
- It includes:
  (*a*) Separation of the product from the reactor.
  (*b*) Purification of the product.
  (*c*) Formulation of the product with suitable preservatives.
  (*d*) Quality control testing and clinical trials in case of drugs.

9. Bioreactors

- Bioreactors are vessels of large volumes (100–1000 litres) in which raw materials are biologically converted into specific products.
- It provides all the optimal conditions for achieving the desired product by providing optimal growth conditions like temperature, pH, substrates, salts, vitamins and oxygen.
- Stirred-tank bioreactors are commonly used bioreactors.

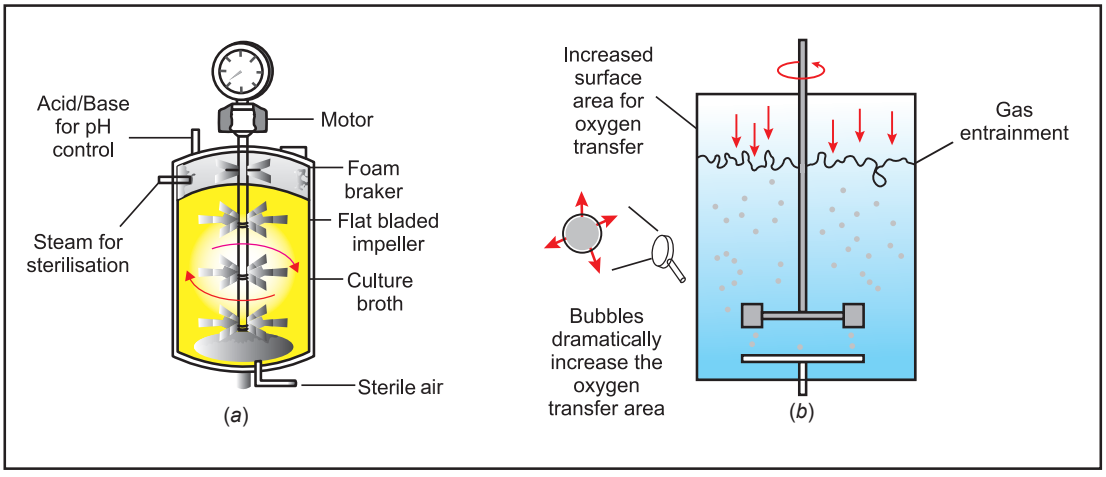


Fig. 11.6. (*a*) Simple stirred-tank bioreactor; (*b*) Sparged stirred-tank bioreactor through which sterile air bubbles are sparged.

- These are cylindrical with curved base to facilitate (*i*) proper mixing of the contents, (*ii*) maintain oxygen availability throughout the bioreactor.
- **Stirred tank reactor** has (*i*) better temperature and pH control, (*ii*) foam control system to prevent foam and shearing damage to cells due to agitation, (*iii*) system sterilisation, and (*iv*) provision to withdraw small volumes of cultures periodically.
- A bioreactor has the following components:
  (*i*) An agitator system
  (*ii*) An oxygen delivery system
  (*iii*) Foam control system
  (*iv*) Temperature control system
  (*v*) pH control system
  (*vi*) Sampling ports to withdraw cultures periodically
- The stirrer mixes the contents and makes oxygen available throughout the bioreactor.
- **Sparged stirred-tank** reactor is a stirred type reactor in which air is bubbled.

NCERT Textbook Questions

Q. 1. Can you list 10 recombinant proteins which are used in medical practice? Find out where they are used as therapeutics (use the internet).

Ans.

S. No.	Recombinant proteins	Therapeutic uses
(*i*)	Human Insulin (Humulin)	Treatment of diabetes type 1.
(*ii*)	Tissue Plasminogen Activator	Treatment for acute myocardial infarction; dissolves blood clot after heart attack and stroke.
(*iii*)	DNase	Treatment of cystic fibrosis.
(*iv*)	Platelet Growth Factor	Stimulation of wound healing.
(*v*)	Calcitonin	Treatment of rickets.
(*vi*)	Reo Pro	Prevention of blood clots.
(*vii*)	Hirudin	Used as an anticoagulant.
(*viii*)	Interferon (α, β and γ)	Treatment of viral infection and cancer.
(*ix*)	Chorionic Gonadotropin	Treatment of infertility.
(*x*)	Interleukins	Enhancing activity of immune system.

Q. 2. Make a chart (with diagrammatic representation) showing a restriction enzyme, the substrate DNA on which it acts, the site at which it cuts DNA and the product it produces.

Ans. Refer to Fig. 11.1.

Q. 3. From what you have learnt, can you tell whether enzymes are bigger or DNA is bigger in molecular size? How did you come to know? ***[HOTS]***

Ans. DNA is bigger in molecular size. DNA is made up of sugar, phosphate and nitrogenous bases. An enzyme is made up of only protein (one or few polypeptides), so there is no complexity of molecules.

Q. 4. What would be the molar concentration of human DNA in a human cell? Consult your teacher. ***[HOTS]***

Ans. The average molecular weight of a nucleotide pair is 330 dalton. Genome size of a diploid human cell is around 6×10^9 bp. The concentration of DNA will be $330 \times 6 \times 10^9$ g/mol.

The molarity can then be calculated as:

$$\frac{\text{Sample DNA concentration (in g)}}{330 \times 6 \times 10^9 \text{ g/mol}}$$

Q. 5. Do eukaryotic cells have restriction endonucleases? Justify your answer. ***[HOTS]***

Ans. Eukaryotic cells have no restriction enzymes as the DNA molecules of eukaryotes are heavily methylated. It is present in prokaryotic cell (like bacteria) where these act as defence mechanism to restrict the growth of bacteriophages.

Q. 6. Besides better aeration and mixing properties, what other advantages do stirred tank bioreactors have over shake flasks?

Ans. Other advantages of stirred tank bioreactors over shake flasks are that these facilitate temperature control system, pH control system, foam control system and sampling ports from where small volume of the cultures can be obtained and tested time to time.

Q. 7. Collect 5 examples of palindromic DNA sequences by consulting your teacher. Better try to create a palindromic sequence by following base-pair rules.

Ans. (*i*) 5′ G A A T T C 3′
3′ C T T A A G 5′

(*ii*) 5′ G G A T C C 3′
3′ C C T A G G 5′

(*iii*) 5′ A C T A G T 3′
3′ T G A T C A 5′

(*iv*) 5′ A A G C T T 3′
3′ T T C G A A 5′

(*v*) 5′ A G G C C T 3′
3′ T C C G G A 5′

Q. 8. Can you recall meiosis and indicate at what stage a recombinant DNA is made?

Ans. A recombinant DNA is made during pachytene stage of meiosis-I by crossing over.

Q. 9. Can you think and answer how a reporter enzyme can be used to monitor transformation of host cells by foreign DNA in addition to a selectable marker? ***[HOTS]***

Ans. A reporter gene encodes an enzyme, with an easily transcriptional activity of a gene of interest. A reporter gene is the one whose phenotypic expression can be monitored and thus it reports about activity or change in advance of the effect of modification, in addition to eliminating non-transformed cells by selectable markers.

Q. 10. Describe briefly the following:

(*a*) Origin of replication (*b*) Bioreactors (*c*) Downstream processing

Ans. (*a*) Origin of replication is a DNA sequence that initiates any piece of linked DNA to replicate and is also called *ori* site. It controls the copy numbers of the linked DNA.

(*b*) Refer to Basic Concepts Point 9.

(*c*) Refer to Basic Concepts Point 8 (*ix*).

Q. 11. Explain briefly

(*a*) PCR (*b*) Restriction enzymes and DNA (*c*) Chitinase

Ans. (*a*) PCR stands for Polymerase Chain Reaction, which is a method for amplification of small segments of DNA.

(*b*) Restriction enzymes are also called 'molecular scissors' because they cut the helix of DNA at a specific site. DNA is the genetic material, which carries and pass the genetic characters or information from one generation to other.

(*c*) Chitinase is an enzyme which is used to cut or break the cell wall of fungi to release its cellular components.

Q. 12. Discuss with your teacher and find out how to distinguish between

(*a*) Plasmid DNA and chromosomal DNA (*b*) RNA and DNA

(*c*) Exonuclease and endonuclease

Ans. **(*a*)**

Table 11.1: Differences between Plasmid DNA and Chromosomal DNA

S. No.	Plasmid DNA	Chromosomal DNA
(*i*)	This is present in prokaryotic cells (bacteria).	This is present in both prokaryotic and eukaryotic cells.
(*ii*)	This is the circular extra-chromosomal DNA not associated with histone proteins.	It is linear and associated with histones proteins in eukaryotes but is double stranded and circular in prokaryotes.
(*iii*)	It gives the cell extra characters like antibiotic resistance.	It contains genes for characters essential for life of organism.

(*b*)

Table 11.2: Differences between DNA and RNA

S. No.	DNA	RNA
(*i*)	It has deoxyribose sugar.	It has ribose sugar.
(*ii*)	It is the genetic material in almost all organisms.	It is the genetic material in only some viruses.
(*iii*)	It is double stranded.	It is single stranded.
(*iv*)	It has A, G, C, T bases.	It has A, G, C, U bases.

(*c*)

Table 11.3: Differences between Exonuclease and Endonuclease

S. No.	Exonuclease	Endonuclease
(*i*)	These cut the end regions of the DNA.	These cut at specific regions within the DNA.
(*ii*)	These act on single strand of DNA.	These act on both strands as well as on DNA strand.

Multiple Choice Questions [1mark]

Choose and write the correct option in the following questions.

1. **Restriction endonuclease**
   (*a*) synthesizes DNA
   (*b*) cuts the DNA molecues randomly
   (*c*) cuts the DNA molecule at specific sites
   (*d*) restricts the synethesis of DNA inside the nuclease

2. **The linking of antibiotic resistance gene with the plasmid vector became possible with**
   (*a*) DNA polymerase (*b*) exonucleases
   (*c*) DNA ligase (*d*) endonucleases

3. **Stirred-tank bioreactors have been designed for**
   (*a*) addition of preservatives to the product
   (*b*) purification of the product
   (*c*) ensuring anaerobic conditions in the culture vessel
   (*d*) availability of oxygen throughout the process

4. **Given below is a sample of a portion of DNA strand giving the base sequence on the opposite strands. What is so special shown in it?**

   5′_____GAATTC_____3′

   3′_____CTTAAG_____5′

   (*a*) Replication completed (*b*) Deletion mutation
   (*c*) Start codon at the 5′ level (*d*) Palindromic sequence of base pairs

5. **There is a restriction endonuclease called *Eco RI*. What does "co" part in it stand for?**
   (*a*) Colon (*b*) Coelom
   (*c*) Coenzyme (*d*) Coli

6. **Agarose extracted from sea weeds is used in**
   (*a*) spectrophotometry (*b*) tissue culture
   (*c*) PCR (*d*) gel electrophoresis

7. **An enzyme catalysing the removal of nucleotides from the ends of DNA is** [*NCERT Exemplar*]
   (*a*) endonuclease (*b*) exonuclease
   (*c*) DNA ligase (*d*) *Hind-II*

8. **The transfer of genetic material from one bacterium to another through the mediation of a viral vector is termed as:** [*NCERT Exemplar*]
   (*a*) transduction (*b*) conjugation
   (*c*) transformation (*d*) translation

9. **Which of the given statements is correct in the context of observing DNA separated by agarose gel electrophoresis?** [*NCERT Exemplar*]
   (*a*) DNA can be seen in visible light
   (*b*) DNA can be seen without staining in visible light
   (*c*) Ethidium bromide stained DNA can be seen in visible light
   (*d*) Ethidium bromide stained DNA can be seen under exposure to UV light

10. **Which of the following is not a characterstic of the plasmids ?**
    (*a*) Extranuclear (*b*) Single-stranded
    (*c*) Independent replication (*d*) Circular DNA

11. DNA fragments generated by the restriction endonuclease in a chemical reaction can be separated by

(*a*) Gel electrophoresis (*b*) Restriction mapping

(*c*) Centrifugation (*d*) PCR

12. Which of the following is not required in the preparation of a recombinant DNA molecule? **[*NCERT Exemplar*]**

(*a*) Restriction endonuclease (*b*) DNA ligase

(*c*) DNA fragments (*d*) *E.coli*

13. In agarose gel electrophoresis, DNA molecules are separated on the basis of their **[*NCERT Exemplar*]**

(*a*) charge only (*b*) size only

(*c*) charge to size ratio (*d*) All of the above

14. The most important feature in a plasmid to be used as a vector is **[*NCERT Exemplar*]**

(*a*) origin of replication (*ori*) (*b*) presence of a selectable marker

(*c*) presence of sites for restriction endonuclease (*d*) its size

15. While isolating DNA from bacteria, which of the following enzymes is not required? **[*NCERT Exemplar*]**

(*a*) Lysozyme (*b*) Ribonuclease

(*c*) Deoxyribonuclease (*d*) Protease

16. Which of the following has popularised the PCR (polymerase chain reactions)? **[*NCERT Exemplar*]**

(*a*) Easy availability of DNA template

(*b*) Availability of synthetic primers

(*c*) Availability of cheap deoxyribonucleotides

(*d*) Availability of 'Thermostable' DNA polymerase

17. Select the correct sequence of processing of PCR.

(*a*) Extension, primer annealing, denaturation

(*b*) Denaturation, primer annealing, extension

(*c*) Denaturation, extension, primer annealing

(*d*) Primer annealing, denatturatiotn, extension

18. Which of the following is/are used in recombinant DNA technology ?

1. Agarose gel 2. Restriction endonuclease

3. Plasmid vector 4. Ethidium bromide

(*a*) 1 and 2 (*b*) 2 and 3

(*c*) 3 and 4 (*d*) All of these

19. An antibiotic resistance gene in a vector usually helps in the selection of **[*NCERT Exemplar*]**

(*a*) competent cells (*b*) transformed cells

(*c*) recombinant cells (*d*) none of the above

20. Significance of 'heat shock' method in bacterial transformation is to facilitate **[*NCERT Exemplar*]**

(*a*) binding of DNA to the cell wall

(*b*) uptake of DNA through membrane transport proteins

(*c*) uptake of DNA through transient pores in the bacterial cell wall

(*d*) expression of antibiotic resistance gene

21. The role of DNA ligase in the construction of a recombinant DNA molecule is [*NCERT Exemplar*]

(*a*) formation of phosphodiester bond between two DNA fragments
(*b*) formation of hydrogen bonds between sticky ends of DNA fragments
(*c*) ligation of all purine and pyrimidine bases
(*d*) None of the above

22. Which of the following steps are catalysed by *Taq* DNA polymerase in a PCR reaction? [*NCERT Exemplar*]

(*a*) Denaturation of template DNA
(*b*) Annealing of primers to template DNA
(*c*) Extension of primer end on the template DNA
(*d*) All of the above

23. A bacterial cell was transformed with a recombinant DNA molecule that was generated using a human gene. However, the transformed cells did not produce the desired protein. Reasons could be: [*NCERT Exemplar*]

(*a*) Human gene may have intron which bacteria cannot process
(*b*) Amino acid codons for humans and bacteria are different
(*c*) Human protein is formed but degraded by bacteria
(*d*) All of the above

24. In genetic engineering, the antibiotics are used

(*a*) as selectable markers
(*b*) to keep the cultures free of inection
(*c*) to select healthy vectors
(*d*) as sequence from where replication starts

25. Which of these is not correctly matched?

(*a*) Gene gun—biolistic gun
(*b*) Plasmids—extrachromosomal DNA
(*c*) DNA ligase—biological scissors
(*d*) Bacteriophages—viruses

26. Which of the following statements does not hold true for restriction enzyme? [*NCERT Exemplar*]

(*a*) It recognises a palindromic nucleotide sequence
(*b*) It is an endonuclease
(*c*) It is isolated from viruses
(*d*) It can produce the same kind of sticky ends in different DNA molecules

Answers

1. (*c*)	**2.** (*c*)	**3.** (*d*)	**4.** (*d*)	**5.** (*d*)	**6.** (*d*)	**7.** (*b*)	**8.** (*a*)	**9.** (*d*)	**10.** (*b*)
11. (*a*)	**12.** (*d*)	**13.** (*d*)	**14.** (*a*)	**15.** (*c*)	**16.** (*d*)	**17.** (*b*)	**18.** (*d*)	**19.** (*b*)	**20.** (*c*)
21. (*a*)	**22.** (*c*)	**23.** (*a*)	**24.** (*a*)	**25.** (*c*)	**26.** (*c*)				

Assertion-Reason Questions

In the following questions a statement of assertion followed by a statement of reason is given. Choose the correct answer out of the following choices.

(a) Assertion and reason both are correct statements and reason is correct explanation for assertion.
(b) Assertion and reason both are correct statements but reason is not correct explanation for assertion.
(c) Assertion is correct statement but reason is wrong statement.
(d) Assertion is wrong statement but reason is correct statement.

1. Assertion : Plasmids are single stranded extrachromosomal DNA.
Reason : Plasmids are found in eukaryotic cells.

2. Assertion : Plasmids are extrachromosomal DNA.
Reason : Plasmids are found in bacteria and are useful in genetic engineering.

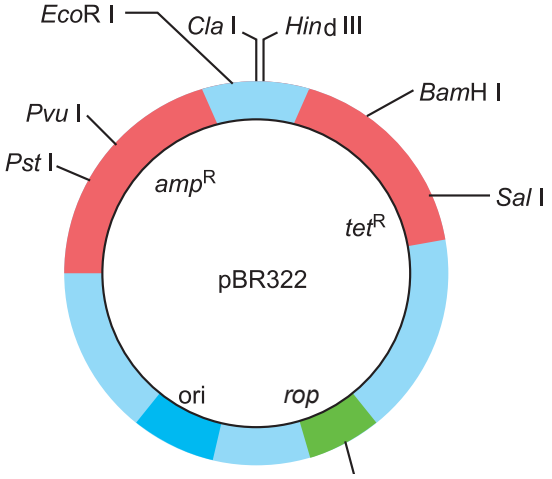
3. **Assertion :** In recombinant DNA technology, human genes are often transferred into bacteria (prokaryotes) or yeast (eukaryote).
   Reason : Both bacteria and yeast multiply very fast to form huge population which express the desired gene.
4. **Assertion :** Insertion of recombinant DNA within the coding sequence of beta-galactosidase results in colourless colonies.
   Reason : Presence of insert results in inactivation of enzyme beta-galactosidase known as insertional inactivation.
5. **Assertion :** In recombinant DNA technology both ligase and nuclease play an important role.
   Reason : Ligase cuts the DNA at specific sites and nuclease joins the DNA fragments.
6. **Assertion :** *E.coli* having *pBR*322 with DNA insert at *Bam*HI site cannot grow in medium containing tetracycline.
   Reason : Recognition site for *Bam*HI is present in tet^r region of *pBR*322.
7. **Assertion :** Downstream processing include separation and purification of product.
   Reason : Before release of the product, it needs to be tested for quality control.
8. **Assertion :** PCR primers do not have self complementary regions.
   Reason : PCR involves use of *Taq* polymerase as it can withstand the high temperature of the process.
9. **Assertion :** Restriction enzymes recognise palindromic sequences.
   Reason : Palindromic sequences read the same in both directions of the strands.
10. **Assertion :** For isolating DNA from yeast cell, chitinase enzyme is necessary.
    Reason : Cell wall of fungi are made up of chitin.

Answers

1. (*c*) **2.** (*a*) **3.** (*a*) **4.** (*a*) **5.** (*c*) **6.** (*a*) **7.** (*b*) **8.** (*d*) **9.** (*b*) **10.** (*a*)

Case-based/Source-based Question

1. **(*i*) Name the organism in which the vector shown is inserted to get the copies of the desired gene.**
   (*ii*) Mention the area labelled in the vector responsible for controlling the copy number of the inserted gene.
   (*iii*) Name and explain the role of a selectable marker in the vector shown.

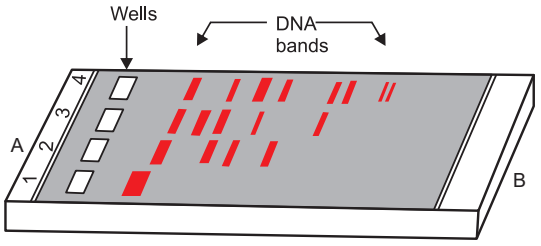


Ans. (*i*) *Escherichia coli*.

(*ii*) Origin of replication or '*ori*' controls copy number of inserted gene.

(*iii*) The selectable markers are *amp*^{R} and *tet*^{R} (resistance to ampicillin, tetracycline). Selectable markers help to select the host cells which contain the vector (transformants) and eliminate non-transformants. If a foreign DNA ligates at the *Bam*HI site of tetracycline resistance gene in the vector pBR322, the recombinant plasmid loses the tetracycline resistance due to insertion of DNA. It can still be selected out from non-recombinant.

2. Rajesh was doing gel electrophoresis to purify DNA fragments. Given below is the sketch of the observations of the experiment performed by him.



(*i*) At which end he would have loaded the samples and where?

(*ii*) Analyse the reason for different positions taken up by the DNA bands.

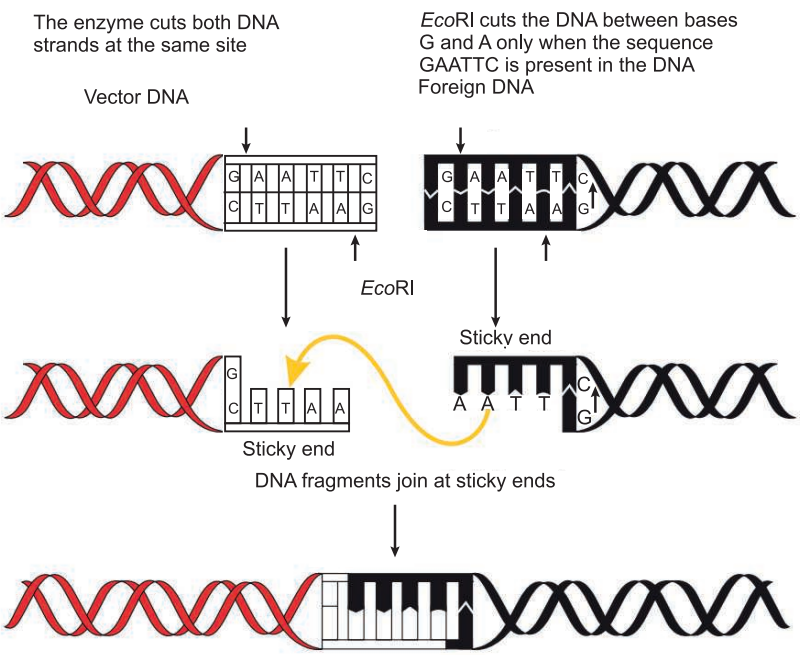
(*iii*) Elaborate the step he would have followed to visualise DNA bands.

Ans. (*i*) He would have loaded the samples near end A; in the wells.

(*ii*) The DNA fragments separate (resolve) according to their size through sieving effect provided by the agarose gel. Hence, the smaller the fragment size, the farther it moves.

(*iii*) After staining the DNA with ethidium bromide followed by exposure to UV radiations the DNA bands appear coloured.

3. Study the diagram given below and answer the questions that follow:



(*i*) What is *Eco*RI?

(*ii*) How is the action of exonuclease different from that of endonuclease?

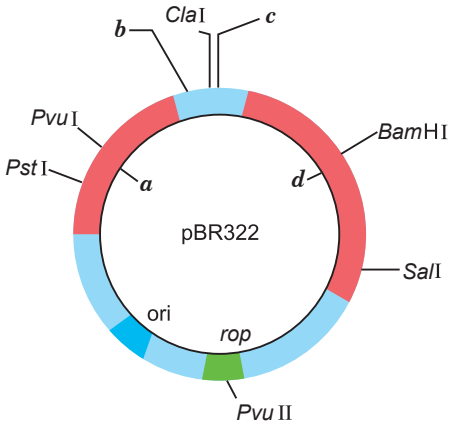
(*iii*) How are 'sticky ends' formed on a DNA strand? Why are they so called?

Ans. (*i*) *Eco*RI is a restriction endonuclease enzyme.

(*ii*) Exonucleases cleave the DNA molecules at their ends whereas endonucleases cleave DNA molecules internally.

(*iii*) Restriction enzymes cut the strands of the DNA, a little away from the centre of the palindromic sites, but between the same two bases on opposite strands. This leaves sticky single stranded position at the ends. These overhanging stretches are aids. These are named so because they form hydrogen bonds with their complementary cut counterparts very easily.

4. Observe the diagram of the first artificial plasmid vector pBR322.



(*i*) Identify the selectable markers in the diagram of *E. coli* vector shown above.

(*ii*) How is the coding sequence of β-galactosidase considered a better marker than the ones identified by you in the diagram? Explain.

(*iii*) Why is it essential to have a 'selectable marker' in a cloning vector? **[*CBSE (AI) 2011*]**

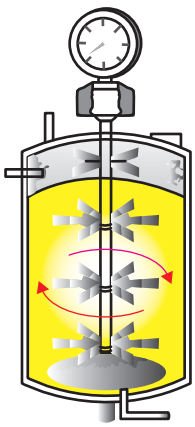
Ans. (*i*) a—gene for ampicillin resistance

d—gene for tetracycline resistance.

(*ii*) The insertion of *r*DNA into the coding sequence of an enzyme β-galactosidase leads to the inactivation of the enzyme. This is called insertional inactivation. The recombinants do not produce blue-coloured colonies in the presence of chromogenic substrate while the non-recombinants produce a blue colour. Thus, coding sequence of β-galactosidase is a better marker.

(*iii*) Selectable markers are essential to identify and eliminate non-transformants, by selectively permitting the growth of the transformant.

5. Bioreactors are vessels for production of large-scale gene products.



Answer the following questions based on the above information.

(*i*) How has the development of bioreactors helped in biotechnology?

(*ii*) What are recombinant proteins?

(*iii*) How do bioreactors help in their production?

Ans. (*i*) In bioreactors large volume of culture can be processed which results in higher yields of the desired specific products (protein/enzyme). The entire process takes place under the controlled conditions of temperature, pH and raw materials.

(*ii*) The protein produced by genetically altered gene in a host is called recombinant protein. Bioreactors are vessels in which raw materials are biologically converted into specific products by microbes.

(*iii*) It provides optimum growth conditions such as temperature, pH, substrate, vitamins, oxygen and salts.

Very Short Answer Questions [1 mark]

Q. 1. Write the two components of the first artificial recombinant DNA molecule constructed by Cohen and Boyer. ***[CBSE (F) 2014, CBSE Sample Paper 2018]***

Ans. The two components were—antibiotic resistance gene and plasmid vector of *Salmonella typhimurium*.

Q. 2. What is the host called that produces a foreign gene product? What is this product called? ***[CBSE (F) 2010]***

Ans. The host that produces a foreign gene product is called competent host. The product is called recombinant protein.

Q. 3. Give any two microbes that are useful in biotechnology. ***[NCERT Exemplar]***

Ans. *E. coli* and *Saccharomyces cerevisiae*.

Q. 4. Mention the uses of cloning vector in biotechnology. ***[CBSE Delhi 2011]***

Ans. Cloning vectors are used for transferring fragments of foreign DNA into a suitable host. They are also used to select recombinants from non-recombinants.

Q. 5. What is the function of restriction enzyme?

Ans. To cut DNA at specific site.

Q. 6. Name the first plasmid used as vector.

Ans. pBR322.

Q. 7. What are palindromes?

Ans. Palindromes are group of letters (sequences) that read same both in forward and backward direction.

Q. 8. What is recombinant DNA?

Ans. Recombinant DNA is the DNA formed by combining DNAs from two different organisms.

Q. 9. Biotechnologists refer to *Agrobacterium tumifaciens* as a natural genetic engineer of plants. Give reasons to support the statement. ***[CBSE (AI) 2011]*** ***[HOTS]***

Ans. This is because *A. tumifaciens* can transfer genes naturally by delivering a piece of T-DNA to plant cells. It has a tumour inducing plasmid.

Q. 10. Why is the enzyme cellulase needed for isolating genetic material from plant cells and not from the animal cells? ***[CBSE Delhi 2010, 2013]*** ***[HOTS]***

Ans. The enzyme cellulase breaks down cellulose which is present in cell walls of plants but absent in animal cells.

Q. 11. Name the compound used for staining the isolated DNA in the gel electrophoresis.

Ans. Ethidium bromide.

Q. 12. Why does DNA move towards the anode in gel electrophoresis? [*HOTS*]

Ans. The DNA fragments are negatively charged so they move towards the positively charged anode.

Q. 13. Suggest a technique to a researcher who needs to separate fragments of DNA. [*CBSE Delhi 2016*]

Ans. Gel electrophoresis is used to separate DNA fragments.

Q. 14. What is gene gun?

Ans. The instrument for bombarding micro-projectile particles (gold/tungsten particles) coated with foreign DNA, with great velocity, into a target cell is called gene gun.

Q. 15. How does an alien DNA gain entry into a plant cell by 'biolistics' method? [*CBSE (F) 2013*]

Ans. In biolistics method, cells are bombarded with high velocity micro-particles of gold or tungsten coated with DNA.

Q. 16. Why EtBr is used in gel electrophoresis inspite of it being highly carcinogenic? [*CBSE Sample Paper 2014*]

Ans. Ethidium bromide (EtBr) exchanges its visible range of wavelength with the invisible wavelength of DNA, to make it visible under UV light.

Q. 17. Mention the type of host cells suitable for the gene guns to introduce an alien DNA. [*CBSE Delhi 2014*] [*HOTS*]

Ans. Plant cells

Q. 18. Why is it not possible for an alien DNA to become part of a chromosome anywhere along its length and replicate normally? [*CBSE (AI) 2014*] [*HOTS*]

Ans. Alien DNA must be linked to *ori* or origin of replication site to start replication.

Q. 19.Name the host cells in which micro-injection technique is used to introduce an alien DNA. [*CBSE (F) 2014*] [*HOTS*]

Ans. Animal cells.

Q. 20. Write the name of the enzymes that are used for isolation of DNA from bacterial and fungal cells respectively for Recombinant DNA technology. [*CBSE Delhi 2011; (AI) 2014; (F) 2014*] [*HOTS*]

Ans. Bacterial cell is treated with enzyme lysozyme.

Fungal cell is treated with chitinase.

Q. 21. Which main technique and instrument is used to isolate DNA from any plant cell? [*CBSE Sample Paper 2014*]

Ans. Centrifugation and centrifuge

Q. 22. What is the cell that receives a recombinant gene called? [*CBSE 2019 (57/4/1)*]

Ans. Competent host cell/recipient cell.

Q. 23. Why is a thermostable DNA polymerase needed in amplification (genetic engineering)? [*HOTS*]

Ans. Because thermostable DNA polymerase remains active even at high temperature required for extension step of PCR.

Q. 24. Identify the reason for selection of DNA polymerase from *Thermus aquaticus* for Polymerase Chain Reaction. [*CBSE Sample Paper 2016*]

Ans. DNA polymerase from *Thermus aquaticus* remains active during the high temperature induced denaturation of double stranded DNA.

Q. 25. How is repetitive/satellite DNA separated from bulk genomic DNA for various genetic experiments? [*CBSE Delhi 2014*]

Ans. By density gradient centrifugation.

Q. 26. How can bacterial DNA be released from the bacterial cell for biotechnology experiments? [*CBSE Delhi 2011*]

Ans. The bacterial cell wall is digested by the enzyme lysozyme to release DNA from the cell.

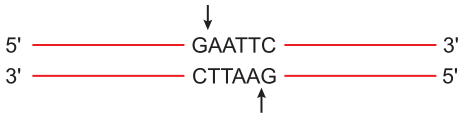
Short Answer Questions [2 marks]

Q. 1. Explain the work carried out by Cohen and Boyer that contributed immensely in biotechnology. ***[CBSE Delhi 2012]***

Ans. Stanley Cohen and Herbert Boyer in 1972 constructed the first recombinant DNA. They isolated the antibiotic resistance gene by cutting out a piece of DNA from the plasmid of a bacterium which was responsible for conferring antibiotic resistance. The cut piece of DNA was then linked with the plasmid DNA of *Salmonella typhimurium* and transferred to *E. coli* for transformation.

Q. 2. Explain with the help of an example the relationship between restriction endonuclease and a palindromic nucleotide sequence. ***[CBSE (F) 2016]***

Ans. Restriction endonuclease recognises a specific palindromic nucleotide sequence in the DNA. Restriction endonuclease cuts the strand of DNA a little away from the centre of palindromic nucleotide sequence but between the same two bases on the opposite strands, leaving single stranded portions at the end called sticky ends.



Q. 3. Explain palindromic nucleotide sequence with the help of a suitable example. ***[CBSE (F) 2014]***

Ans. The palindrome in DNA is a sequence of base pairs that reads same on the two strands when orientation of reading is kept the same. For example, the following sequences reads the same on the two strands in 5′ ⟶ 3′ direction. This is also true if it is read in the 3′ ⟶ 5′ direction.

5′ — — GAATTC — — 3′
3′ — — CTTAAG — — 5′

Q. 4. Why are molecular scissors so called? Write their use in biotechnology. ***[CBSE (F) 2014]***

Ans. (*a*) The restriction endonucleases are called molecular scissors, as they cut the DNA segments at particular locations, *e.g.*, *Eco*RI.

(*b*) The restriction enzymes cut the DNA strands a little away from the centre of the palindromic sites, but between the same two bases on the opposite strands. This leaves single stranded portions with overhanging stretches called sticky ends on each strand as they form hydrogen bonds with their complementary cut counterparts. This stickiness at the ends facilitates the action of the enzyme DNA ligase.

Q. 5. Explain the role of the enzyme *Eco*RI in recombinant DNA technology. ***[CBSE (F) 2016]***

Ans. *Eco*RI inspects length of DNA and recognises specific palindromic nucleotide sequences. It then binds with DNA and cuts each of the two strands of double helix at specific points.

Refer to Basic Concepts Point 4 (Mechanism of Action of Endonucleases).

The first endonuclease discovered was *Hin*dII.

Q. 6. Write the convention used for naming restriction enzymes. ***[CBSE (F) 2011]***

OR

Explain with the help of a suitable example the naming of a restriction endonuclease. ***[CBSE Delhi 2014]***

Ans. The convention for naming restriction enzymes is that the first letter to the name comes from the Genus and the second two letters come from species and third letter indicates the strain of the prokaryotic cell from which they are isolated *e.g.*, *Eco*RI comes from *Escherichia coli* RI, here R stands for the strain and I follows the order in which the enzyme was isolated.

Q. 7. Name the natural source of agarose. Mention one role of agarose in biotechnology.

Ans. The natural source of agarose is sea weed. Agarose is a natural polymer. It is used to develop the matrix for gel electrophoresis. It helps in the separation of DNA fragments based on their size.

Q. 8. Write any four ways used to introduce a desired DNA segment into a bacterial cell in recombinant technology experiments. **[*CBSE (AI) 2013*]**

Ans. (*i*) The desired DNA segment is inserted into a cloning vector and the bacterial cell can be made to take it up after making them competent by treating them with specific concentration of divalent cations such as calcium.

(*ii*) Microinjection

(*iii*) Biolistics

(*iv*) Disarmed pathogen vector

Q. 9. State how has *Agrobacterium tumefaciens* been made a useful cloning vector to transfer DNA to plant cells. **[*CBSE Delhi 2014*]**

Ans. *Agrobacterium tumifaciens* is known to be a natural vector and consists of a pathogenic plasmid. It is capable of passing its DNA to plants and induce tumour by integrating its DNA with host genome. The tumour causing gene in the plasmid of this bacteria is replaced by gene of interest and is now used as a cloning vector to transfer the DNA into plant cells.

Q. 10. What are 'cloning sites' in a cloning vector? Explain their role. Name any two such sites in pBR322. **[*CBSE (AI) 2014*]**

Ans. Cloning sites are the recognition sites on plasmid. The restriction enzymes recognise these sites for cutting and ligation of alien DNA at this place. For example, *Eco*RI, *Bam*HI.

Q. 11. (*a*) Mention the difference in the mode of action of exonuclease and endonuclease.

(*b*) How does restriction endonuclease function? **[*CBSE Delhi 2013*]**

Ans. (*a*) Exonuclease removes nucleotides from the ends of DNA whereas endonuclease cuts at specific positions within DNA at specific positions.

(*b*) Restriction endonuclease recognises and cuts specific palindromic nucleotide sequences in the DNA.

Q. 12. How does a restriction nuclease function? Explain. **[*CBSE (AI) 2014*]**

Ans. Restriction nuclease cuts DNA at specific sites. Nucleases are of two types exonuclease and endonuclease.

Exonuclease cuts DNA at the ends, whereas endonuclease cuts at specific sites within DNA.

Q. 13. Would you like to choose an exonuclease enzyme while producing a recombinant DNA molecule? **[*NCERT Exemplar*] [*HOTS*]**

Ans. No, as exonuclease acts on the free ends of linear DNA molecule. Therefore, instead of producing DNA fragments with sticky ends, it will shorten or completely degrade the DNA fragment containing the gene of interest, and the circular plasmid (vector) will not get cut as it lacks free ends.

Q. 14. You have created a recombinant DNA molecule by ligating a gene to a plasmid vector. By mistake, your friend adds exonuclease enzyme to the tube containing the recombinant DNA. How will your experiment get affected as you plan to go for transformation now? **[*NCERT Exemplar*] [*HOTS*]**

Ans. The experiment will not likely be affected as recombinant DNA molecule is circular and closed, with no free ends. Hence, it will not be a substrate for exonuclease enzyme which removes nucleotides from the free ends of DNA.

Q. 15. Restriction enzymes present in the cloning site of a vector should not have more than one recognition site. Comment. **[*NCERT Exemplar*] [*HOTS*]**

Ans. If the restriction enzymes have more than one recognition site in a vector, then the vector itself will get fragmented on treatment with the restriction enzyme.

Q. 16. A plasmid without a selectable marker was chosen as vector for cloning a gene.

Ans. In a gene cloning experiment, first a recombinant DNA molecule is constructed, where the gene of interest is ligated to the vector and introduced inside the host cell (transformation). Since, not all the cells get transformed with the recombinant/plasmid DNA, in the absence of selectable marker, it will be difficult to distinguish between transformants and non-transformants, because role of selectable marker is in the selection of transformants.

Q. 17. Write the use of the following in biotechnology.

(*a*) Chilled ethanol **(*b*) Microinjection**

(*c*) Bioreactor **(*d*) Plasmid** **[*HOTS*]**

Ans. (*a*) It is added to precipitate the purified DNA to isolate it.

(*b*) It is used to inject the foreign gene into a host cell, directly.

(*c*) It is the set up to culture large volumes of transgenic bacteria to get large quantities of the product protein.

(*d*) It is the vector to transform a foreign gene.

Q. 18. How can DNA segments, separated by gel electrophoresis, be visualised and isolated?

Ans. The separated DNA molecules are visualised only after staining DNA with ethidium bromide followed by exposure to UV radiation. They appear as bright orange coloured bands. The separated bands of DNA (on the gel) are cut from the agarose gel and extracted from the gel piece. This process is called elution.

Q. 19. Explain the process of gel-electrophoresis technique. **[*CBSE 2019 (57/2/2)*]**

Ans. Refer to Basic Concepts Point 5.

Q. 20. Why does the 'insertional inactivation' method to detect recombinant DNA is preferred to 'antibiotic resistance' procedure? **[*CBSE (F) 2016, 2017*]**

Ans. In insertional inactivation method, the presence of a chromogenic substrate gives blue coloured colonies in absence of an insert. Presence of an insert in the enzyme site does not produce colour. This is because insertional inactivation of the β-galactosidase has taken place due to the insert.

Antibiotic resistance method requires duplicate plating. It is a cumbersome procedure to perform.

Q. 21. (*a*) A recombinant vector with a gene of interest inserted within the gene of α-galactosidase enzyme, is introduced into a bacterium. Explain the method that would help in selection of recombinant colonies from non-recombinant ones.

(*b*) Why is this method of selection referred to as "insertional inactivation"?

[*CBSE (AI) 2012*] [*HOTS*]

Ans. (*a*) Bacteria is grown in a medium with chromogenic substrate, blue coloured colonies show no recombinations and colonies with no blue colour show presence of recombinants.

(*b*) Gene for the enzyme is inactivated by insertion of foreign DNA.

Q. 22. How is insertional inactivation of an enzyme used as a selectable marker to differentiate recombinants from non-recombinants? **[*CBSE (F) 2014*] [*HOTS*]**

Ans. When a recombinant DNA is inserted within the coding sequence of an enzyme β-galactosidase, it results into inactivation of the enzyme. The bacterial colonies having recombinant plasmid, show no colouration while those without recombinant plasmid show blue colour.

Q. 23. Why and how bacteria can be made 'competent'? **[*CBSE Delhi 2013*]**

Ans. Bacteria are made competent to accept the DNA or plasmid molecules. This is done by treating them with specific concentration of a divalent cation such as calcium to increase pore size in cell wall. The cells are then incubated with recombinant DNA on ice, followed by placing them briefly at 42°C and then putting it back on ice.

Q. 24. A wine maker and a molecular biologist who has developed a recombinant vaccine, both claim themselves to be biotechnologist. Who in your opinion is right? **[*HOTS*]**

Ans. Both are right because biotechnology is a very wide area which deals with techniques of using a 'natural' organism (or its parts) as well as genetically modified organism to produce products and processes useful for mankind. A wine maker employs a strain of yeast to produce wine by fermentation (a natural phenomenon), while the molecular biologist has cloned gene for the antigen (that is used as vaccine) in an organism which allows the production of the antigen in large amount.

Q. 25. For producing a recombinant protein (for therapeutic purpose) in large scale, which vector would you choose—a low copy number or high-copy number? [*NCERT Exemplar*] [*HOTS*]

Ans. High-copy number, because higher the copy number of vector plasmid, higher the copy number of gene and consequently, protein coded by the gene is produced in high amount.

Q. 26. DNA being hydrophilic cannot pass through the cell membrane of a host cell. Explain how does recombinant DNA get introduced into the host cell to transform the latter. [*HOTS*]

Ans. Refer to Basic Concepts Point 7.

Q. 27. A vector is engineered with three features which facilitate its cloning within the host cell. List the three features and explain each one of them. [*CBSE Sample Paper 2014*]

Ans. **(*i*) Origin of replication/*ori* site—**From here the replication starts (and any piece of DNA when linked, can be made to replicate within the host cell).

(*ii*) At least two Selectable markers—Helpful in identifying and eliminating non-transformants.

(*iii*) Unique Restriction sites for more than one restriction enzymes—The foreign DNA links to this region of the plasmid.

Q. 28. How is DNA isolated in purified form from a bacterial cell?

Ans. DNA, a genetic material is isolated in purified form by treating the bacterial cells with the enzymes such as lysozyme to remove the cell wall. The RNA thus released can be removed by treating them with ribonuclease and enzyme proteases is added to remove proteins. Finally, chilled ethanol is added to precipitate the purified DNA.

Q. 29. Name the source of the DNA polymerase used in PCR technique. Mention why it is used. [*CBSE (AI) 2013*]

Ans. The source is the bacterium *Thermus aquaticus*. It is used because it is thermostable and do not denature at high temperatures.

Q. 30. Explain any two methods of vectorless gene transfer.

Ans. The two methods of vectorless gene transfer are:

(*i*) Micro-injection: The technique of introducing foreign gene in a target cell by injecting the DNA, directly into the nucleus, by micro-needle is called micro-injection.

(*ii*) Electroporation: It is the process in which transient holes are produced in the plasma membrane of the target cell, to incorporate foreign DNA.

Q. 31. What is meant by gene cloning? [*NCERT Exemplar*]

Ans. Gene cloning refers to a process in which a gene of interest is ligated to a vector. The recombinant DNA thus produced is introduced in a host cell by transformation. Each cell gets one DNA molecule and when the transformed cell grows to a bacterial colony, each cell in the colony has a copy of the gene.

Q. 32. Why is *Agrobacterium tumifaciens* a good cloning vector? Explain.

Ans. *Agrobacterium tumifaciens* is a soil bacterium which causes disease in many dicot plants. It is able to deliver a piece of DNA known as T-DNA, to transform the normal cells into tumour cells and direct these tumour cells to produce the chemicals required by the pathogen. The tumour inducing (Ti) plasmid of *Agrobacterium tumifaciens* has now been modified into a cloning vector which is no more pathogenic to the plants but still deliver genes of interest into a variety of plants.

Q. 33. What modification is done in the *Ti* plasmid of *Agrobacterium tumefaciens* to convert it into a cloning vector? [*NCERT Exemplar*]

Ans. T-DNA is the only essential part required to make *Ti* plasmid a cloning vector. The plasmid is disarmed by deleting the tumour inducing genes in the plasmid so that it becomes an effective cloning vector and remove it harmful effect.

Q. 34. What does 'competent' refer to in competent cells used in transformation? [*NCERT Exemplar*]

Ans. Competent means bacterial cells which by various methods like treatment with $CaCl_2$ are made capable of taking up foreign DNA.

Q. 35. Describe the role of $CaCl_2$ in preparation of competent cells. [*NCERT Exemplar*]

Ans. $CaCl_2$ is known to increase the efficiency of DNA uptake to produce transformed bacterial cells. The divalent Ca^{2+} ions supposedly create transient pores in the bacterial cell wall, by which the entry of foreign DNA is facilitated into the bacterial cells.

Q. 36. What is the significance of adding proteases at the time of isolation of genetic material (DNA)? [*NCERT Exemplar*]

Ans. Role of proteases is to degrade the proteins present inside a cell (from which DNA is being isolated). If the proteins are not removed from DNA preparation then they could interfere with any downstream treatment of DNA.

Q. 37. Name the source organism that possesses *Taq* polymerase. What is so special about the function of this enzyme? [*CBSE (AI) 2012*]

OR

Name the organism from where the thermostable DNA polymerase is isolated. State its role in genetic engineering. [*CBSE (F) 2011*]

Ans. Source organism: *Thermus aquaticus*

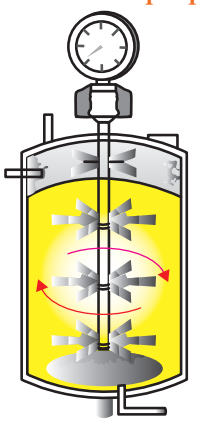
The enzyme can tolerate high temperature and is thus thermostable. It does not get denatured during PCR at high temperature.

Q. 38. How are recombinant vectors created? Why is only one type of restriction endonuclease required for creating one recombinant vector? [*CBSE (F) 2011*]

Ans. The construction of recombinant DNA is done by linking a gene encoding antibiotic resistance with a native plasmid. These plasmid DNA act as vectors to transfer the piece of DNA attached to it.

Only one type of restriction endonuclease is required for creating recombinant vector because when cut by the same enzyme, the resultant DNA fragments have the same sticky ends, which can be joined together using DNA ligases.

Q. 39. Name the type of bioreactor shown. Write the purpose for which it is used. [*CBSE (AI) 2011*]



Ans. The given bioreactor is the simple stirred tank bioreactor.

Its purpose is large scale production of recombinant protein or enzymes, using microbial plants/animals/human cells.

Q. 40. (*a*) Explain how to find whether an *E.coli* bacterium has transformed or not when a recombinant DNA bearing ampicillin resistant gene is transferred into it.

(*b*) What does the ampicillin resistant gene act as in the above case? [*CBSE Delhi 2013*] [*HOTS*]

Ans. (*a*) *E.coli* bearing transferred recombinant DNA are first grown on ampicillin containing medium and then transferred on to a medium containing tetracycline. The transformants will grow only in ampicillin containing medium and not in tetracycline containing medium. The non-transformants, on the other hand, will grow in both the mediums.

(*b*) Ampicillin resistant gene acts as a selectable marker and helps in selecting the transformants.

Q. 41. How can the following be made possible for biotechnology experiments?

(*a*) Isolation of DNA from bacterial cell.

(*b*) Reintroduction of the recombinant DNA into a bacterial cell. [*CBSE (F) 2012*] [*HOTS*]

Ans. (*a*) By treating cell with lysozyme

(*b*) Microinjection/gene gun

Q. 42. Write the role of '*ori*' and 'restriction' site in a cloning vector pBR322. [*CBSE Delhi 2014*]

Ans. *ori* is the site where replication starts. This site is responsible for controlling the copy number of linked DNA. If we want to produce many copies of target DNA, we should clone in a vector whose *ori* supports high copy number.

Restriction site is the site of ligation of alien/foreign DNA in the vector, in one of the two antibiotic resistance site or coding sequence of α–galactosidase.

Q. 43. Rearrange the following in the correct sequence to accomplish an important biotechnological reaction:

(*a*) *In vitro* synthesis of copies of DNA of interest

(*b*) Chemically synthesised oligonucleotides

(*c*) Enzyme DNA-polymerase

(*d*) Complementary region of DNA

(*e*) Genomic DNA template

(*f*) Nucleotides provided

(*g*) Primers

(*h*) Thermostable DNA-polymerase (from *Thermus aquaticus*)

(*i*) Denaturation of *ds*DNA [*CBSE (AI) 2015*] [*HOTS*]

Ans. Correct sequence is

$$i \rightarrow e \rightarrow b/g \rightarrow g/b \rightarrow c/b \rightarrow h/c \rightarrow f \rightarrow d \rightarrow a$$

Q. 44. Name the source organism from which *Ti* plasmid is isolated. Explain the use of this plasmid in biotechnology.

Ans. *Ti* plasmid is isolated from *Agrobacterium tumifaciens*.

Ti plasmid of *Agrobacterium tumifaciens* has been modified into a cloning vector, which is not pathogenic to plants but still is able to use the mechanisms to deliver genes of interest into plants.

Q. 45. While doing a PCR, 'denaturation' step is missed. What will be its effect on the process? [*NCERT Exemplar*]

Ans. If denaturation of double-stranded DNA does not take place, then primers will not be able to anneal to the template, no extension will take place, hence no amplification will occur.

Q. 46. What would happen when one grows a recombinant bacterium in a bioreactor forget to add antibiotic to the medium in which the recombinant is growing bacterium? [*NCERT Exemplar*]

Ans. In the absence of antibiotic, there will be no pressure on recombinants to retain the plasmid (containing the gene of your interest). Since, maintaining a high copy number of plasmids is a metabolic burden to the microbial cells, it will thus tend to lose the plasmid.

Q. 47. Is there any difference between recombinant DNA and recombinant protein? Support your answer. [*HOTS*]

Ans. *r*DNA is the plasmid vector containing the foreign DNA whereas recombinant protein is the product of transgenic gene in the host body or cell.

Q. 48. Where and why do we use *Taq* polymerase enzyme when it works exactly as DNA polymerase? ***[CBSE Sample Paper 2014]*** **[HOTS]**

Ans. In PCR, because it is a thermostable DNA polymerase enzyme, is isolated from bacteria *Thermus aquaticus* from hot water springs, and it does not get denatured at high temperature which is required during PCR and works as normal DNA polymerase enzyme (whereas the normal DNA polymerase gets denatured at high temperature).

Q. 49. Name the most commonly used bioreactor and describe its working. ***[CBSE Delhi 2018]***

Ans. The most commonly used bioreactor is stirred-tank bioreactor.

A stirred-tank bioreactor is usually cylindrical and have a stirrer which mixes the reactor contents evenly and makes oxygen available throughout the bioreactor. Optimum conditions of temperature, pH and foam control are provided.

Long Answer Questions–I [3 marks]

Q. 1. List the steps involved in *r*DNA technology.

Ans. **Steps in *r*DNA technology:**

(*i*) Isolation of DNA.
(*ii*) Fragmentation of DNA by restriction endonucleases.
(*iii*) Isolation of the desired DNA fragments.
(*iv*) Amplification of the gene of interest.
(*v*) Ligation of the DNA fragment into a vector using DNA ligase.
(*vi*) Transfer of recombinant DNA into the host organism.
(*vii*) Culturing the host cell on a suitable medium on a large scale.
(*viii*) Extraction of the desired product.
(*ix*) Downstream processing of the products as finished products are ready for marketing.

Q. 2. List the key tools used in recombinant DNA technology. ***[CBSE Delhi 2011; (F) 2014]*** **[HOTS]**

Ans. The key tools used in recombinant DNA technology are:

(*i*) Restriction enzymes
(*ii*) Polymerase enzyme
(*iii*) Ligase enzyme
(*iv*) Vectors
(*v*) Host organism/cell.

Q. 3. Write the steps you would suggest to be undertaken to obtain a foreign-gene-product. ***[CBSE Delhi 2017]***

Ans. Refer to Basic Concepts Point 8.

Q. 4. (*a*) Explain the significance of 'palindromic nucleotide sequence' in the formation of recombinant DNA.

(*b*) Write the use of restriction endonuclease in the above process. ***[CBSE (AI) 2017]***

Ans. (*a*) Palindromic nucleotide sequence is the recognition (specific) sequence present both on the vector and on a desired or alien DNA for the action of the same (specific) restriction endonuclease to act upon.

(*b*) (*i*) Every endonuclease inspects the entire DNA sequence for the palindromic recognition sequence.
(*ii*) On finding the palindrome, the endonuclease binds to the DNA.
(*iii*) It cuts the opposite strands of DNA in the sugar–phosphate backbone; a little away from the centre of the palindrome sites but between the same bases on both strands.
(*iv*) This results in the formation of single stranded overhanging stretches at the end of each strand called sticky ends.
(*v*) The sticky ends facilitate the action of the enzyme DNA ligase by readily forming hydrogen bonds with complementary strands.

Q. 5. Explain three basic steps to be followed during genetic modification of an organism.
[*CBSE (F) 2017*]

Ans. The three basic steps are:

(*i*) Identification of DNA with desirable genes.

(*ii*) Introduction of the identified DNA into the host.

(*iii*) Maintenance of introduced DNA in the host and transfer of the DNA to its progeny.

Q. 6. Explain the action of the restriction endonuclease *Eco*RI. **[*CBSE (F) 2010*]**

Ans. (*i*) The recognition sequence shows palindrome character in which the sequence of base pairs read the same on both the DNA strands, *i.e.*, same in 5′ → 3′ or 3′ → 5′ directions, *e.g.*,

5′ — G A A T T C — 3′

3′ — C T T A A G — 5′

(*ii*) The restriction endonuclease acts on specified length of a DNA and binds to the DNA at the recognition sequence.

(*iii*) It cuts the opposite double helix of DNA in the sugar-phosphate backbones, a little away from the centre of the palindrome sites.

(*iv*) There are overhanging stretches called sticky ends on each strand, which form hydrogen bonds with their complementary cut counterparts. This stickiness of the ends facilitates the action of the enzyme DNA ligase.

Q. 7. Prepare a flow chart in formation of recombinant DNA by the action of restriction endonuclease enzyme *EcoRI*. **[*CBSE (F) 2015*]**

Ans. Refer to Fig. 11.1.

Q. 8. A recombinant DNA is formed when sticky ends of vector DNA and foreign DNA join. Explain how the sticky ends are formed and get joined. **[*CBSE (AI) 2010*]**

OR

***Eco*RI is used to cut a segment of foreign DNA and that of a vector DNA to form a recombinant DNA. Show with the help of schematic diagrams.**

(*i*) The set of palindromic nucleotide sequence of base pairs the *Eco*RI will recognise in both the DNA segments. Mark the site at which *Eco*RI will act and cut both the segments.

(*ii*) Sticky ends formed on both the segments where the two DNA segments will join later to form a recombinant DNA. **[*CBSE Delhi 2010*]**

Ans. The vector DNA and foreign DNA are cut by the same restriction enzyme, such as *Eco*RI, to form the same kind of sticky ends. Then these sticky ends are joined by the enzyme DNA ligase.

For figure, refer to Fig. 11.1.

Q. 9. Draw a schematic sketch of pBR322 plasmid and label the following in it:

(*a*) Any two restriction sites.

(*b*) *ori* and *rop* genes.

(*c*) An antibiotic resistant gene. **[*CBSE Delhi 2012*]**

Ans. Refer to Fig. 11.3.

Q. 10. (*a*) What is *Eco*RI? What does 'R' represent in this?

(*b*) Explain its action.

Ans. (*a*) *Eco*RI is a restriction endonuclease, obtained from an *E. coli* bacterium.

R represents the name of the strain.

(*b*) It cuts the DNA between bases G and A on both the strands only when the sequence GAATTC is present in DNA.

Q. 11. (*a*) Name the selectable markers in the cloning vector pBR322? Mention the role they play.

(*b*) Why is the coding sequence of an enzyme β-galactosidase is a preferred selectable marker in comparison to the ones named above? **[*CBSE (AI) 2016*]**

Ans. (*a*) Selectable markers are amp^R/ampicillin resistance genes and tet^R/tetracycline resistance gene. They help in identifying and eliminating non-transformants/non-recombinants and selectively permitting the growth of the transformants/recombinants.

(*b*) This is because it is simpler and less cumbersome. In the presence of chromogenic substrate recombinants form colourless colonies and non-recombinants form blue in colonies.

Q. 12. (*a*) Draw the figure of vector pBR322 and label the following:

(*i*) Origin of replication

(*ii*) Ampicillin resistance site

(*iii*) Tetracycline resistance site

(*iv*) *Bam*H1 restriction site

(*b*) Identify the significance of origin of replication. **[*CBSE Sample Paper 2016*]**

Ans. (*a*) Refer to Fig. 11.3.

(*b*) Origin of replication is responsible for controlling the copy number of the DNA sequence inserted.

Q. 13. (*a*) In pBR322, foreign DNA has to be introduced in tet^R region. From the restriction enzymes given below, which one should be used and why?

***Pvu*I, *Eco*RI, *Bam*HI**

(*b*) Give reasons, why the other two enzymes cannot be used.

[*CBSE Sample Paper 2015, 2017, 2018*]

Ans. (*a*) *Bam*HI should be used, as restriction site for this enzyme is present in tet^R region.

(*b*) *Pvu*I will not be used, as restriction site for this enzyme is present in amp^R region (not in tet^R).

*Eco*RI will not be used, as restriction site for this enzyme is not present in selectable marker tet^R.

Q. 14. Name and explain the technique used for separating DNA fragments and making them available for biotechnology experiments. **[*CBSE (F) 2013, 2015*]**

OR

How are the DNA fragments separated and isolated for DNA fingerprinting? Explain.

[*CBSE (F) 2015*]

Ans. Refer to Basic Concepts Point 5.

Q. 15. Why are genes encoding resistance to antibiotics considered useful selectable markers for *E. coli* cloning vector? Explain with the help of one example. **[*HOTS*]**

Ans. Genes encoding resistance to antibodies are considered useful selectable markers for *E. coli* cloning vector.

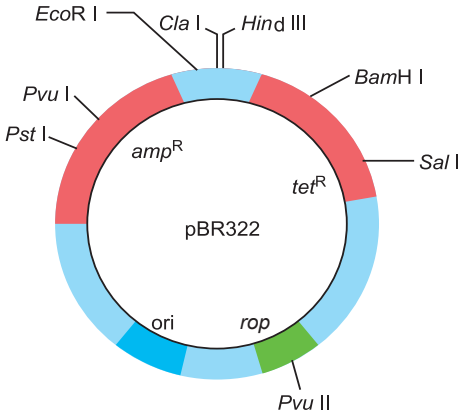
If a recombinant DNA bearing gene for resistance to an antibiotic (*e.g.*, ampicillin) is transferred into *E. coli* cells, the host cells become transformed into ampicillin-resistant cells. If these transformed cells are spread on agar plates containing ampicillin, only transformants will grow, and the non-transformed recipient cells will die as they do not contain the gene for ampicillin resistance. Thus, transformed cells can be selected. The gene for ampicillin resistance, in this case, is a useful selectable marker.

Q. 16. How does β-galactosidase coding sequence act as a selectable marker? Explain. Why is it a preferred selectable marker to antibiotic resistance genes? **[*CBSE (F) 2017; 2019 (57/4/1)*]**

Ans. When a recombinant DNA is inserted within the coding sequence of the enzyme β-galactosidase, it results into inactivation of the enzyme. The presence of a chromogenic substrate gives blue coloured colonies if the plasmid in the bacteria does not have an insert, whereas presence of insert do not produce any colour.

Selection of recombinants due to inactivation of antibiotics is a cumbersome procedure because it requires simultaneous plating on two plates having different antibiotics. Therefore, selectable markers are preferred for selection of recombinants.

Q. 17. Explain the importance of (*a*) ori, (*b*) *amp*^{R} and (*c*) *rop* in the *E. coli* vector shown below:

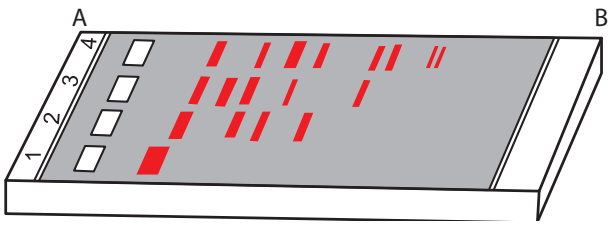


Ans. **(*a*) *ori*:** Ori is a sequence from where replication starts and any piece of DNA when linked to this sequence can be made to replicate within the host cells. It is also responsible for controlling the copy number of the linked DNA.

(*b*) *amp*^{R}: The ligation of alien DNA is carried out at a restriction site present in any antibiotic resistance gene.

(*c*) *rop*: It codes for the proteins involved in the replication of the plasmid.

Q. 18.



(*a*) Mark the positive and negative terminals.

(*b*) What is the charge carried by DNA molecule and how does it help in its separation?

(*c*) How the separated DNA fragments are finally isolated?

[*CBSE Sample Paper 2015, 2017, 2018*] [*HOTS*]

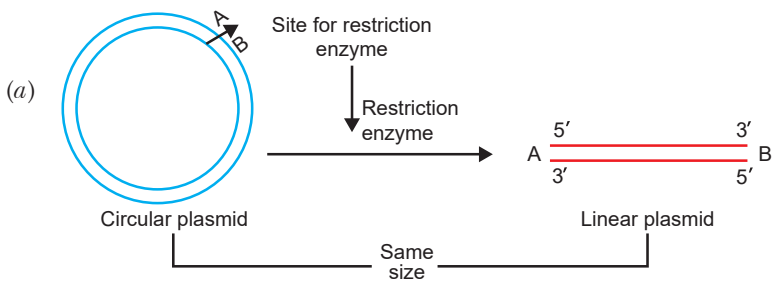
Ans. (*a*) Positive terminal – 'B'
Negative terminal – 'A'

(*b*) DNA is negatively charged. Because of its negative charge, DNA moves towards the positive electrode (anode).

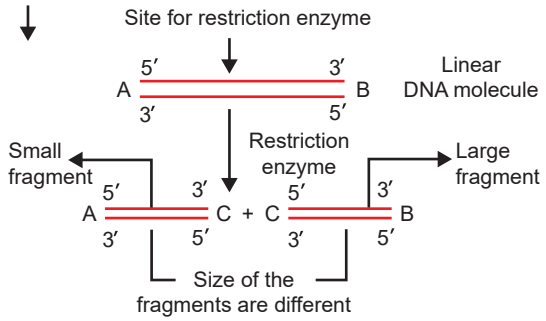
(*c*) The separated DNA fragments are separated by elution. The separated bands of DNA are cut out from the agarose gel and extracted from the gel piece.

Q. 19. A plasmid DNA and a linear DNA (both of the same size) have one site for a restriction endonuclease. When cut and separated on agarose gel electrophoresis, plasmid shows one DNA band while linear DNA shows two fragments. Explain. **[*NCERT Exemplar*] [*HOTS*]**

Ans. It is because plasmid is a circular DNA molecule. When cut with enzyme, it becomes linear but does not get fragmented. Whereas, a linear DNA molecule gets cut into two fragments. Hence, a single DNA band is observed for plasmid while two DNA bands are observed for linear DNA in agarose gel.



(*b*)



Q. 20. A mixture of fragmented DNA was electrophoresed in agarose gel. After staining the gel with ethidium bromide, no DNA bands were observed. What could be the reason? **[*NCERT Exemplar*] [*HOTS*]**

Ans. The reasons that could be possible are as follows:

(*i*) DNA sample that was loaded on the gel may have got contaminated with nuclease (exo- or endo- or both) and completely degraded.

(*ii*) Electrodes were put in opposite orientation in the gel assembly, *i.e.*, anode towards the wells (where DNA sample is loaded). Since DNA molecules are negatively charged, they move towards anode and hence move out of the gel instead of moving into the matrix of gel.

(*iii*) Ethidium bromide was not added at all or was not added in sufficient concentration and so DNA was not visible.

(*iv*) After staining with Ethidium bromide it was not observed under UV.

Q. 21. (*a*) Why must a cell be made 'competent' in biotechnology experiments? How does calcium ion help in doing so?

(*b*) State the role of 'biolistic gun' in biotechnology experiments. **[*CBSE (AI) 2016*]**

Ans. (*a*) A cell must be made competent so that it can take up the hydrophilic DNA from the external medium. Divalent calcium ions increases the efficiency, of DNA entering the cell through pores in the cell wall.

(*b*) Biolistic gun is used to introduce alien DNA into the plant cell by bombarding them with high velocity microparticles (gold or tungsten coated with DNA).

Q. 22. Explain the process by which a bacterial cell can be made 'competent'. Why is it essential to make bacterial cells 'competent' in recombinant DNA technology? **[*CBSE (F) 2010*]**

OR

How can be a host made competent? Explain the different methods.

Ans. Refer to Basic Concepts Point 7.

Q. 23. What is *Ti* plasmid? Name the organism where it is found. How does it help in genetic engineering? **[*CBSE Delhi 2011*]**

Ans. An extra-chromosomal DNA which delivers gene of interest into variety of plants and act as cloning vector is called *Ti* plasmid. They are present in *Agrobacterium tumifaciens. Ti* plasmid vectors are used for genetic transformation in many dicot plants. The tumour inducing (*Ti*) plasmid of *Agrobacterium tumifaciens* has been modified into a cloning vector which is no more pathogenic to the plants but is still able to use the mechanisms to deliver genes of interest into a variety of plants.

Q. 24. Expand the following and mention one application of each:

(*i*) PCR (*ii*) ELISA **[*CBSE Delhi 2013*]**

Ans.

	Expansion	Application
(*i*) PCR	Polymerase Chain Reaction	Amplification of gene of interest/In forensic study
(*ii*) ELISA	Enzyme Linked Immunosorbent Assay	Diagnostic test for AIDS

Q. 25. Many copies of a specific gene of interest are required to study the detailed sequencing of bases in it. Name and explain the process that can help in developing large number of copies of this gene of interest. **[*CBSE (F) 2015*]**

Ans. Polymerase Chain reaction (PCR).

For explanation refer to Basic Concepts Point 8(*iv*).

Q. 26. How is the amplification of a gene sample of interest carried out using Polymerase Chain Reaction (PCR)? **[*CBSE (AI) 2012*]**

OR

Suggest and describe a technique to obtain multiple copies of a gene of interest *in vitro*. **[*CBSE Delhi 2016*]**

Ans. Refer to Basic Concepts Point 8(*iv*) and Fig. 11.5.

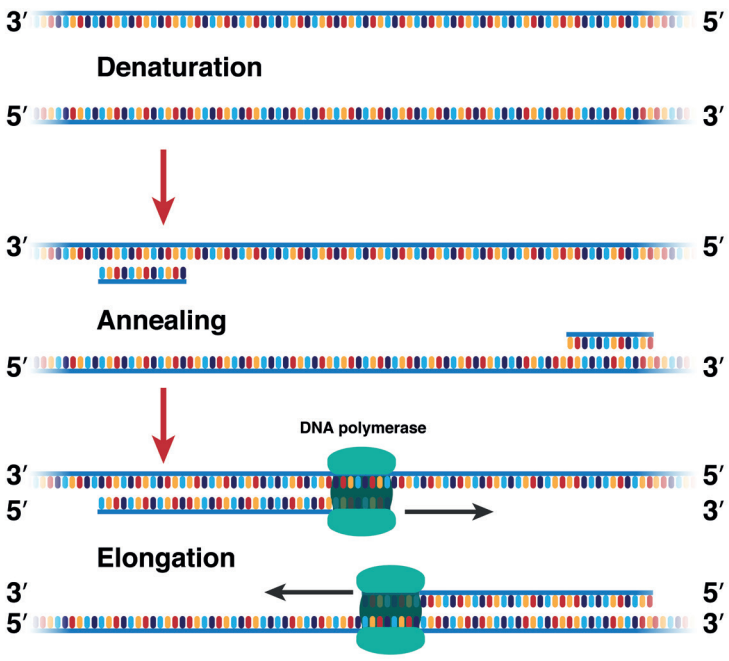
Q. 27. How can a bioreactor be made to function at optimal state in order to obtain a desired foreign gene product? Explain. **[*CBSE (F) 2017*]**

Ans. A stirred-tank bioreactor is the most commonly used bioreactor. It comes with a curved base to facilitate the mixing of the reactor contents. The stirrer facilitates even mixing and oxygen availability throughout the bioreactor. The bioreactor has an agitator system, an oxygen delivery system and a foam control system, a temperature control system, pH control system and sampling port so that volumes of the cultures can be withdrawn periodically.

Q. 28. Describe the roles of heat, primers and the bacterium *Thermus aquaticus* in the process of PCR. **[*CBSE (AI) 2011*]**

Ans.
- Heat denatures or helps in separation of DNA into two strands.
- Primer–Enzyme DNA Polymerase extend the primers using the nucleotides provided in the reaction and the genomic DNA as template.
- ***Thermus aquaticus*:** It is the source of thermostable DNA polymerase or *Taq* polymerase.

Q. 29. A schematic representation of polymerase chain reaction (PCR) up to the extension stage is given below. Answer the questions that follow:



(*i*) Name the process '*a*'. **(*ii*) Identify '*b*'**

(*iii*) Identify '*c*' and mention its importance in PCR. **[*CBSE (F) 2010*] [*HOTS*]**

Ans. (*i*) *a*—Denaturation process

(*ii*) *b*—Primers

(*iii*) *c*—*Taq* DNA polymerase. *Taq* polymerase is a thermostable enzyme which remains active during the high temperature required for extension of DNA.

Q. 30. (*a*) List the three steps involved in Polymerase Chain Reaction (PCR).

(*b*) Name the source organism of *Taq* polymerase. Explain the specific role of this enzyme in PCR. **[*CBSE (F) 2014*]**

Ans. (*a*) The three steps involved in polymerase chain reaction (PCR):

(*i*) Denaturation of double stranded DNA (*ds*DNA) at high temperature.

(*ii*) Annealing of two sets of primers.

(*iii*) Extension of primers to form *ds*DNA by *Taq* polymerase and deoxynucleotides.

(*b*) Source organism of *Taq* polymerase is the bacterium *Thermus aquaticus*. This enzyme is heat tolerant and can repeatedly amplify DNA at high temperatures.

Q. 31. Draw a labelled sketch of sparged stirred-tank bioreactor. Write its application. **[*CBSE Delhi 2015*]**

Ans. Refer to Fig. 11.6 (*b*).

Application: Produces larger biomass leading to higher yields of desired protein.

Q. 32. Name two commonly used bioreactors. State the importance of using a bioreactor. **[*CBSE Delhi 2013*]**

Ans. Two commonly used bioreactors are simple stirred tank bioreactor and sparged stirred tank bioreactor.

A bioreactor is used for

(*i*) processing large volumes of culture.

(*ii*) large scale production of recombinant proteins.

(*iii*) biologically converting raw materials into specific products. (*Any two*)

Q. 33. "A very small sample of tissue or even a drop of blood can help determine paternity". Provide a scientific explanation to substantiate the statement. **[*CBSE (AI) 2015*] [*HOTS*]**

Ans. (*i*) DNA from all cells of an individual shows the same degree of polymorphism and therefore becomes a useful identification tool.

(*ii*) Polymorphs are heritable and the child inherits 50% of the chromosome from each parent.

(*iii*) With the help of PCR, the small amount of DNA from blood can be amplified and be used in DNA finger printing to identify the paternity.

Long Answer Questions–II [5 marks]

Q. 1. (*a*) With the help of diagrams show the different steps in the formation of recombinant DNA by action of restriction endonuclease enzyme *Eco*RI.

(*b*) Name the technique that is used for separating the fragments of DNA cut by restriction endonucleases. **[*CBSE (AI) 2011*]**

Ans. (*a*) Refer to Fig. 11.1.

(*b*) Gel electrophoresis is used for separating the fragments of DNA cut by restriction endonucleases.

Q. 2. Name and describe the technique that helps in separating the DNA fragments formed by the use of restriction endonuclease. **[*CBSE (AI) 2014*]**

Ans. Gel electrophoresis helps in separating DNA fragments.

DNA fragments are negatively charged then they are forced to move towards anode under an electric field through agarose gel matrix. The fragments separate according to their size through sieving effect. Hence the smaller fragments move faster and further than the larger ones.

Refer to Basic Concepts Point 5.

Q. 3. (*a*) Why are engineered vectors preferred by biotechnologists for transferring the desired genes into another organism?

(*b*) Explain how do "*ori*", "selectable markers" and "cloning sites" facilitate cloning into a vector.

Ans. (*a*) Engineered vectors are preferred by biotechnologists because they help in easy linking of foreign DNA and selection of recombinants from non-recombinants.

(*b*) Refer to Basic Concepts Point 6(*i*)–(*iii*).

Q. 4. (*i*) Describe the characteristics that a cloning vector must possess.

(*ii*) Why DNA cannot pass through the cell membrane? Explain. How is a bacterial cell made 'competent' to take up recombinant DNA from the medium? ***[CBSE (AI) 2011]***

Ans. (*i*) A cloning vector must have the following characteristics:

(*a*) *ori* or origin of replication which can make large number of copies

(*b*) Selectable marker *i.e.*, genes encoding for an antibiotic resistance or genes encoding for α-galactosidase.

(*c*) Recognition site for the restriction enzyme to recognise.

(*ii*) DNA is a hydrophilic molecule, therefore it cannot pass through the cell membrane.

The bacterial cells can be made competent by treating them with a specific concentration of a divalent ion like calcium. The cells are then incubated on ice followed by a heat shock by placing them briefly at 42°C and then putting back on ice.

Q. 5. If a desired gene is identified in an organism for some experiments, explain the process of the following:

(*i*) Cutting this desired gene at specific location.

(*ii*) Synthesis of multiple copies of this desired gene. ***[CBSE (AI) 2011]***

Ans. (*i*) The desired gene is cut using the enzymes restriction endonucleases. Firstly, the restriction endonucleases that recognise the palindromic nucleotide sequence of the desired gene is identified. The endonuclease inspects the entire DNA sequences to find and recognise the site. It cuts each of the double helix at a specific point which is a little away from the centre of the palindromic site. The cutting site is between the same two bases on the opposite strands. This results in over-hanging single stranded stretches which act as sticky ends.

(*ii*) Multiple copies of the desired gene is synthesised by polymerase chain reaction (PCR) method. In this method, the desired gene is synthesised *in vitro*. The double stranded DNA is denatured using high temperature of 95°C and the strands are separated. Each separated strand acts as template.

Two sets of oligonucleotide primers are annealed to the denatured DNA strands. The thermostable *Taq* polymerase extends the primers, using nucleotides provided in the reaction mixture. Finally the amplified fragments are ligated into recipient cells.

Q. 6. (*a*) Mention the role of vectors in recombinant DNA technology. Give any two examples.

(*b*) With the help of diagrammatic representation only, show the steps of recombinant DNA technology.

Ans. (*a*) **Role of vectors:** The vectors have the ability to replicate within the bacterial cells independent of the control of chromosomal DNA. If an alien piece of DNA is linked to the vector like bacteriophage or plasmid DNA, it can be made to multiply, its number being equal to the copy number of the vector. Vectors are also used in the selection of recombinants from non-recombinants. Plasmids and bacteriophages are the most commonly used vectors.

(*b*) Refer to Fig. 11.4.

Q. 7. Which methodology is used while sequencing the total DNA from a cell? Explain it in detail.

Ans. Methodology used: ***[CBSE Sample Paper 2017]***

- Sequence Annotation – total DNA from a cell is isolated, converted into random fragments of relatively smaller sizes, and cloned in suitable host using specialized vectors.

- The cloning resulted into amplification of each piece of DNA fragment.
- The fragments were sequenced using automated DNA sequencers, these sequences are then arranged based on some overlapping regions (present in them).
- This requires generation of overlapping fragments (for sequencing).
- Specialised computer based programmes were developed, and these sequences were subsequently annotated and assigned to each chromosome.

Q. 8. For selection of recombinants, insertional inactivation of antibiotic marker has been superceded by insertional inactivation of a marker gene coding for a chromogenic substrate. Give reasons. **[*NCERT Exemplar*] [*HOTS*]**

Ans. Selection of recombinants due to inactivation of antibiotics is a laborious process as it requires:

(*i*) a vector with two antibiotic resistance markers,

(*ii*) preparation of two kinds of media plates, with one antibiotic each.

Transformed cells are first plated on the antibiotic plate which has not been insertionally inactivated (say, ampicillin) and incubated overnight for growth of transformants. For selection of recombinants, these transformants are replica-plated on second antibiotic (say, tetracycline) plate (which got inactivated due to insertion of gene). Non-recombinants grow on both the plates (one carrying ampicillin and the other carrying tetracycline) while recombinants will grow only on ampicillin plate.

This entire exercise is laborious and takes more time (two overnight incubation) as well. However, if we choose insertional inactivation of a marker that produces colour in the presence of a chromogenic compound, we can distinguish between the recombinants and non-recombinants on a single medium plate (containing one antibiotic and the chromogenic compound) after overnight growth.

Q. 9. (*a*) Explain how recombinants and non-recombinants are differentiated on the basis of colour production in the presence of a chromogenic substrate. Name that procedure.

(*b*) Describe the temperature treatment that enhances the bacteria to take up the *r*DNA. **[*HOTS*]**

Ans. (*a*) The procedure is called insertional inactivation.

In this method recombinants and non-recombinants are differentiated on the basis of the ability to produce colour in the presence of a chromosomic substrate. In this method, a *r*DNA is inserted in an enzyme – β-galactosidase which leads to inactivation of the enzyme which does not produce colour due to insertion.

(*b*) (*i*) Host cells are incubated with *r*DNA on ice.

(*ii*) Followed by placing them briefly at 42°C.

(*iii*) Then transfer them back on ice.

This enables the host cells (bacteria) to take up the *r*DNA.

Self-Assessment Test

Time allowed: 1 Hour **Max. marks: 30**

1. Choose and write the correct option in the following questions. **(3×1 = 3)**

(i) Rising of dough is due to

(a) multiplication of yeast (b) production of CO_2

(c) emulsification (d) hydrolysis of wheat flour starch into sugars.

(ii) 'Restriction' in Restriction enzyme refers to

(a) cleaving of phosphodiester bond in DNA by the enzyme

(b) cutting of DNA at specific position only

(c) prevention of the multiplication of bacteriophage by the host bacteria

(d) all of the above

(iii) Which of the following should be chosen for best yield if one were to produce a recombinant protein in large amounts?

(a) Laboratory flask of largest capacity

(b) A stirred-tank bioreactor without in-lets and out-lets

(c) A continuous culture system

(d) Any of the above

2. In the following questions a statement of assertion followed by a statement of reason is given. Choose the correct answer out of the following choices. **(3×1 = 3)**

(a) Assertion and reason both are correct statements and reason is correct explanation for assertion.

(b) Assertion and reason both are correct statements but reason is not correct explanation for assertion.

(c) Assertion is correct statement but reason is wrong statement.

(d) Assertion is wrong statement but reason is correct statement.

(i) Assertion : In GMOs desirable DNA segment is introduced into a suitable host.

Reason : The gene transfer is done using a biolistic gun only.

(ii) Assertion : The palindromic sequences at which endonucleases act vary from organism to organism.

Reason : The palindromic sequence of *Eco*RI is GAATTC.

(iii) Assertion : A temperature control system is an important requirement for bioreactor.

Reason : Every microorganism or enzyme is functional only at an optimum temperature conditions.

3. What is plasmid? **(1)**

4. Why is *Taq* polymerase preferred in PCR? **(1)**

5. (a) Why are restriction endonucleases known as molecular scissors?

(b) Give the palindromic sequence recognised by *Eco*RI. **(2)**

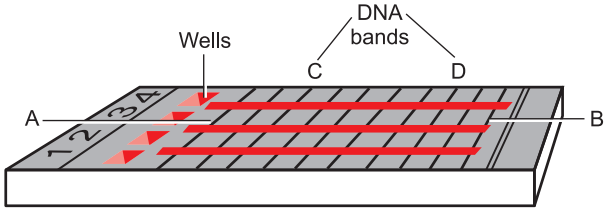
6. Differentiate between rDNA and cDNA. **(2)**

7. Which is the most commonly used bioreactor? Explain its functioning. **(2)**

8. Draw a schematic diagram of the *E.coli* cloning vector pBR322 and mark the following in it :
   (a) *ori* (b) *rop*
   (c) ampicillin resistance gene (d) tetracycline resistance gene **(2)**

9. Name and explain the techniques used in the separation and isolation of DNA fragments to be used in recombinant DNA technology. **(3)**

10. Study the diagram given below and answer the questions that follow: **(3×1 = 3)**



   (i) Why have DNA fragments in band 'D' moved farther away in comparison to those in band 'C'?
   (ii) Identify the anode end in the diagram.
   (iii) How are these DNA fragments visualised? [CBSE (F) 2011]

11. What are the steps in the process of recombinant DNA technology? **(3)**

12. (a) Describe the different steps in one complete cycle of PCR.
   (b) State the purpose of such an amplified DNA sequence. **(5)**

Answers

1. (*i*)—(*b*), (*ii*)—(*c*), (*iii*)—(*c*) **2.** (*i*)—(*c*), (*ii*)—(*c*), (*iii*)—(*a*)

Chapter–12

Biotechnology and its Applications

basic concepts

- Biotechnology has varied applications, some of which include
  (*i*) therapeutics
  (*ii*) diagnostics
  (*iii*) genetically modified crops for agriculture
  (*iv*) processed food
  (*v*) bioremediation
  (*vi*) waste treatment
  (*vii*) energy production.
- There are three critical research areas of biotechnology:
  (*i*) Providing best catalyst as improved organism, usually a microbe or pure enzyme.
  (*ii*) Creating optimal conditions by engineering for a catalyst to act.
  (*iii*) Downstream processing technologies to purify the protein/organic compound.

1. Biotechnological Applications in Agriculture

- Food production can be increased by the following ways:
  (*a*) Agrochemical-based agriculture.
  (*b*) Organic agriculture.
  (*c*) Genetically engineered crop-based agriculture.
- The Green Revolution succeeded in increasing food supply because of
  (*a*) use of improved crop varieties.
  (*b*) use of agrochemicals (fertilisers and pesticides).
  (*c*) use of better management practices.
- Agrochemicals are expensive for farmers in developing countries and also have harmful effects on environment. Therefore, genetically modified crops were developed.
- **Genetically modified organisms (GMOs)** are plants, bacteria, fungi and animals whose genes have been altered by manipulation.
- Genetic modification of crops have resulted in
  (*a*) increased tolerance against abiotic stresses (cold, drought, salt, heat).
  (*b*) reduced reliance on chemical pesticides (pest-resistant crops).
  (*c*) reduced post-harvest losses.
  (*d*) increased efficiency of minerals used by plants (this prevents early exhaustion of fertility of soil).
  (*e*) enhanced nutritional value of food, *e.g.*, vitamin 'A' enriched rice (golden rice).
  (*f*) creation of tailor-made plants to supply alternative resources such as starches, fuels and pharmaceuticals to industries.

(i) Bt cotton

- Some strains of *Bacillus thuringiensis* produce proteins that kill some insects like lepidopterans (tobacco budworm, armyworm), coleopterans (beetles) and dipterans (flies, mosquitoes).
- *B. thuringiensis* forms protein crystals which contain a toxic insecticidal protein.
- Bt toxins are initially inactive protoxins but after ingestion by the insect their inactive toxin becomes active due to the alkaline pH of the gut, which solublises the crystals.
- The activated toxin binds to the surface of midgut epithelial cells thus creating pores which causes cell swelling and lysis, further leading to death of the insects.

Fig. 12.1 Cotton boll: (*a*) destroyed by bollworms; (*b*) a fully mature cotton boll

- Specific Bt toxin genes obtained from *Bacillus thuringiensis* are used in several crop plants like cotton.
- The toxin is coded by a gene called *cry* which is of various types. For example, proteins encoded by the genes *cryIAc* and *cryIIAb* control the cotton bollworms and that of *cryIAb* control corn borer.
- Bt tobacco was first cultured to kill hornworm (*Manduca sexta*).

(ii) Pest resistant plants

- A nematode *Meloidogyne incognita* infects the roots of tobacco plants which reduces the production of tobacco.
- It can be prevented by using RNA interference (RNAi) process which is checked by silencing of specific *m*RNA due to a complementary *ds*RNA.
- *ds*RNA binds and prevents translation of the *m*RNA (**silencing**).
- The source of this *ds*RNA could be from an infection by viruses having RNA genomes or mobile genetic elements (transposons) which replicate through an RNA intermediate.
- By using *Agrobacterium* vectors, nematode-specific genes were introduced into the host plants which produce both sense and anti-sense RNA in the host cells.
- These two RNAs are complementary to each other and form a double-stranded RNA (*ds*RNA) that initiates RNAi and hence silence the specific *m*RNA of the nematode.
- The parasite cannot survive in the transgenic host, so protects the plants from pests.

2. Biotechnological Applications in Medicine

- The recombinant DNA technology is used for production of therapeutic drugs which are safe and effective.
- It avoids unwanted immunological responses, commonly observed with similar products isolated from non-human sources.
- About 30 recombinant therapeutics have been approved for human use in the world. In India, 12 are being marketed presently.

(i) Genetically engineered insulin

- Insulin contains two short polypeptide chains—chain A and chain B linked by disulphide bridges.
- In mammals, insulin is synthesised as a pro-hormone (that needs to be processed to become mature and functional hormone). It contains an extra stretch called C peptide.

- C peptide is absent in mature insulin and is removed during maturation into insulin.
- Earlier, insulin was extracted from pancreas of slaughtered cattle and pigs but some patients began developing allergies.
- **Disadvantages of extracting insulin from animals:**
  (*i*) Insulin being a hormone is produced in very little amounts in the body. Hence, a large number of animals need to be sacrificed for obtaining small quantities of insulin. This makes the cost of insulin very high, demand being manifold higher than supply.
  (*ii*) Slaughtering of animal is not ethical.
  (*iii*) There is potential of immune response in humans against the administered insulin which is derived from animals.
  (*iv*) There is possibility of slaughtered animals being infested with some pathogen which may contaminate insulin.

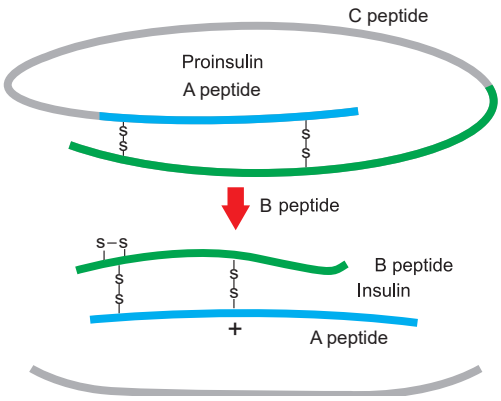


Fig. 12.2 Maturation of proinsulin into insulin after removal of C-peptide

- Production of insulin by *r*DNA techniques was achieved by an American company, Eli Lilly, in 1983. It prepared two DNA sequences corresponding to A and B chains of human insulin and introduced them in plasmids of *E. coli* for production. The A and B chains produced, were separated, extracted and combined, by creating disulfide bonds to form human insulin called humulin.

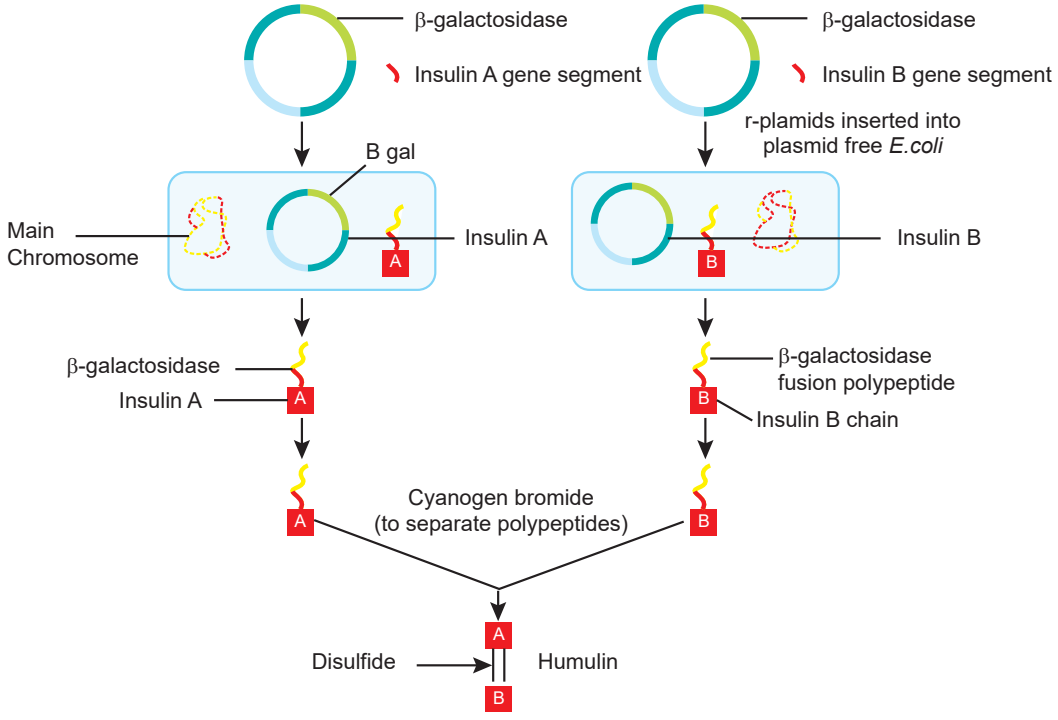


Fig. 12.3 Formation of insulin by Recombinant DNA technology

(ii) Gene therapy

- **Gene therapy** is a collection of methods that allows correction of gene defects, diagnosed in a child or embryo.
- By insertion of normal genes, the defective mutant allele of the genes are replaced and non-functional gene is compensated.

- For the first time in 1990, **M. Blease** and **W. F. Andresco** of National Institute of Health, attempted gene therapy on a 4 year old girl with **adenosine deaminase (ADA) deficiency**.
- ADA is caused due to deletion of gene for adenosine deaminase.
- In some cases, it can be cured by bone marrow transplantation and enzyme replacement therapy but it is not fully curative.
- In gene therapy, lymphocytes from patient's blood were grown in a culture and functional ADA, *c*DNA was introduced in these lymphocytes using a retroviral vector.
- The lymphocytes were transferred into the patient's body. Periodic infusion of such genetically engineered lymphocytes is done because these cells are mortal.
- For permanent cure, gene isolated from the bone marrow cells producing ADA, at early embryonic stage can be a possible cure.
- Other diseases like cystic fibrosis, haemophilia, cancer, Parkinson's, etc., are also treated by gene therapy.

(iii) Molecular diagnosis

- Early detection of a disease is not possible by conventional diagnosis methods.
- Some techniques used for early diagnosis are:

(a) Polymerase chain reaction

- Low concentration of the pathogen in the body does not allow its detection.
- The nucleic acid of the pathogen (bacteria or virus) is amplified by PCR for its detection.
- It is being used for detection of HIV in suspected AIDS patients and genetic mutations in suspected cancer patients.

(b) Recombinant DNA technology

- A single stranded DNA or RNA tagged with a radioactive molecule is called probe.
- In this method, a probe is allowed to hybridise to its complementary DNA in the clone of cells.
- The cells are then detected by **autoradiography**.
- The cell with mutated gene will not be observed on the photographic film because the probe was not complementary to the mutated gene.

(c) Enzyme linked immunosorbent assay (ELISA)

- It is based on the principle of antigen–antibody interaction.
- Either the presence of antigens (proteins, glycoprotein, etc.) are detected or the antibodies produced against the pathogen are detected.

(iv) Stem Cell Technology

- **Stem cells** are undifferentiated biological cells. These can differentiate into specialised cells, can divide to produce more stem cells and even give rise to different cells/tissues.
- Stem cells are found in multicellular organisms.
- Adult stem cells are used in medical therapies, for example, in bone marrow transplantation.
- Stem cells can also be taken from umbilical cord blood just after birth.
- Stem cells can be useful to treat diabetes, heart disease, spinal cord injury, cystic fibrosis, cancer, rheumatoid arthiritis, etc.

3. Transgenic Animals

- Animals whose DNA is manipulated to possess and express an extra (foreign) gene are known as transgenic animals. Transgenic rats, rabbits, pigs, sheep and cows have been produced.
- Following are the common reasons for developing transgenic animals:

(i) Study of normal physiology and development

- Useful to study gene regulation, their effect on the normal functions of the body and its development.
- For example, study of complex growth factors like insulin-like growth factor.

(ii) Study of diseases

- Study of genes which are responsible for diseases in humans and their treatment.
- Transgenic models have been developed for many human diseases like cancer, cystic fibrosis, rheumatoid arthritis and Alzheimer's disease.

(iii) Biological products

- Useful biological products can be produced by introducing, into transgenic animals, the portion of DNA (or genes) which codes for a particular product.
- For example, human protein (α-1-antitrypsin) is used to treat emphysema.
- In 1997, the first transgenic cow, Rosie, produced human protein-enriched milk (2.4 g/L).
- The milk contained the human alpha-lactalbumin and was more nutritionally balanced for human babies than natural cow milk.

(iv) Vaccine safety

- Transgenic mice are developed to test safety of vaccines, before being used on humans.
- For example, polio vaccine.

(v) Chemical safety testing

- Transgenic animals are made to carry genes, which make them more sensitive to the toxic substances than non-transgenic animals.
- On exposing to the toxic substances, their effects are studied in less time.

4. Ethical Issues

- Genetic modification of organisms show unpredictable results when such organisms are introduced into the ecosystem.
- The modification and use of living organisms for public services (as food and medicine sources, for example) creates problems with patents granted.
- Government of India has formed the organisations like **GEAC** (Genetic Engineering Approval Committee) to decide the validity and safety of GM organisms for public safety.
- Angered public is questioning, that certain companies granted patents for products and technologies which are grown, identified and used by farmers and indigenous people related to a specific region/country.
- Rice is being used since thousands of years in Asia's agricultural history, of which 200,000 varieties are in India alone.
- Basmati is unique for its aroma and flavour, whose 27 varieties are cultivated in India.
- In 1997, an American company got patent rights for Basmati rice through the US Patent and Trademark Office, and was allowed to sell a 'new variety' in US and abroad.
- This new variety of Basmati was derived from Indian farmer's varieties.
- Indian Basmati was crossed with semi-dwarf varieties and claimed as an invention or a novelty.
- Besides Basmati rice, now attempts are in progress for turmeric and neem.
- Our rich legacy will be reduced by other countries/individuals, if we do not pay attention or counter these patent application.

5. Biopiracy

- Biopiracy is defined as the use of bioresources by multinational companies and other organisations, without proper authorisation from the countries and concerned people, without compensatory payment.
- Generally, financially rich nations are poor in biodiversity and traditional knowledge, while developing and under-developed nations are rich in biodiversity and traditional knowledge, related to bioresources.
- Traditional knowledge related to bioresources can be exploited to develop modern applications and are used to save time, efforts and expenditure during their commercialisation.

- Some nations are developing laws, to prevent such unauthorised exploitation of their bioresources and traditional knowledge.
- To check these problems, Indian Parliament has recently cleared the second amendment of the **Indian Patents Bill**, that takes such issues into consideration.

6. Patent

- A patent is a set of exclusive rights granted by a state (national government) to an inventor or their assignee for a limited period of time in exchange for a public disclosure of an invention.
- Patents satisfy three criteria: novelty, non-obviousness, utility.
  - **Novelty:** It means that the innovation must be new.
  - **Non-obviousness:** It may not be documented but is otherwise well-known.
  - **Utility:** Product should be of particular use for human beings.

Controversies in India Regarding Patent and Biopiracy

(*i*) **Turmeric:** In May 1955, patent was granted by US patent office to University of Mississippi Medical Centre for 'Use of Turmeric in wound healing'. The patent was challenged by Dr. R.A Mashelkar and it was established that use of turmeric as healing agent was known in India for centuries. So, the patent was revoked.

(*ii*) **Neem:** In 1996 Vandana Shiva challenged the patent granted to the firm of W.R. Grace & Co. by European Patent Office, Munich, for fungicidal uses of Neem oil. Ancient Indian texts were flagged to point out that there was no 'Novelty' factor and India had known them for long. So patent was overturned in 2005.

(*iii*) **Basmati Rice:** In September 1997, Texas Company—'Roce Tec' was given patent on 'Basmati rice lines and grains'. But later it lost most of the claims of the patent.

NCERT Textbook Questions

Q. 1. Crystals of Bt toxin produced by some bacteria do not kill the bacteria themselves because—

(*a*) bacteria are resistant to the toxin; **(*b*) toxin is immature;**

(*c*) toxin is inactive; **(*d*) bacteria encloses toxin in a special sac.**

[*HOTS*]

Ans. (*c*) toxin is inactive.

Q. 2. What are transgenic bacteria? Illustrate using any one example.

Ans. The bacteria whose DNA is manipulated to carry and express a foreign DNA is called transgenic bacteria. These microbes are used for producing important biochemicals. They have been synthesising alcohol, enzymes, steroids and antibiotics. Example, *Bacillus thuringiensis* for Bt cotton. For details refer basic concept point 1(*i*) and 2(*i*).

Q. 3. Compare and contrast the advantages and disadvantages of production of genetically modified crops.

Ans. **Advantages of genetically modified crops:**

- Reduces the use of chemical fertilisers and pesticides which cause pollution (air, water and soil).
- Production of new resistant varieties against pathogen, droughts, salinity, etc.
- Provides raw materials to industries like pharmaceuticals.
- Genetically modified crops have enhanced nutritional quality and yield.
- These crops grow fast and produce high yield through modifications.

Disadvantages of genetically modified crops:

- Proteins produced by GM organisms might cause allergy and other reactions.
- Resistance characters might develop in intestinal bacteria against antibiotics.
- Resistant genes transferred by pollen to the weeds may also become resistant to pests.

Q. 4. What are Cry proteins? Name an organism that produce it. How has man exploited this protein to his benefit?

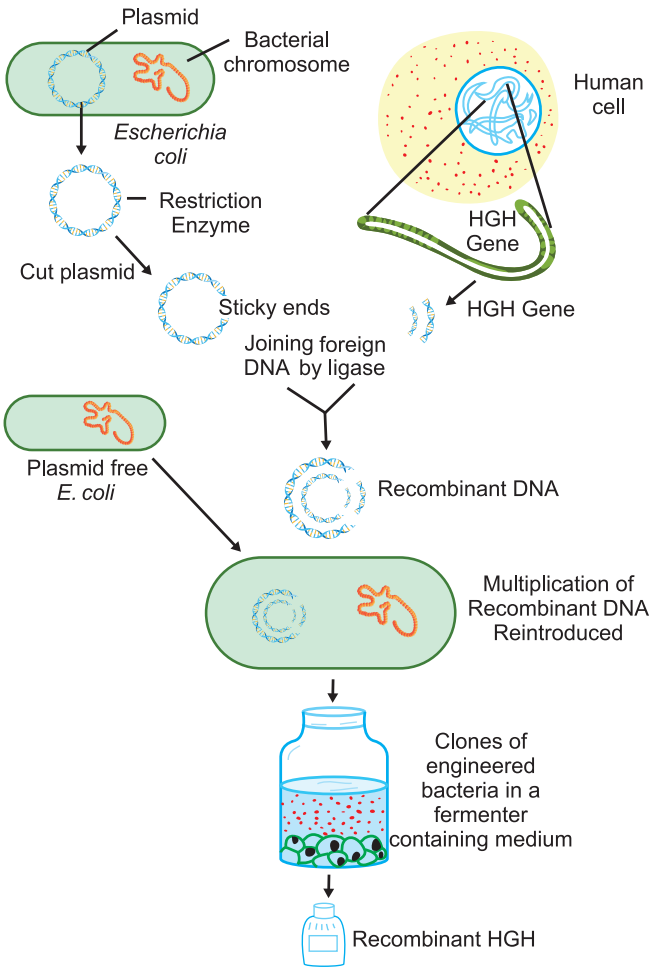
Ans. Cry protein (crystal protein) is a toxin coded by a gene *cry* and is poisonous to some insects, thus giving resistant characters to the plants. *Bacillus thuringiensis* produces Cry protein. Cry protein producing gene is transferred to the plants to provide resistance against insect larvae. Man has developed several transgenic crops by introducing these genes from bacteria to crop plants such as Bt cotton, Bt corn, etc.

Q. 5. What is gene therapy? Illustrate using the example of adenosine deaminase (ADA) deficiency.

Ans. Gene therapy is a method which corrects or replaces the defective genes. In 1900, first clinical gene therapy was given to a 4-year old girl with adenosine deaminase (ADA) deficiency. This enzyme plays an important role in functioning of immune system. This disorder is caused due to the deletion of the gene for adenosine deaminase. In gene therapy, lymphocytes from the blood of the patient are grown in a culture outside the body. A functional ADA *c*DNA (using a retroviral vector) is then introduced into these lymphocytes, which are returned to the patients. However, as these cells are not immortal, hence the patient requires periodic infusion of such genetically engineered lymphocytes.

Q. 6. Diagrammatically represent the experimental steps in cloning and expressing a human gene (say the gene for growth hormone) into bacterium like *E. coli*.

Ans. It is possible to produce HGH (human growth hormone) by recombinant DNA technology. This is represented diagrammatically as follows:



Steps involved in gene transfer in the production of human growth hormone

Q. 7. Can you suggest a method to remove oil (hydrocarbon) from seeds based on your understanding of *r*DNA technology and chemistry of oil?

Ans. To remove oil from seeds, the genes responsible for formation of glycerol or fatty acids need to be identified and removed by using restriction endonucleases. The restricted DNA of the seed then needs to be ligated using the enzyme ligase and allowed to grow in nutrient media under aseptic condition.

Q. 8. Find out from internet what is golden rice. ***[HOTS]***

Ans. Golden rice is a genetically modified rice that contains β-carotene (provitamin A). This provitamin A is converted into vitamin A inside the body and gives the rice grain its characteristic golden colour. It produces two new enzymes that completes the β-carotene expression in the grain. It is intended to complement current strategies in the fight against vitamin A deficiency.

Q. 9. Does our blood have proteases and nucleases?

Ans. Blood does not contain proteases and nucleases because their function is to breakdown proteins and nucleic acids.

Q. 10. Consult internet and find out how to make orally active protein pharmaceutical. What is the major problem to be encountered? ***[HOTS]***

Ans. Orally active protein pharmaceutical can be made by lining it with a substance that will dissolve after it has passed through the stomach.

The major problem encountered is that the stomach enzymes and acids may denature the therapeutic protein and render it ineffective.

Multiple Choice Questions [1mark]

Choose and write the correct option in the following questions.

1. What is antisense technology?

(*a*) When a piece of RNA that is complementary in sequence is used to stop expression of a specific gene.

(*b*) RNA polymerase producing DNA.

(*c*) A cell displaying a foreign antigen used for synthesis of antigens.

(*d*) Production of somaclonal variants in tissue cultures.

2. *Cry* I endotoxins obtained from *Bacillus thuringiensis* are effective against

(*a*) nematodes (*b*) bollworms

(*c*) mosquitoes (*d*) flies

3. Human insulin is being commercially produced from a transgenic species of

(*a*) *Rhizobium* (*b*) *Saccharomyces*

(*c*) *Escherichia* (*d*) *Mycobacterium*

4. Which one of the following is commonly used in transfer of foreign DNA into crop plants?

(*a*) *Meloidogyne incognita* (*b*) *Agrobacterium tumefaciens*

(*c*) *Penicillium expansum* (*d*) *Trichoderma harzianum*

5. What is true about Bt toxin?

(*a*) Bt protein exists as active toxin in the *Bacillus*.

(*b*) The activated toxin enters the ovaries of the pest to sterilise it and thus prevent its multiplication.

(*c*) The concerned *Bacillus* has antitoxins.

(*d*) The inactive protoxin gets converted into active form in the insect gut.

6. Genetic engineering has been successfully used for producing

(*a*) transgenic mice for testing safety of polio vaccine before use in humans

(*b*) transgenic models for studying new treatments for certain cardiac diseases

(*c*) transgenic cow-Rosie which produces high fat milk for making ghee

(*d*) animals like bulls for farm work as they have super power

7. Bt cotton is not [NCERT Exemplar]

(a) a GM plant (b) insect resistant

(c) a bacterial gene expressing system (d) resistant to all pesticides

8. C-peptide of human insulin is [NCERT Exemplar]

(a) a part of mature insulin molecule

(b) responsible for formation of disulphide bridges

(c) removed during maturation of proinsulin to insulin

(d) tesponsible for its biological activity.

9. GEAC stands for [NCERT Exemplar]

(a) Genome Engineering Action Committee (b) Ground Environment Action Committee

(c) Genetic Engineering Approval Committee (d) Genetic and Environment Approval committee

10. α-1-antitrypsin is [NCERT Exemplar]

(a) an antacid (b) an enzyme

(c) used to treat arthritis (d) used to treat emphysema

11. Human insulin is being commercially produced from a transgenic species of

(a) *Rhizobium* (b) *Saccharomyces* (c) *Escherichia* (d) *Mycobacterium*

12. A probe which is a molecule used to locate homologous sequences in a mixture of DNA or RNA molecules could be: [NCERT Exemplar]

(a) a *ss*RNA (b) a *ss*DNA

(c) either RNA or DNA (d) can be ssDNA but not ssRNA

13. Choose the correct option regarding retrovirus. [NCERT Exemplar]

(a) An RNA virus that synthesises DNA during infection

(b) A DNA virus that synthesises RNA during infection

(c) A *ss*DNA virus

(d) A *ds*RNA virus

14. The site of production of ADA in the body is [NCERT Exemplar]

(a) erythrocytes (b) lymphocytes

(c) blood plasma (d) osteocytes

15. A protoxin is [NCERT Exemplar]

(a) a primitive toxin (b) a denatured toxin

(c) toxin produced by protozoa (d) inactive toxin

16. Pathophysiology is the [NCERT Exemplar]

(a) study of physiology of pathogen (b) study of normal physiology of host

(c) study of altered physiology of host (d) none of the above

17. The trigger for activation of toxin of *Bacillus thuringiensis* is [NCERT Exemplar]

(a) acidic pH of stomach (b) high temperature

(c) alkaline pH of gut (d) mechanical action in the insect gut

18. Bt corn has been made resistant from corn borer disease by introduction of the gene

(a) *cryIAb* (b) amp^R (c) *cryIIAb* (d) *trp*

19. A bioreactor refers to

(a) fermentation tank (b) tank for biochemical reactions

(c) organisms reacting to a stimulus (d) tank for biochemical waste

20. Golden rice is [NCERT Exemplar]

(a) a variety of rice grown along the yellow river in China

(b) long stored rice having yellow colour tint

(c) a transgenic rice having gene for β-carotene

(d) wild variety of rice with yellow coloured grains

21. In RNAi, genes are silenced using [NCERT Exemplar]

(a) *ss*DNA (b) *ds*DNA

(c) *ds*RNA (d) *ss*RNA

22. The first clinical gene therapy was done for the treatment of [NCERT Exemplar]

(a) AIDS

(b) Cancer

(c) Cystic fibrosis

(d) SCID (Severe Combined Immuno Deficiency resulting form deficiency of ADA)

23. ADA is an enzyme which is deficient in a genetic disorder SCID. What is the full form of ADA? [NCERT Exemplar]

(a) Adenosine deoxyaminase (b) Adenosine deaminase

(c) Aspartate deaminase (d) Arginine deaminase

24. Silencing of a gene could be achieved through the use of [NCERT Exemplar]

(a) RNAi only (b) antisense RNA only

(c) both RNAi and antisense RNA (d) none of the above

25. Biopiracy means

(a) use of biopatents

(b) thefts of plants and animals

(c) stealing of bioresources

(d) exploitation of bioresources without authentic permission

26. During the processing of 'proinsulin' into mature 'insulin'

(a) A – chain is removed (b) C – chain is removed

(c) B – chain is removed (d) No peptide chain is removed

Answers

1. (a)	**2.** (b)	**3.** (c)	**4.** (b)	**5.** (d)	**6.** (a)	**7.** (d)	**8.** (c)	**9.** (c)	**10.** (d)
11. (c)	**12.** (c)	**13.** (a)	**14.** (b)	**15.** (d)	**16.** (c)	**17.** (c)	**18.** (a)	**19.** (a)	**20.** (c)
21. (c)	**22.** (d)	**23.** (b)	**24.** (c)	**25.** (d)	**26.** (b)				

Assertion-Reason Questions

In the following questions a statement of assertion followed by a statement of reason is given. Choose the correct answer out of the following choices.

(a) Assertion and reason both are correct statements and reason is correct explanation for assertion.

(b) Assertion and reason both are correct statements but reason is not correct explanation for assertion.

(c) Assertion is correct statement but reason is wrong statement.

(d) Assertion is wrong statement but reason is correct statement.

1. Assertion : *Agrobacterium tumefaciens* is popular in genetic engineering because it spontaneously transfers tumour inducing gene to broad leaf dicot plants.

Reason : A gene incorporated in the bacterial chromosomal genome gets autonomically transferred to be crop with which the bacterium is associated.

2. Assertion : Genetic engineering is mainly involved in production of transgenic animals that produce proteins.

Reason : Transgenic plants can be obtained by combination of tissue culture and genetic engineering.

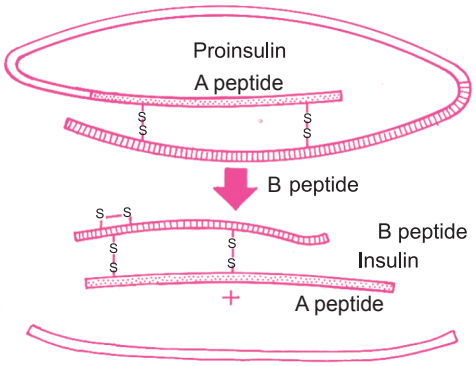
3. **Assertion :** The first gene therapy was given for ADA deficiency.
   Reason : The normal gene for ADA was delivered to patient's cells using retroviral vector.
4. **Assertion :** Orgnisations like Genetic Engineering Approval Committee (GAEC) monitor GM researches.
   Reason : Some ethical standards are required to evaluate the morality of all human activities.
5. **Assertion :** Human insulin is produced in *E. coli*.
   Reason : In mammals, insulin is synthesised as a pro-hormone which contains an extra stretch of protein.
6. **Assertion :** The RNAi can be introduced in an organism only by inserting the gene encoding complementary RNA.
   Reason : The complement of the mRNA sense strand usually contains the sequence of codons for producing functional protein.
7. **Assertion :** 'Cry' proteins are named so because they are crystal proteins.
   Reason : 'Cry' proteins solubilise in alkaline pH of the insect's gut and activate Bt toxin.
8. **Assertion :** Patents are granted by government to an inventor.
   Reason : Patent prevents other from commercial use of an invention.
9. **Assertion :** Stem cells are undifferentiated biological cells found in multicellular organisms.
   Reason : They are obtained from only umbilical cord blood just after birth.
10. **Assertion :** Indian Patents Bill takes cases of biopiracy in consideration.
    Reason : Biopiracy is the use of bioresources by multinational companies without proper authorisation from concerned persons and countries.

Answers

1. (*c*) **2.** (*d*) **3.** (*b*) **4.** (*a*) **5.** (*b*) **6.** (*d*) **7.** (*b*) **8.** (*a*) **9.** (*c*) **10.** (*b*)

Case-based/Source-based Question

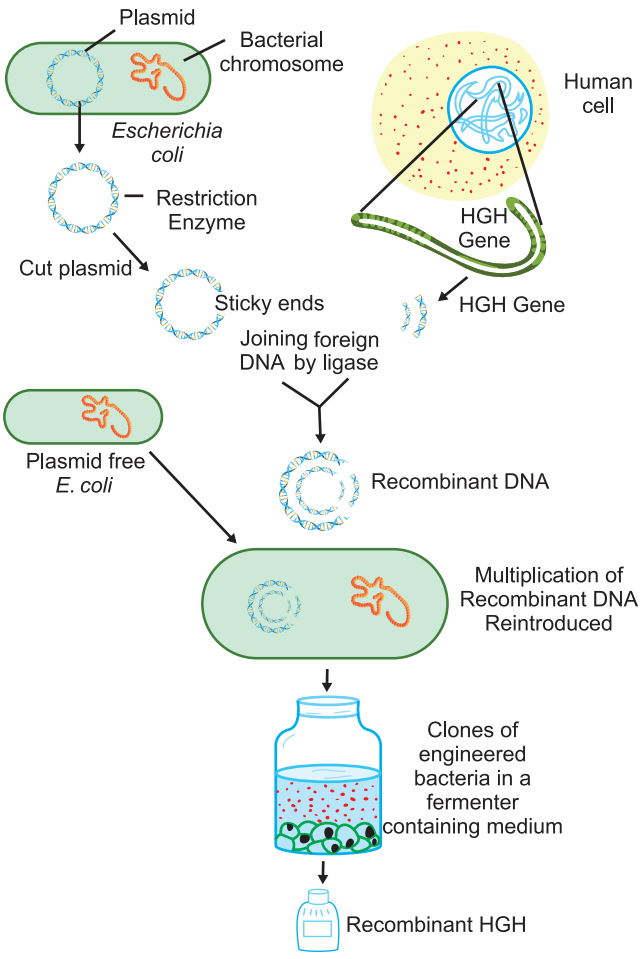
1. Refer to the diagram of maturation of proinsulin into insulin to answer the following questions.



(*i*) How are two short polypeptide chains of insulin linked together?
(*ii*) State the role of C-peptide in human insulin.
(*iii*) Mention the chemical change that proinsulin undergoes, to be able to act as mature insulin.

Ans. (*i*) Two short polypeptide chains of insulin are linked together by disulphide bridges.
(*ii*) C-peptide (extra stretch of polypeptide) makes the insulin inactive.
(*iii*) An extra stretch called C-peptide is removed from pro-insulin during maturation.

2.



Human growth hormone can be cloned and expressed experimentally with the steps shown above.

(*i*) What is the host called that produces a foreign gene product? What is this product called?

(*ii*) Write the name of the enzymes that are used for isolation of DNA from bacterial and fungal cells respectively for Recombinant DNA technology.

(*iii*) How can bacterial DNA be released from the bacterial cell for biotechnology experiments?

Ans. (*i*) The host that produces a foreign gene product is called competent host. The product is called recombinant protein.

(*ii*) Bacterial cell is treated with enzyme lysozyme.

Fungal cell is treated with chitinase.

(*iii*) The bacterial cell wall is digested by the enzyme lysozyme to release DNA from the cell.

Very Short Answer Questions [1 mark]

Q. 1. Give the name of HGH (Human Growth Hormones), developed during recombinant DNA technology and used for treating hypopituitary dwarfism in human. ***[HOTS]***

Ans. Somatotropin.

Q. 2. What is "Flavr Savr"?

Ans. It is a transgenic tomato variety which has blocked production of polygalacturonase.

Q. 3. Mention the source organism of the gene *cryIAc* and its target pest. ***[CBSE (F) 2011]***

Ans. Source organism — *Bacillus thuringiensis*

Target pest — Cotton bollworms

Q. 4. Why is the gene encoding for 'Cry' protein inserted into a crop plant? **[*HOTS*]**

Ans. Cry protein producing gene is transferred to the plant to provide resistance against insect larvae.

Q. 5. Name the specific type of gene that is incorporated in a cotton plant to protect the plant against cotton boll worm infestation. **[*CBSE (AI) 2017*]**

Ans. *Cry IAc/Cry IIAb* genes are incorporated in a cotton plant.

Q. 6. State a method of cellular defence which works in all eukaryotic organisms. **[*CBSE Sample Paper 2015, 2018*]**

Ans. RNA interference.

Q. 7. What is the significance of the process of RNA interference (RNAi) in eukaryotic organisms?

Ans. RNA interference in all eukaryotic organisms is a method of cellular defence.

Q. 8. Mention the chemical change that proinsulin undergoes, to be able to act as mature insulin. **[*CBSE Sample Paper 2018*]**

Ans. An extra stretch called C-peptide is removed from pro-insulin during maturation.

Q. 9. State the role of transposons in silencing of *m*RNA in eukaryotic cells. **[*CBSE (AI) 2013*]**

Ans. Transposons or mobile genetic elements in viruses are the sources of the complementary *ds*RNA, which in turn bind to specific *m*RNA and cause RNA interference of the parasite.

Q. 10. Name two genetically modified hormones.

Ans. Insulin and human growth hormones.

Q. 11. Write the two uses of PCR technique in diagnosis.

Ans. Two uses of PCR technique:

(*i*) It is used to detect HIV in suspected AIDS patients.

(*ii*) It is used to detect mutations in gene, in suspected cancer patients.

Q. 12. PCR requires very high temperature conditions where most of the enzymes get denatured. How was this problem resolved in a PCR? **[*CBSE Sample Paper 2017*]**

Ans. This problem was resolved by the use of a thermostable DNA polymerase, Taq polymerase derived from *Thermus aquaticus* which remains active during the high temperature and induces denaturation of double stranded DNA.

Q. 13. Name a molecular diagnostic technique to detect the presence of a pathogen in its early stage of infection. **[*CBSE Delhi 2010*]**

Ans. ELISA (Enzyme Linked Immunosorbent Assay)

Q. 14. Name any two techniques that serve the purpose of early diagnosis of some bacterial/viral human diseases. **[*CBSE (F) 2011*]**

Ans. Enzyme linked immuno sorbent (ELISA) and Polymerase Chain Reaction (PCR) serve the purpose of early diagnosis of human diseases.

Q. 15. Name the first transgenic cow. Which gene was introduced in this cow? **[*NCERT Exemplar*]**

Ans. Rosie was the first transgenic cow. Human α-lactalbumin gene was introduced.

Q. 16. What was the speciality of the milk produced by the transgenic cow Rosie?

Ans. The first transgenic cow, Rosie, produced milk with human alpha-lactalbumin (2.4 g protein/litre of milk) which was nutritionally, more balanced product for human babies than natural cow milk.

Q. 17. What is Chakravarthy bug? Give its scientific name and its application?

Ans. Chakravarthy bug is a super bug of *Pseudomonas* with multiple plasmids. They are helpful in removing oil spills.

Q. 18. Name a recombinant vaccine that is currently being used in vaccination program?

Ans. Hepatitis B recombinant vaccine, Engerix-B, is used for vaccination of hepatitis virus.

Q. 19. State the cause of adenosine deaminase enzyme deficiency. **[*CBSE (AI) 2015*]**

Ans. Deletion of gene for adenosine deaminase.

Q. 20. Suggest any two possible treatments that can be given to a patient exhibiting adenosine deaminase deficiency. **[*CBSE (AI) 2015*]**

Ans. (*i*) Enzymes replacement therapy (in which functional ADA is injected)
(*ii*) Bone marrow transplantation
(*iii*) Gene therapy/Culturing the lymphocytes followed by introduction of functional ADA *c*DNA into it and returning it into the patient's body. (*Any two*)

Q. 21. A boy has been diagnosed with ADA deficiency. Suggest any one possible treatment. **[*CBSE (AI) 2014*] [*NCERT Exemplar*] [*HOTS*]**

Ans. Bone marrow transplant/enzyme replacement therapy/gene therapy.

Q. 22. Why do children cured by enzyme-replacement therapy for adenosine deaminase deficiency need periodic treatment? **[*CBSE (AI) 2015*] [*HOTS*]**

Ans. As enzyme replacement therapy does not cure the disease completely, it requires periodic treatment.

Q. 23. What are transgenic animals? Give an example. **[*CBSE (AI) 2016*]**

Ans. Animals that have had their DNA manipulated, to possess and express an extra (foreign) gene are known as transgenic animals. Example, Rosie is a transgenic cow.

Q. 24. What is biopiracy? **[*CBSE Delhi 2015, 2016; (AI) 2017*]**

Ans. Biopiracy is the use of bioresources by multinational companies and other organisations without proper authorization or compensation payment to the concerned country or organisation.

Q. 25. State the purpose for which the Indian Government has set up GEAC. **[*CBSE (F) 2013*]**

OR

Mention two objectives of setting up GEAC by our government. **[*CBSE (AI) 2016*]**

Ans. GEAC was set up to make decisions regarding the validity of GM research and the safety of introducing GM-organisms for public services.

Q. 26. A multinational company outside India tried to sell new varieties of turmeric without proper rights. What is such an act referred to?

Ans. Biopiracy.

Q. 27. For which variety of Indian rice, patent was filed by a USA Company? **[*NCERT Exemplar*] [*HOTS*]**

Ans. Indian Basmati was crossed with semi-dwarf variety and was claimed as a new variety for which the patent was filed by a USA company.

Short Answer Questions [2 marks]

Q. 1. Highlight any four advantages of genetically modified organisms (GMOs).

OR

Describe any three potential applications of genetically modified plants. **[*CBSE (AI) 2015*]**

Ans. Advantages of GMOs:
(*i*) Tolerance against abiotic stresses (cold, drought, salt, heat).
(*ii*) Reduce reliance on chemical pesticides.
(*iii*) Reduce post-harvest losses.
(*iv*) Increase efficiency of mineral usage by plants.

Q. 2. Expand GMO. How is it different from a hybrid? **[*NCERT Exemplar*]**

Ans. GMO stands for genetically modified organism. It differs from a hybrid because in a hybrid, cross is done between total genomes of two species or strains, whereas in a GMO, foreign genes are introduced in the organism and is usually maintained as extra-chromosomal entity or is integrated into the genome of the organism and their is change in only one phenotype.

Q. 3. Name the source and the types of *cry* genes isolated from it for incorporation into crops by biotechnologists. Explain how have these genes brought beneficial changes in the genetically modified crops.

Ans. Source of *cry* gene is *Bacillus thuringiensis*.

The following type of *cry* genes are isolated from it: *cry*IAc, *cry*IIAb, *cry*IAb.

The introduction of *cry* gene acts as biopesticide. The *cry* gene produce crystals of toxic insecticidal protein. The activated toxin causes death of the insect.

Q. 4. *cry*IAb is introduced in a plant to control infestation by corn borer.

(*a*) Name the resultant plant after successful insertion of the gene desired.

(*b*) Summarise the action of the gene introduced. **[*CBSE Sample Paper 2015, 2017, 2018*]**

Ans. (*a*) Bt corn

(*b*) *Cry*IAb/Bt toxin gene codes for crystal protein; the Bt toxin protein exists as an inactive protein, but once an insect ingests it, it gets converted into an active form due to the alkaline pH of the gut which solubilises the crystal. The activated toxin binds to the surface of mid gut and creates pores that cause swelling, lysis and eventually death of the insect.

Q. 5. Name a genus of baculovirus. Why are they considered good biocontrol agents?

[*CBSE (AI) 2016; 2019 (57/4/1)*]

Ans. *Nucleopolyhedrovirus* is a genus of baculovirus.

They are species-specific, have narrow-spectrum insecticidal application and no negative impact on non-target organisms, hence they are considered good biocontrol agents.

Q. 6. Bt cotton is resistant to pest, such as lepidopteran, dipterans and coleopterans. Is Bt cotton resistant to other pests as well? **[*NCERT Exemplar*] [*HOTS*]**

Ans. Bt cotton is made resistant to only certain specific taxa of pests. It is quite likely that in future, some other pests may infest the Bt cotton plants. It is similar to immunisation against small-pox which does not provide immunity against other pathogens like those that cause cholera, typhoid, etc.

Q. 7. What is GEAC and what are its objectives? **[*NCERT Exemplar*]**

Ans. GEAC (Genetic Engineering Approval Committee) is an Indian government organisation. Its objective are to:

(*a*) examine the validity of GM (Genetic modification of organism) research.

(*b*) inspect the safety of introducing GM for public services and for their large scale use.

Q. 8. (*a*) How does *cry*IAc gene express itself in its host?

(*b*) State the role of this gene in controlling the infestation of bollworm. **[*CBSE (F) 2012*]**

OR

Name the insect pest that is killed by the products of *cry*IAc gene. Explain how the gene makes the plant resistant to the insect pest. **[*CBSE (AI) 2010*]**

Ans. (*a*) *cry*IAc gene codes for a toxic insecticidal protein that controls the cotton bollworms.

(*b*) This gene codes for a toxin that becomes active when ingested by the insect. The activated toxin binds to the surface of mid-gut epithelial cells thus creating pores which causes cell swelling and lysis, further leading to death of the insects.

Q. 9. How has the bacterium *Bacillus thuringiensis* helped us in controlling caterpillars of insect pests?

Ans. *Bacillus thuringiensis* products are endotoxin which when ingested and released in the gut of the larvae of insect pest disrupts the insect gut lining thereby killing them.

Q. 10. Why do the toxic insecticidal proteins secreted by *Bacillus thuringiensis* kill the insect and not the bacteria itself? **[*CBSE Delhi 2014, (F) 2010*]**

Ans. The Bt toxin protein exists as inactive protoxins but once an insect ingests the inactive toxin, it is converted into an active form of toxin due to the alkaline pH of the gut which solubilise the crystals. Therefore, it does not kill the bacteria.

Q. 11. Name the genes responsible for making Bt cotton plants resistant to bollworm attack. How do such plants attain resistance against bollworm attacks? Explain. ***[CBSE Delhi 2012]***

Ans. Bt cotton has *cryIAc*/*cryIIAb* genes. These genes produce crystals of protoxin.

When bollworm bites the cotton fruits, it consumes the toxic insecticidal protein. The alkaline pH in its gut activates the toxin. The activated toxin binds to mid-gut epithelial cells resulting in the lysis of cells leading to the death of the insect.

Q. 12. Nematode-specific genes are introduced into the tobacco plants using *Agrobacterium* vectors to develop resistance in tobacco plants against nematodes. Explain the events that occur in tobacco plant to develop resistance.

OR

How has RNA*i* technique helped to prevent the infestation of roots in tobacco plants by a nematode *Meloidogyne incognita*? ***[CBSE Delhi 2010, 2016]***

Ans. Refer to Basic Concepts Point 1(*ii*).

Q. 13. (*a*) Tobacco plants are damaged severely when infested with *Meloidogyne incognita*. Name and explain the strategy that is adopted to stop this infestation.

(*b*) Name the vector used for introducing the nematode specific gene in tobacco plant.

[CBSE (AI) 2012]

Ans. (*a*) Gene expression can be controlled by using RNA molecule and this technology is called RNA interference or RNAi or gene silencing. During this process nematode specific gene is introduced into host plant (using *Agrobacterium*) which produces *ds*RNA. This silences specific *m*RNA of the nematode and parasite dies.

(*b*) *Agrobacterium tumifaciens*.

Q. 14. (*a*) State the role of DNA ligase in biotechnology.

(*b*) What happens when *Meloidogyne incognita* consumes cells with RNA*i* gene?

[CBSE Delhi 2012]

Ans. (*a*) DNA ligase joins the DNA fragments with same sticky ends. It also links Okazaki fragments or discontinuously synthesised fragments. DNA ligose is used to link desired gene with plasmid to form recombinant DNA. (*Any one*)

(*b*) The specific *m*RNA of the nematode is silenced and the parasite dies.

Q. 15. Why does the Bt toxin not kill the bacterium that produces it but kills the insect that ingests it? ***[CBSE Delhi 2014]***

Ans. Bt toxin exist as inactive protoxin in the bacterium. It becomes active only when it enters the gut of insect due to the alkaline pH of the gut which solubilise the crystals.

Q. 16. A corn farmer has perennial problem of corn-borer infestation in his crop. Being environmentally conscious he does not want to spray insectisides. Suggest solution based on your knowledge of biotechnology. Write the steps to be carried out to achieve it.

[CBSE 2019 (57/2/1)]

Ans. The following steps should be followed:

(*i*) Isolation of Bt toxin genes from *Bacillus thuringiensis*.

(*ii*) Incorporation of gene into corn.

(*iii*) Toxin coded by gene *cryIAb* in corn, kills the pests and the pest dies.

Q. 17. Explain the process of RNA interference. ***[CBSE Delhi 2011]***

Ans. RNA interference takes place in all eukaryotic organisms as a method of cellular defence. It involves silencing of a specific *m*RNA due to complementary *ds*RNA molecule that binds to and prevents translation of the *m*RNA.

Q. 18. (*a*) Given below is a single stranded DNA molecule. Frame and label its sense and antisense RNA molecule.

5′ ATGGGGCTC 3′

(*b*) How the RNA molecules made from above DNA strand help in silencing of the specific RNA molecules? **[*CBSE Sample Paper 2016*]**

Ans. (*a*) 5′ ATGGGGCTC 3′ sense
3′ TACCCCGAG 5′ antisense
5′AUGGGGCUC 3′ sense
3′UACCCCGAG 5′ antisense

(*b*) The two strands of RNA (*i.e.*, sense and antisense) being complementary will bind with each other and form double stranded RNA as a result its translation and protein expression would be inhibited.

Q. 19. Differentiate between gene therapy and gene cloning.

Ans. **Table 12.1: Difference between Gene Therapy and Gene Cloning**

Gene therapy	Gene cloning
The process of replacing defective gene responsible for hereditary disease by the normal gene is called gene therapy.	The technique to produce identical copies of a particular segment of DNA or a gene.

Q. 20. How is a mature, functional insulin hormone different from its pro-hormone form? **[*NCERT Exemplar*]**

Ans. Mature functional insulin is obtained by processing of pro-hormone which contains extra peptide called C-peptide. This C-peptide is removed during maturation of pro-insulin to insulin.

Q. 21. Explain how a hereditary disease can be corrected. Give an example of first successful attempt made towards correction of such diseases. **[*CBSE Delhi 2011*]**

Ans. A hereditary disease can be corrected by gene therapy. In this method, normal genes are inserted into a person's cells and tissues to treat a disease.

The first successful attempt for gene therapy was done for adenosine deaminase (ADA) deficiency.

Q. 22. Gene therapy is an attempt to correct a genetic defect by providing a normal gene into the individual. By this the normal function can be restored. Alternate method would be to provide the gene product (protein/enzyme) known as enzyme replacement therapy, which would also restore the function. Which in your opinion is a better option? Give reason for your answer. **[*NCERT Exemplar*] [*HOTS*]**

Ans. Gene therapy would be a better option because it has the potential to completely cure the patient. It is because the correct gene once introduced in the patient, can continue to produce the correct protein enzyme. Enzyme therapy does not offer permanent cure as it needs to be given to the patient on regular basis. It is also more expensive.

Q. 23. A person is born with a hereditary disease, suggest the possible corrective method for it. Illustrate by giving a specific example. **[*HOTS*]**

Ans. The possible corrective method is gene therapy.

For example, ADA (Adenosine deaminase) deficiency has been treated through gene therapy. Lymphocytes from the blood of the patient are grown in a culture. A functional ADA *c*DNA is introduced into these lymphocytes, which are subsequently returned to the patient. The permanent cure is done by introducing ADA *c*DNA into cells at early embryonic stages.

Q. 24. How did an American Company, Eli Lilly use the knowledge of *r*DNA technology to produce human insulin? **[*CBSE (F) 2014, (AI) 2015*]**

Ans. Two chains of DNA sequence corresponding to A and B chains of human insulin were prepared. They introduced them into plasmids of *E. coli* to produce separate A and B chains. The A and B chains extracted were then combined by creating disulphide bonds and form human insulin.

Q. 25. (*a*) Mention the cause and the body system affected by ADA deficiency in humans.

(*b*) Name the vector used for transferring ADA-DNA into the recipient cells in humans. Name the recipient cells. **[*CBSE (AI) 2012*]**

Ans. (*a*) The cause is the defective gene not producing ADA. The immune system is affected.

(*b*) A retroviral vector is used, recipient cells are lymphocytes.

Q. 26. Write the functions of adenosine deaminase enzyme. State the cause of ADA deficiency in humans. Mention a possible permanent cure for a ADA deficiency patient. [*CBSE Delhi 2013*]

Ans. Adenosine deaminase enzyme is responsible for the proper functioning of the immune system. ADA deficiency is caused by deletion of gene for adenosine deaminase. A possible permanent cure would be gene therapy, if it is detected at early embryonic stage.

Q. 27. Why is the functional insulin thus produced considered better than the ones used earlier by diabetic patients?

Ans. The insulin prepared by *r*DNA technology does not produce sensitive allergic reactions and immunological reactions whereas those used earlier produced allergic reactions and other complications to the foreign protein as earlier they were extracted from pancreas of slaughtered cattle or pigs.

Q. 28. How has recombinant technology helped in large scale production of vaccines? Explain giving one example. [*CBSE (F) 2012*]

Ans. Production of insulin by *r*DNA techniques was achieved by an American company, Eli Lilly, in 1983. It prepared two DNA sequences corresponding to A and B chains of human insulin and introduced them in plasmids of *E. coli* for production. The A and B chains produced were separated, extracted and combined by creating disulfide bonds to form human insulin.

Q. 29. How is 'Rosie' considered different from a normal cow? Explain. [*CBSE (AI) 2011*]

Ans. Rosie is a transgenic cow.

Rosie produces human protein-enriched milk containing human α-lactalbumin.

Q. 30. What is gene therapy? Name the first clinical case where it was used. [*CBSE Delhi 2014*]

Ans. Gene therapy is a collection of methods that allows correction of a gene defect that has been diagnosed in a child/embryo.

Genes are inserted into an individual's cells and tissues to treat disease.

The first clinical case where it was used was for caring Adenosine deaminase (ADA) deficiency.

Q. 31. Why is the introduction of genetically engineered lymphocytes into an ADA deficiency patient not a permanent cure? Suggest a possible permanent cure. [*CBSE Delhi 2010*] [*HOTS*]

Ans. Introduction of genetically engineered lymphocytes into an ADA deficiency patient is not a permanent cure because these cells are not immortal and the patient requires periodic infusion of such genetically engineered lymphocytes. A possible permanent cure can be isolating the gene producing adenosine deaminase (ADA) from bone marrow cells and introducing it into cells at early embryonic stages.

Q. 32. How have transgenic animals proved to be beneficial in:

(*a*) Production of biological products?

(*b*) chemical safety testing? [*CBSE (AI) 2014*] [*HOTS*]

Ans. (*a*) Rosie–the transgenic cow, produced human proteins containing human α-lactalbumin. Transgenic animals have been made to produce α-1-antitrypsin used to treat emphysema.

(*b*) Toxicity testing – Transgenic animals are more sensitive to toxic substances, so the results are obtained in less time.

Q. 33. How is PCR used to detect gene mutation in case of suspected cancer patient?

Ans. A single stranded small DNA or RNA is tagged with radioactive molecule to be used as a probe. The probe is hybridised with DNA in cancer cells, to be followed by autoradiography. The clone with mutated gene will not appear in the autoradiography, because the probe will not have the complementary sequence with mutated gene.

Q. 34. Why are yeasts used extensively for functional expression of eukaryotic genes? [*HOTS*]

Ans. Yeasts are simplest unicellular eukaryotic organisms and like bacteria they are genetically well characterised, easy to grow and manipulate. They can be readily cultured in small culture vessels as well as in large-scale bioreactors.

Q. 35. ELISA technique is based on the principles of antigen and antibody interaction. Can this technique be used in the molecular diagnosis of a genetic disorder, such as phenylketonuria? [*NCERT Exemplar*] [*HOTS*]

Ans. Yes. One can use antibody against the enzyme (that is responsible for the metabolism of phenylalanine) to develop ELISA-based diagnostic technique. The patient in which the enzyme protein is absent would give negative result in ELISA when compared to normal individual.

Q. 36. Biopiracy should be prevented. State why and how. [*CBSE (AI) 2011*] [*HOTS*]

Ans. Biopiracy is unauthorised exploitation of bioresources of developing or under-developed countries. Hence, it should be prevented.

It can be prevented by developing laws to obtain proper authorisation and by paying compensatory benefits.

Q. 37. PCR is a useful tool for early diagnosis of an infectious disease. Comment. [*HOTS*]

Ans. PCR is a very sensitive technique which enables the specific amplification of desired DNA from a limited amount of DNA template. Hence, it can detect the presence of an infectious organism in the infected patient at an early stage of infection (even before the infectious organism has multiplied to large number).

Q. 38. What is Biopiracy? State the initiative taken by the Indian Parliament towards it. [*CBSE Delhi 2014*]

Ans. Biopiracy is the use of bioresources by organisations without proper authorisation from the countries and people concerned without compensatory payment.

The government has cleared patent terms, emergency provisions and research and development initiative.

Long Answer Questions–I [3 marks]

Q. 1. What is GMO? List any five possible advantages of a GMO to a farmer. [*CBSE Delhi 2016*]

Ans. **Genetically modified organisms (GMOs)** are plants, bacteria, fungi and animals whose genes have been altered by manipulation.

For advantages of a GMO, Refer to Basic Concept 1.

Q. 2. Mention some transgenic plants and their potential applications.

Ans. **Table 12.2: Some transgenic plants and their potential applications**

S. No.	Transgenic plants	Useful applications
(*i*)	Flavr Savr tomato	Better nutrient quality.
(*ii*)	*Brassica napus*	Contains hirudin (a protein) that prevents blood clotting. Hirudin is synthesised chemically and it is transferred into *Brassica napus*.
(*iii*)	Bt cotton	It has resistance to bollworm infestation, tolerance to herbicide, high yielding.
(*iv*)	Wheat	Resistant against herbicide PPT (Commercial name "Basta"—26 per cent PPT).
(*v*)	Potato	Content of starch increased by about 20–40 per cent.
(*vi*)	Corn, brinjal	Insect resistance.
(*vii*)	Maize, soyabean	Herbicide resistance.
(*viii*)	Golden rice	Rich in vitamin-A.

Q. 3. Name the process involved in the production of nematode-resistant tobacco plants, using genetic engineering. Explain the strategy adopted to develop such plants. [*CBSE (F) 2011*]

Ans. The process involved in the production of nematode-resistant plants is RNA interference or RNAi. Using *Agrobacterium* vectors, nematode-specific genes were introduced into the host plant. The introduction of DNA was such that it produced both sense and antisense RNA in the host cells.

These two RNA's being complementary to each other formed a double stranded RNA (*ds*RNA) that initiated RNAi and thus, silenced the specific *m*RNA of the nematode. The consequence was that the parasite could not survive in a transgenic host expressing specific interfering RNA. The transgenic plant, therefore, got itself protected from the parasite.

Q. 4. How have biotechnologists effectively used *Agrobacterium tumefaciens* in plants and retroviruses in animals? Explain. ***[CBSE 2019 (57/5/2)]***

Ans. In plants the tumor inducing (Ti) plasmid of *Agrobacterium tumefaciens* has been modified into a cloning vector, which is no more pathogenic to the plants, but is still able to use the mechanisms to deliver genes of our interest into a variety of plants. In animals retroviruses have been disarmed and are used to deliver desirable genes into animal cells. Once a gene or a DNA fragment has been ligated into a suitable vector it is transferred into a bacterial/plant or animal host (where it multiples).

Q. 5. Why do lepidopterans die when they feed on Bt cotton plant? Explain how does it happen. ***[CBSE Delhi 2017]***

Ans. Bt cotton contains inactive toxin protein or protoxin. These are insecticidal proteins in the form of crystal protein. Once the insect ingests its, the inactive protoxin is converted into active form due to alkaline pH in the gut, which solubilise the crystals. The activated toxins bind to the surface of midgut epithelial cells, thus creating pores which causes cell swelling and lysis, eventually leading to the death of the insect pest.

Q. 6. Name the pest that destroys the cotton bolls. Explain the role of *Bacillus thuringiensis* in protecting the cotton crop against the pest to increase the yield. ***[CBSE (AI) 2013]***

Ans. Cotton bollworms destroy the cotton bolls. *Bacillus thuringienesis* has Bt toxin genes. These genes produce toxic proteins that kill the pests. Bt toxins are initially inactive protoxins but after ingestion by the insect their inactive toxin becomes active due to the alkaline pH of the gut. The activated toxin binds to the surface of midgut epithelial cells thus killing the insects. Specific Bt toxins were isolated from *Bacillus thuringienesis* and incorporated into the cotton plants to make them pest resistant.

Q. 7. Biotechnology has helped farmers to get pest resistant cotton crops. Explain the technique adopted along with its mode of action. (Mention six points) ***[CBSE Sample Paper 2016]***

Ans. The technique involves the use of a popularly known biopesticide Bt toxin produced by bacteria *Bacillus thuriengiensis*. Bt toxin protein when ingested by the insect gets converted to its active form due to alkaline pH of the gut. The activated toxin binds to the surface of midgut epithelial cells. It creates pores in these cells that cause swelling and lysis and eventually kills the insect. The genes (cry genes) encoding this protein are isolated from the bacterium and incorporated into crop plants like cotton. The proteins encoded by these cry genes control the pest. Specifically, *cryIAc* and *cryIIAb* control cotton bollworm (*Helicoverpa armigera*), an insect belonging to Lepidoptera which earlier used to destroy the whole crop.

Q. 8. (*i*) Give the scientific name of the soil bacterium which produces crystal (Cry) proteins.
(*ii*) How are these proteins useful in agriculture?
(*iii*) What do the differently written terms 'Cry' and '*cry*' represent respectively?

Ans. (*i*) *Bacillus thuringiensis*.
(*ii*) These Cry proteins are toxic to certain larvae of insects and thus provide resistance against them. The gene encoding Cry proteins are used in several crop plants (Bt toxin). Such a crop plant is resistant to the particular insect pest.
(*iii*) Cry represents crystal protein while *cry* refers to the gene encoding the Cry protein.

Q. 9. What do you understand by the term biopesticide? Name and explain the mode of action of a popular biopesticide. Biopesticides are methods of controlling pests that rely on natural predation rather than introduced chemicals/or living organisms used to kill pests. ***[NCERT Exemplar]***

Ans. Biopesticide is a pesticide which is:

(*a*) not chemical in nature.

(*b*) more specific in action against the pest.

(*c*) safer for environment than chemical pesticides.

A popularly known biopesticide is Bt toxin, which is produced by a bacterium called *Bacillus thuringiensis*. Bt toxin gene has been cloned from this bacterium and expressed in plants. Bt toxin protein when ingested by the insect, gets converted to its active form due to the alkaline pH of the gut. The activated toxin binds to the surface of midgut epithelial cells and create pores that cause cell swelling and lysis and eventually kills the insect.

Q. 10. (*a*) List any four beneficial effects of GM plants.

(*b*) Explain how has *Bacillus thuringiensis* contributed in developing resistance to cotton bollworms in cotton plants. **[*CBSE (F) 2013*]**

Ans. (*a*) (*i*) Increases tolerance against abiotic stresses (cold, drought, salt, heat).

(*ii*) Reduces reliance on chemical pesticides (pest-resistant crops).

(*iii*) Reduces post-harvest losses.

(*iv*) Increases efficiency of minerals used by plants (this prevents early exhaustion of fertility of soil).

(*v*) Enhances nutritional value of food, *e.g.*, vitamin 'A' enriched rice (golden rice). (*Any four*)

(*b*) Refer to Basic Concepts Point 1(*i*).

Q. 11. How did the process of RNA interference help to control the nematode from infecting roots of tobacco plants? Explain. **[*CBSE Delhi 2014*]**

Ans. Using *Agrobacterium* vectors, nematode specific genes are introduced into host plant. The introduction of DNA produced both sense and anti sense RNA in host cells. These two RNA's being complementary formed a double stranded RNA (*ds*RNA) that initiated RNAi and silenced the specific *m*RNA of the nematode. As a result, the parasite could not survive in the transgenic host expressing specific interfering RNA.

Q. 12. Name the host plant and the part that *Meloidogyne incognita* infects. Explain the role of *Agrobacterium* in production of *ds*RNA in host plant. **[*CBSE (AI) 2015*]**

Ans. *Meloidogyne incognita* infects the roots of tobacco plant.

For role of *Agrobacterium*, Refer to Basic Concepts Point 1(*ii*).

Q. 13. How has the use of *Agrobacterium* as vectors helped in controlling *Meloidogyne incognitia* infestation in tobacco plants? Explain in correct sequence. **[*CBSE Sample Paper 2018*]**

Ans. By using *Agrobacterium* vectors, nematode-specific genes were introduced into the host plants which produce both sense and anti-sense RNA in the host cells.

These two RNAs are complementary to each other and form a double-stranded RNA (*ds*RNA) that initiates RNAi and hence silence the specific *m*RNA of the nematode.

The parasite cannot survive in the transgenic host, so protects the plants from pests.

Q. 14. Gene expression can be controlled with the help of RNA molecule. Explain the method with an example. **[*NCERT Exemplar*] [*HOTS*]**

Ans. Gene expression can be controlled by using RNA molecule and this technology is called RNA interference or RNAi. It is used to block the expression of certain genes and also referred to as gene silencing. During this process, RNA complementary to *m*RNA being produced by the gene, is introduced into the cell. This RNA binds to the *m*RNA making it double stranded and therefore stops its translation. Resistance to nematode *Meloidogyne incognita* in tobacco has been achieved by this method.

Q. 15. Explain the synthesis of genetically engineered human insulin. **[*CBSE (F) 2012*]**

Ans. Refer to Basic Concepts Point 2 (*i*).

Q. 16. List the disadvantages of insulin obtained from the pancreas of slaughtered cow and pigs.
[*NCERT Exemplar*] [*HOTS*]

Ans. (*i*) Insulin being a hormone is produced in very little amounts in the body. Hence, a large number of animals need to be sacrificed for obtaining small quantities of insulin. This makes the cost of insulin very high, demand being manifold higher than supply.
(*ii*) Slaughtering of animal is also not ethical.
(*iii*) There is potential of immune response in humans against the administered insulin which is derived from animals.
(*iv*) There is possibility of slaughtered animals being infested with some infectious micro-organism which may contaminate insulin.

Q. 17. Describe the various stages involved in gene transfer for the commercial production of human insulin by Eli Lilly. **[*CBSE (F) 2011*]**

Ans. (*a*) Eli Lilly prepared two DNA sequences corresponding to the A and B chains of human insulin.
(*b*) Sticky ends were produced in the *Escherichia coli* plasmid and the insulin gene by treating them both with the same restriction endonucleases.
(*c*) These two are then joined together by the enzyme DNA ligase.
(*d*) The bacteria are then grown in sterilised bioreactors in the appropriate growth medium.
(*e*) The chains A and B are produced separately, extracted and purified.
(*f*) These two chains are then combined by creating disulfide bonds to form human insulin.

Q. 18. Recombinant DNA-technology is of great importance in the field of medicine. With the help of a flow chart, show how this technology has been used in preparing genetically engineered human insulin. **[*CBSE Delhi 2015*]**

Ans. Refer to Fig. 12.3.

Q. 19. Why is proinsulin so called? How is insulin different from it? **[*CBSE (AI) 2013*]**

Ans. Proinsulin is called so because it is an inactive form of insulin.

S.No.	Insulin	Proinsulin
(*i*)	It is made up of two short polypeptide chains A and B linked by disulphide bridges.	Along with the two polypeptide chains in insulin, it contains an extra stretch called C peptide.
(*ii*)	It is functional.	It is non-functional.

Q. 20. Plasmid is a boon to biotechnology. Justify this statement quoting the production of human insulin as an example.

Ans. Plasmids are extra-chromosomal, self-replicating, usually circular, double-stranded DNA molecules found naturally in many bacteria.

In 1983, Eli Lilly an American company, first prepared two DNA sequences corresponding to A and B chains of human insulin and introduced them in plasmids of *E. coli* to produce insulin chains. These chains A and B were produced separately, extracted and combined by creating disulfide bonds to form functional human insulin (humulin).

Q. 21. (*a*) What is gene therapy?
(*b*) Describe the procedure of such a therapy that could be a permanent cure for a disease. Name the disease. **[*CBSE (F) 2016*]**

Ans. Refer to Basic Concepts Points 2(*ii*).

Q. 22. (*a*) Name the deficiency for which first clinical gene therapy was given.
(*b*) Mention the causes of and one cure for this deficiency. **[*CBSE Delhi 2013*]**

Ans. (*a*) Adenosine deaminase deficiency (ADA).
(*b*) **Cause:** Deletion of ADA gene.
Cure: Bone marrow transplantation/enzyme replacement therapy/giving functional ADA to patient by injection/infusion of genetically engineered lymphocytes/introducing gene isolated from marrow cells producing ADA into cells at early embryonic stages. (*Any one*)

Q. 23. Describe the gene therapy procedure for an ADA-deficient patient. **[*CBSE Delhi 2013*]**

Ans. Refer to NCERT Textbook Questions, Q. 5.

Q. 24. Explain process of gene therapy to treat adenosine deaminase deficiency. Mention two disadvantages of this procedure. **[*CBSE (AI) 2016*]**

Ans. (*i*) Lymphocytes from the blood of the patient are grown on culture outside the body.

(*ii*) A functional ADA *c*DNA is then introduced into these lymphocytes using a retroviral vector.

(*iii*) The genetically engineered lymphocyte are returned to the blood of patient.

Disadvantages: Therapy is not completely curative as cells do not remain alive and periodic infusion of lymphocytes is required.

Q. 25. How did Eli Lilly synthesise the human insulin? Mention one difference between this insulin and the one produced by the human pancreas. **[*CBSE (F) 2009, (AI) 2010*]**

Ans. Eli Lilly prepared two DNA sequences corresponding to A and B chains of human insulin and introduced them in plasmids of *E. coli* to produce insulin chains. Chains A and B were produced separately, extracted and combined by creating disulfide bonds to form human insulin. Insulin in human pancreas is synthesised as a pro-hormone containing the C peptide, which is removed to form mature hormone. The synthesised insulin did not contain C peptide and was directly prepared in mature form.

Q. 26. A person is born with a hereditary disease with a weakened immune system due to deficiency of an enzyme. Suggest a technique for complete cure for this disease, identify the deficient enzyme and explain the technique used for cure. **[*CBSE Sample Paper 2015, 2017, 2018*]**

Ans. Gene therapy can completely cure this disease.

The disease is due to ADA (Adenosine deaminase) deficiency.

Lymphocytes from the blood of the patient are grown in a culture. A functional ADA *c*DNA is introduced into these lymphocytes, which are subsequently returned to the patient. The permanent cure is done by introducing ADA *c*DNA into cells at early embryonic stages.

Q. 27. (*a*) How do organic farmers control pests? Give two examples.

(*b*) State the difference in their approach from that of conventional pest control methods. **[*CBSE (AI) 2016*]**

Ans. (*a*) By natural predation or biological control.

Examples: Lady bird used to kill aphids, dragon flies used to kill mosquitoes, *Bacillus thuringiensis* used to kill cotton bollworm.

(*b*)

S.No.	Conventional pest control	Organic farming based pest control
(*i*)	Use of chemical insecticides and pesticides.	No chemical used.
(*ii*)	Harmful to non-target organisms.	Not harmful to non-target organisms.
(*iii*)	Cause environmental pollution.	No adverse impact on environment.

Q. 28. (*a*) Why are transgenic animals so called?

(*b*) Explain the role of transgenic animals in (*i*) Vaccine safety and (*ii*) Biological products with the help of an example each. **[*CBSE Delhi 2013*]**

Ans. (*a*) Transgenic animals are so called because these animals have their DNA manipulated.

(*b*) (*i*) Vaccine safety: Transgenic mice are developed to test safety of polio vaccine before being used on humans.

(*ii*) Human protein (α-1-antitrypsin) is used to treat emphysema.

Q. 29. List the three molecular diagnostic techniques that help detect pathogens from suspected patients. Mention one advantage of these techniques over conventional methods.

Ans. The three molecular diagnostic techniques that help to detect pathogens from suspected patients are:

(*a*) Recombinant DNA technology

(*b*) Polymerase chain reaction (PCR)

(*c*) Enzyme-linked immunosorbent assay (ELISA)

These techniques are better than the conventional methods because they help in early diagnosis of the disease even when the bacteria or virus concentration is very low & no symptoms are visible for the disease.

Long Answer Questions–II [5 marks]

Q. 1. (*a*) Name the source from which insulin was extracted earlier. Why is this insulin no more in use by diabetic people?

(*b*) Explain the process of synthesis of insulin by Eli Lilly Company. Name the technique used by the company.

(*c*) How is the insulin produced by human body different from the insulin produced by the above mentioned company? ***[CBSE (AI) 2011]***

Ans. (*a*) Earlier, insulin was extracted from pancreas of slaughtered cattle and pig. This insulin is not in use as some patients developed allergic reaction to this foreign protein.

(*b*) Eli Lilly used the following procedure for insulin synthesis:

(*i*) Two DNA sequences corresponding to A and B chains of insulin were prepared.

(*ii*) These sequences were then introduced in plasmids of *E. coli*.

(*iii*) The two insulin chains are produced separately.

(*iv*) The two chains are extracted and combined by creating disulphide bonds to form the assembled mature molecule of insulin.

(*c*) The pro-hormone produced in the human body has an extra stretch of C-peptide.

Q. 2. (*a*) Why is *Bacillus thuringiensis* considered suitable for developing GM plants?

(*b*) Explain how it has been used to develop GM crops.

Ans. (*a*) Some strains of *Bacillus thuringiensis* produce proteins that kill some insects like lepidopterans (tobacco budworm, armyworm), coleopterans (beetles) and dipterans (flies, mosquitoes). Bt toxins are initially inactive protoxins but after ingestion by the insect their inactive toxin becomes active due to the alkaline pH of the gut which solublise the crystals. The activated toxin binds to the surface of midgut epithelial cells thus creating pores which causes cell swelling and lysis, further leading to death of the insects.

(*b*) *Bacillus thuringiensis* produces Cry protein. Cry protein producing gene is transferred to the plant to provide resistance against insect larvae. Man has developed several transgenic crops by introducing these genes from bacteria to crop plants such as Bt cotton, Bt corn, etc.

Q. 3. One of the main objectives of biotechnology is to minimise the use of insecticides on cultivated crops. Explain with the help of a suitable example how insect resistant crops have been developed using techniques of biotechnology.

Ans. Refer to Basic Concepts Point 1(*i*).

Q. 4. (*a*) Name the nematode that infests and damages tobacco roots.

(*b*) How are transgenic tobacco plants produced to solve this problem?

OR

How is a transgenic tobacco plant protected against *Meloidogyne incognita*? Explain the procedure.

Ans. (*a*) Nematode *Meloidogyne incognita* infects the roots of tobacco plant.

(*b*) Refer to Basic Concepts Point 1(*ii*).

Q. 5. Explain the different uses of biotechnology in medical field.

Ans. (*i*) The recombinant DNA technology is used for production of therapeutic drugs which are safe and effective.

(*ii*) About thirty recombinant therapeutics have been approved for human use in the world including India.

(*iii*) The genetically engineered insulin helps in maintaining the glucose–glycogen balance in the body.

(*iv*) Gene therapy treatment is used in the defective heredity by introduction of normal healthy and functional genes.

(*v*) It is used in the treatment of diseases like cystic fibrosis, haemophilia, AIDS, cancer, Parkinson's, etc.

(*vi*) Due to advancement in the field of biotechnology, it is now possible to develop recombinant vaccines with specific actions and less side effects.

(*vii*) Also, monoclonal antibodies are produced with high specificity, for specific antigens and are ideal for diagnosis of specific diseases. One of the major role of these monoclonal antibodies is immune suppression for kidney transplantation.

Q. 6. Define transgenic animals. Explain in detail any four areas where they can be utilised. ***[NCERT Exemplar]***

Ans. Refer to Basic Concepts Point 3.

Self-Assessment Test

Time allowed: 1 Hour **Max. marks: 30**

1. Choose and write the correct option in the following questions. **(3×1 = 3)**

(i) *Cry IIAb* endotoxins obtained from *Bacillus thuringiensis* are effective against

(a) flies (b) mosquitoes

(c) bollworms (d) nematodes

(ii) Peptide A and peptide B is linked by how many disulphide linkage between their proinsulin?

(a) 1 (b) 2

(c) 3 (d) 4

(iii) *Meloidogyne incognita* infects

(a) stem of tobacco (b) leaf of tobacco

(c) root of tobacco (d) all of these

2. In the following questions a statement of assertion followed by a statement of reason is given. Choose the correct answer out of the following choices. **(3×1 = 3)**

(a) Assertion and reason both are correct statements and reason is correct explanation for assertion.

(b) Assertion and reason both are correct statements but reason is not correct explanation for assertion.

(c) Assertion is correct statement but reason is wrong statement.

(d) Assertion is wrong statement but reason is correct statement.

(i) Assertion : RNAi is a method of cellular defence occurring in all eukaryotic organisms.

Reason : RNAi silences a specific *m*RNA as it binds to it to form *ds*RNA.

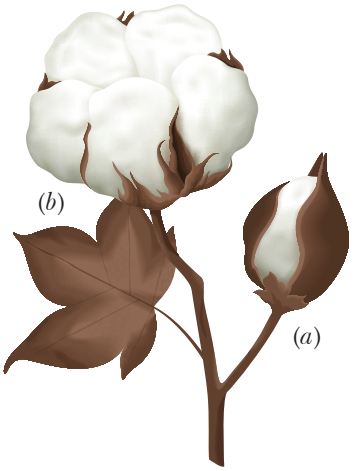
(ii) Assertion : GEAC has been set up to keep a check on GM research.

Reason : Genetic modification of organisms can have unpredictable results.

(iii) **Assertion** : Insulin used for diabetics was earlier extracted from pancreas of live animals.

Reason : It caused allergy to some patients.

3. What is the possible source of RNA interference (RNA*i*) gene? **(1)**
4. What are cry genes? In which organism are they present? [*CBSE (AI) 2017*] (1)
5. What is meant by ADA deficiency? How is gene therapy a solution to this problem? Why is it not a permanent cure? **(2)**
6. What happens when *Meloidogyne incognita* consumes cells with RNAi gene? **(2)**
7. What are transgenic bacteria? Illustrate using any one example. **(2)**
8. How is a probe used in molecular diagnostics? **(2)**
9. What is *Agrobacterium* mediated genetic transformation described as natural genetic engineering in plants? **(3)**
10. Given below is the figure of two types of cotton bolls: one destroyed by bollworms and the other is fully matured one. **(3×1 = 3)**



Answer the following questions on the basis of above figure:

(i) What is Bt cotton?

(ii) Bt toxins are released as inactive crystals in the bacterial body. What happens to it in the cotton bollworm body that it kills the bollworm?

(iii) List the type of cry genes that provide resistance to corn plants and cotton plants respectively against lepidopterans.

11. Explain the role of Ti plasmids in biotechnology. **(3)**
12. Explain the application of *r*DNA technology. **(5)**

Answers

1. (*i*)—(*c*), (*ii*)—(*b*), (*iii*)—(*c*) **2.** (*i*)—(*b*), (*ii*)—(*b*), (*iii*)—(*c*)

Chapter–13

Organisms and Populations

basic concepts

1. Ecology

- It is a branch of science which deals with the interactions among organisms and between the organism and its physical (abiotic) environment.

2. Organisational Levels of Ecology

- **Organism:** Living component of the environment at individual level is called organism.
- Ecology at the organismic level is **physiological ecology** which reveals how different organisms are adapted to their environments. The organism is the smallest level of ecological hierarchy.
- **Population:** Population is defined as the sum total of all individuals of a species in a specific geographical area.
- **Species:** The species are the group of individuals of one or more populations which resemble each other and can interbreed among themselves.
- **Biotic community:** The assemblage of all the populations of different species present in an area that interact among themselves are called biotic community. It is of three types:
  - (*i*) Plant community
  - (*ii*) Animal community
  - (*iii*) Microbial community
- **Ecosystem:** The sum total of the biotic (living) and abiotic (non-living) components of a particular geographical area, being integrated through exchange of energy and recycling of nutrients are collectively called ecosystem.
- **Biome:** The large unit of environment consisting of a major vegetation type and its associated fauna in a specific climatic zone is called a biome.
- **Biosphere:** All the ecosystems of the world are collectively called biosphere.
- **Niche:** The ecological niche of an organism represents the range of conditions that it can tolerate, the resources it utilises and its functional role in the ecological system. Each species occupies a distinct niche and no two species occupy the same niche.

3. Environment

- Environment is referred to as the sum total of all the physical and biotic conditions which influence the organism in terms of survival and reproduction.
- Different seasons result due to
  - (*i*) rotation of earth around the sun.
  - (*ii*) tilting of the earth on its axis.

- The major biomes of the world include desert, grassland, rainforest and tundra.
- Formation of different biomes is due to
  (*i*) annual variations in intensity and duration of temperature.
  (*ii*) annual variations in precipitation.
- The above annual variations together with annual variation in precipitation (remember precipitation include both rain and snow) thus form major biomes.
- The biomes may be desert, rainforest and tundra.
- Regional and local variations within each biome lead to the formation of different habitats.

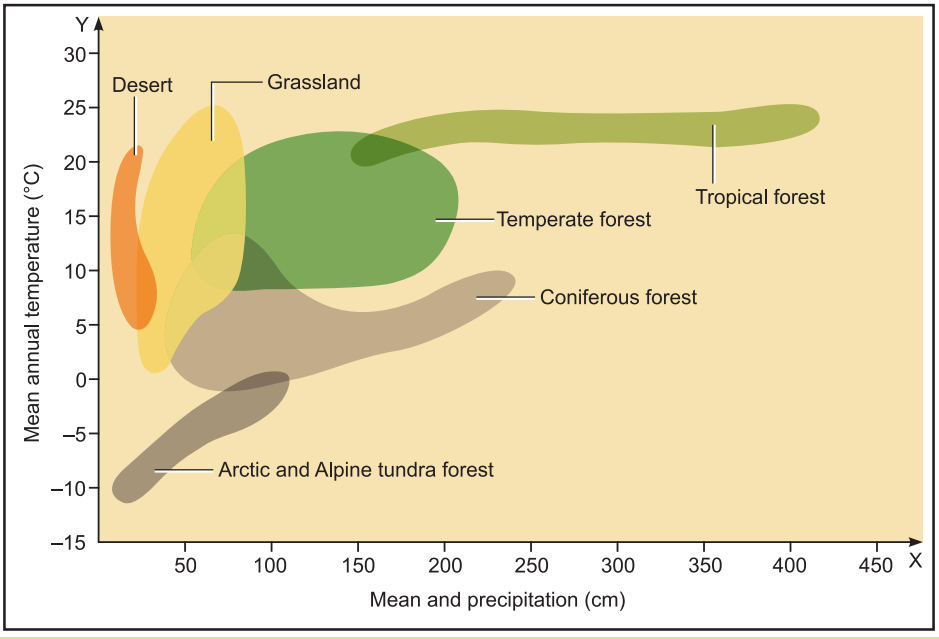
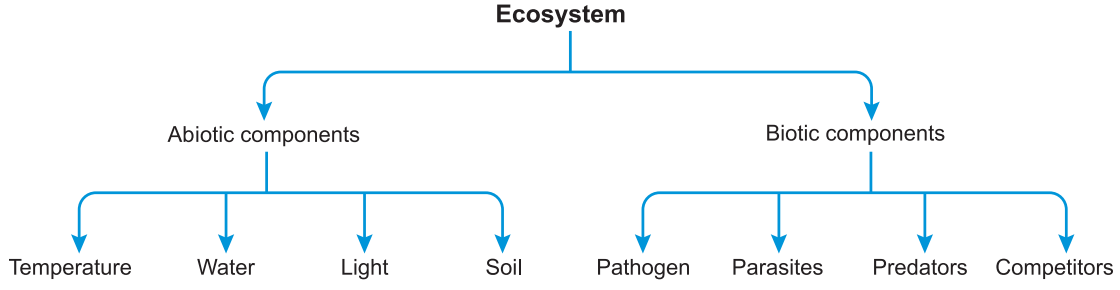


Fig. 13.1 Biome distribution with respect to annual temperature and precipitation

4. Components of Ecosystem



5. Major Abiotic Factors

(i) Temperature

- It is the most ecologically relevant environmental factor.
- It is observed that seasonally, the average temperature on land varies.
- The temperature decreases progressively from the equator to the poles and from plains to the mountain top.

- The range of temperature varies from subzero levels in polar areas to >50°C at high altitude in tropical deserts in summer.
- The temperature can affect the kinetics of enzymes and through it the basal metabolism and other physiological functions of the organisms.
- The organism tolerating the high range of temperature is called **eurythermal** *e.g.*, cyclops, Artemisia, Toad lizard and the organism which can tolerate narrow range of temperature is called **stenothermal** *e.g.*, palms, corals, snakes, some fishes.
- Level of thermal tolerance of different species determine their geographical distribution.

(ii) Water

- It is the next important factor as life is unsustainable without water.
- The amount of water in an environment determines the productivity and distribution of plants.
- For aquatic habitat, the quality of water becomes important like pH value, salinity and temperature of water.
- The organisms tolerating wide range of salinities are called **euryhaline** *e.g.*, migratory fish like Hilsa, Salmon and the organisms that tolerate only narrow range of salinities are called **stenohaline** *e.g.*, number of organism.
- Fresh water forms cannot live in sea water for long because of osmotic problems.

(iii) Light

- Light is important because autotrophs make food with the help of light (photosynthesis) and O_2 is evolved during this process.
- The small plants like herbs and shrubs can perform photosynthesis under very low light conditions as they are overshadowed by tall trees.
- The plants depend on sunlight to meet their photoperiodic requirement for flowering.
- For many animals, light is important in that they use the diurnal and seasonal variations in light intensity and duration (photoperiod) as cues for timing their foraging, reproductive and migratory activities.
- In deep sea, animals have special devices for life as many are luminescent like Angler fish.

(iv) Soil

- The nature and properties of soil varies with different places.
- The nature and properties of soil depend on the climate and weathering process.
- The characteristics of soil: soil-composition, grain size and aggregation, determine the percolation and water holding capacity of the soil.
- The vegetation in an area is determined by some soil parameters like pH, mineral composition and topography.

6. Responses to Abiotic Factors

- During the course of million years of existence, many species would have evolved a relatively constant internal (within the body) environment that permits all biochemical reactions and physiological functions to proceed with maximum efficiency and thus, enhances the overall fitness of the species.
- The organisms try to maintain the constancy of its internal environment (a process called **homeostasis**) despite varying external environmental conditions that tend to upset its homeostasis.

7. How do Living Organisms Cope with Environment?

(i) Regulate

- Some organisms maintain homeostasis by physiological and behavioural means, such organisms are called regulators. All birds and mammals and few lower vertebrate and invertebrate species maintain homeostasis by thermoregulation and osmoregulation.
- The success of mammals is largely due to their ability to maintain a constant body temperature.
- In summers, when outside temperature is more than our body temperature, we sweat profusely and the resulting evaporative cooling brings down the body temperature.

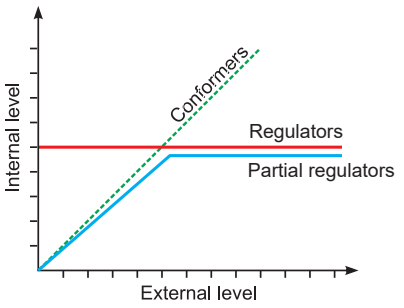


Fig. 13.2 Diagrammatic representation of organismic response

- In winters, when temperature is lower we shiver, a kind of exercise that produces heat and raises the body temperature.
- Plants do not have such mechanism to maintain internal temperatures.

(ii) Conform

- Majority (99%) of animals and nearly all plants cannot maintain a constant internal environment. Their body temperature is determined by ambient temperature.
- The osmotic concentration of the body fluids change with that of the ambient water osmotic concentration, such animals and plants are simply called conformers.
- Loss or gain of heat is a function of surface area. The small animals have larger surface area relative to their volume. They lose body heat very fast in low temperature. So, they expend energy to generate body heat through metabolism for adjusting. Therefore, very small animals like shrews and humming birds are rarely found in polar regions.
- During evolution, some species have evolved the ability to regulate but only over a limited range of environment conditions and beyond that limit they conform.

(iii) Migration

- The temporary movement of organisms from the stressful habitat to a more hospitable area and return when favourable conditions reappear, is called **migration**.
- The long distance migration is very common in birds. In winter, famous Keoladeo National Park (Bharatpur) in Rajasthan hosts thousands of migratory birds coming from Siberia and other extremely cold northern regions.
- Examples of migratory animals, are Siberian crane, Whale, Caribou, Lamprey, Eel, Salmon.

(iv) Suspend

- Some bacteria, fungi and lower plants, under unfavourable conditions slow down metabolic rate and form a thick-walled spore to overcome stressful conditions. These spores germinate under onset of suitable environment.
- The animals that fail to migrate, might avoid the stress by escaping in time, *e.g.*, bear frog goes into **hibernation** during winter.
- Snail and fish go into **aestivation** to avoid summer.
- Zooplanktons under unfavourable conditions enter **diapause**, a stage of suspended development.
- Cyst formation in *Amoeba*.

8. Adaptations

- Any morphological, physiological and behavioural attribute of the organism that enables it to survive and reproduce in its habitat is called **adaptation**.
- Over a long period of time, many adaptations have evolved and are incorporated in the gene, thus becoming heritable.

(i) Adaptation in Kangaroo rat (*Dipodomys merriami*)

- The Kangaroo rat in North American deserts is capable to meet its internal water requirement by oxidation of fat where water is a by-product.
- It has the ability to concentrate its urine for minimum loss of water through excretory products.
- Prevents water loss by living in burrows during day.
- Solidification of faeces.
- Nasal counter current mechanism to retrieve moisture from air being exhaled.

(ii) Adaptation in desert plants

- Desert plants have thick waxy coating on leaves called cuticle, for minimum loss of water through transpiration.
- They have special photosynthetic pathway (CAM) that enables minimum loss of water during daytime because stomata remain closed.
- Some desert plants, *e.g.*, *Opuntia* develop spines instead of leaves and photosynthetic function is carried out by the flattened stem.
- Stomata are arranged in deep pits to minimise loss through transpiration.

(iii) Adaptation in mammals in cold climate

- Mammals have shorter ears and limbs to minimise heat loss. This is called **Allen's rule**.
- Seals (aquatic mammals) have a thick layer of fat (blubber) below their skin that acts as an insulator and reduces excessive loss of body heat.

(iv) Adaptation in desert lizards

- They absorb heat from the sun when the body temperature drops below the comfort zone.
- They move into shade when ambient temperature rises above the comfort levels.
- Some burrow into soil to escape above ground heat.

(v) Adaptation at high altitude in humans

- People at high altitudes (> 3,500 m like in Rohtang Pass, near Manali, Mansarovar in China occupied Tibet) experience **altitude sickness**.
- **Symptoms:** Nausea, fatigue, heart palpitations.
- **Cause:** The people living in high altitudes compensate low oxygen by increasing production of red blood cells (RBCs).
- The binding capacity of haemoglobin decreases and breathing rate increases.
- People travelling to high altitude get slowly **acclimatized** (adjust) and **stop experiencing altitude sickness** by:
  - (*a*) Increasing RBC production
  - (*b*) Decreasing Binding capacity of hemoglobin.
  - (*c*) Increasing breathing rate.
- People living at high altitudes of Himalayas have higher RBC count or total Hb than people living in plains.

(vi) Biochemical Adaptations

- Biochemical Adaptations in marine invertebrates and fish living at great depths in oceans where pressure is more than 100 times the normal atmospheric pressure.

(vii) Adaptations in fish found in Antarctic Waters (temperature below zero)

- These fishes show **cold hardening** *i.e.*, physiological adaptation allowing animals to live comfortably in cold conditions. It is of two types:
  - **(*a*) Freeze tolerance:** Extracellular spaces contain ice nucleating proteins that form ice. Small amount of water is withdrawn from cells and thus cells have high solute concentration that protects them from freezing.
  - **(*b*) Freeze avoiding animals:** Body fluids of these animals contain antifreeze solutes like glycerol, antifreeze proteins which lower the freezing point of body fluids below 0°C and thus ice formation is prevented and animals remain active, *e.g.*, Ice fish (*Chaenocephalus*).

(viii) Adaptations in Archaebacteria

- **Most animals** have metabolism and physiology functioning optimally in narrow temperature range (37°C for human beings) but **Archaebacteria** flourish in hot springs and deep sea hydrothermal vents where temperature exceeds 100°C because they have special enzymes and plasma membrane constituents that help them to metabolise comfortably at high temperature.

9. Population Attributes

- **Population** is defined as the total number of individuals of a species in a specific geographical area, sharing/ competing for similar resources which can interbreed under natural conditions to produce fertile offsprings and function as a unit of biotic community.
- Population ecology links ecology to population genetics and evolution.
- **Characteristics of a population:**
  - **(*i*) Population size or density** of a species is the number of individuals of a species per unit area or volume

$$\text{Population Density (PD)} = \frac{\text{Number of individuals in a region (N)}}{\text{Number of unit area in a region (S)}}$$

$$\text{PD} = \frac{\text{N}}{\text{S}}$$

  - **(*ii*) Birth or natality rate:** It is expressed as the number of births per 1,000 individuals of a population per year.
  - **(*iii*) Death or mortality rate:** It is expressed as the number of deaths per 1,000 individuals of a population per year.
  - **(*iv*) Sex ratio:** It is expressed as the number of females per 1,000 males of a population in given time.
- A population at any given time is composed of individuals of different ages. When the age distribution (per cent individuals of a given age or age group) is plotted for the population, the resulting structure is called **age pyramid**.
- For human population, the age pyramids generally show age distribution of males and females in a combined diagram.
- The shape of the pyramids reflects the growth status of the population and is of three types:
  - **(*a*) Expanding (Triangular shaped pyramid):** Number of prereproductive individuals is very large, reproductive individuals moderate in no. and postreproductive are fewer. Population is growing and show rapid increases.
  - **(*b*) Stable (Bell shaped pyramid):** Population size remains stable, neither growing nor diminishing *i.e.*, all the age group are evenly balanced.
  - **(*c*) Declining (Urn shaped pyramid):** Population is declining or diminishing population showing negative growth.

- The pyramids also indicate the ratio of pre-reproductive, reproductive and post-reproductive individuals in a population.

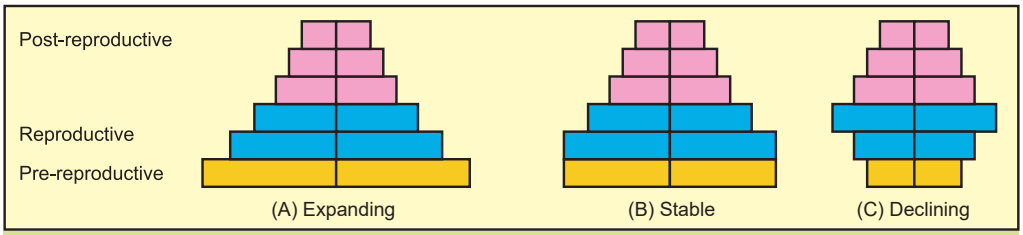


Fig. 13.3 Representation of age pyramids for human population

10. Population Growth

- The size of a population depends on food availability, predation pressure and weather. Therefore, size of the population is not a static parameter.

  Population Density (N) = Number of individuals or % **cover** or biomass.

- The population density depends on few basic processes:

  (*i*) Natality: It is the number of births during a given period of time. It increases the population density.

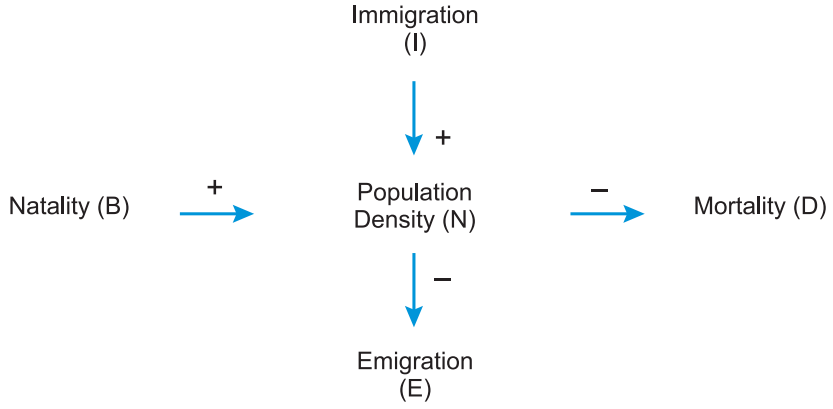
  So birth rate = $\frac{28}{20}$ = 0.4 per second

  (*ii*) Mortality: It is the number of deaths in a given time period. It decreases the population density. *e.g.*, if 4 individuals out of 40 fruit flies died during specified time interval.

  $$\text{Death rate} = \frac{4}{40} = 0.1 \text{ Individuals per fruitfly per week}$$

  (*iii*) Immigration: It is the number of individuals of same species added to a habitat in a given time period. It increases the population density.

  (*iv*) Emigration: It is the number of individuals of same species that move to a different habitat in a given time period. It decreases the population density.



- The population density is given by the following equation:

  $$N_t = N_0 + [(B + I) - (D + E)]$$

  where N_t = population density at time t, B = birth rate, I = immigration, D = death rate, E = emigration, and N_0 = population in the beginning.

- This equation shows that the population density will increase, if the number of births plus the number of immigrants (B+I) is more than the number of deaths plus the number of emigrants, *i.e.*, (D+E), otherwise it will decrease.

11. Population Growth Models

- There are two models of population growth:
  (*i*) The exponential growth
  (*ii*) Logistic growth

(i) Exponential Growth

- The exponential or geometric growth is common where the resources (food + space) are unlimited.
- Each species has the ability to realise fully its innate potential to grow in number.
- The equation for exponential growth can be derived as follows:

$$\frac{dN}{dt} = (b - d) \times N,$$

Let $(b - d) = r$, then

$$\frac{dN}{dt} = rN$$

Integral form of exponential growth equation is

$$N_t = N_0 e^{rt}$$

where, N = population size,
N_t = population density after time t,
N_0 = population density at time zero,
r = intrinsic rate of natural increase,
e = the base of natural logarithms (2.71828),
b = birth rate (per capita births)
d = death rate (per capita death rates).

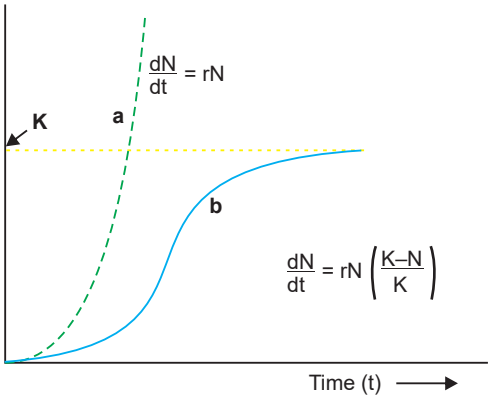


Fig. 13.4 Population growth curve:
(a) When resources are not limiting the growth, plot is exponential.
(b) When resources are limiting the growth, plot is logistic, K is carrying capacity.

- 'r' is an important parameter assessing impacts of biotic and abiotic factors on population growth. 'r' for flour beetle was 0.12, for Norway rat was 0.015 and for human population in India was 0.0205 in 1981.
- In exponential growth, when N in relation to time is plotted on graph, the curve becomes J shaped.

(ii) Logistic growth

- The resources become limited at certain point of time, so no population can grow exponentially.
- This growth model is more realistic.
- Every ecosystem or environment or habitat has limited resources to support a particular maximum number of individuals called its **carrying capacity (K)**.
- When N is plotted in relation to time t, the logistic growth show sigmoid curve and is also called **Verhulst–Pearl logistic growth**. It is given by the following equation:

$$\frac{dN}{dt} = rN\left[\frac{K - N}{K}\right]$$

where N = population density at time t
r = intrinsic rate of natural increase
K = carrying capacity.

- Graph shows lag phase, followed by phases of acceleration and deceleration and finally an asymptote when population density reaches the carrying capacity.

12. Life History Variation

- **Darwinian fitness** refers to the populations where they evolve to maximise their reproductive fitness, *i.e.*, high 'r' value.
- Under selection pressures, organisms evolve towards the most efficient reproductive strategy.
- The rate of breeding varies from species to species, as some organisms breed once in their lifetime (Pacific salmon fish, bamboo), while others breed many times during their lifetime (most birds and mammals).
- Some organisms produce a large number of small-sized offsprings (oysters, pelagic fishes), while others produce a small number of large-sized offsprings (birds, mammals).
- Ecologists suggest that life history traits of organisms have evolved in relation to the constraints, imposed by the abiotic and biotic components of the habitat, in which they live.

13. Population Interaction

- **Interspecific interactions** are interactions of populations of two different species.
- The interactions may be
  - beneficial/positive effect indicated by +.
  - harmful/detrimental/negative effect indicated by –.
  - neutral interaction/no effect on the species indicated by 0.

Table 13.1 Population Interactions

Species A	Species B	Name of Interaction
+	+	Mutualism
–	–	Competition
+	–	Predation
+	–	Parasitism
+	0	Commensalism
–	0	Amensalism

(i) Predation

- It is an interspecific interaction, where an animal, called **predator**, kills and consumes the other weaker animal called **prey**.
- Predation is nature's way of transferring energy to higher trophic levels, *e.g.*, a tiger (predator) eating a deer (prey), a sparrow (predator) eating fruit or seed (prey), etc.
- **The role of predators:**
  (*a*) Predators keep prey population under control. This is called biological control.
  (*b*) Predators also help in maintaining species diversity in a community, by reducing the intensity of competition among prey species.
  (*c*) Besides acting as 'conduits' for energy transfer across trophic levels, predators play other important roles. In absence of predator species, prey species could achieve very high population densities and lead to ecosystem instability.
- When certain exotic species are introduced into a geographical area, they become invasive and start spreading fast because the invaded land does not have its natural predators, *e.g.* Prickly pear cactus introduced in 1920's into Australia created **havoc** by spreading to millions of hectares and thus was brought under control only after a cactus feeding predator (a moth) was introduced into the **country** from its natural habitat.
- If a predator is too efficient and over-exploits its prey, then the prey might become extinct and following it, the predator will also become extinct due to the lack of food.

- They also help in maintaining species diversity in a community by reducing intensity of competition among **competing** prey species, *e.g.*, In rocky **intertidal** communities of American Pacific Coast, star fish Pisaster is important predator. In the beginning when all starfishes were removed from an intertidal area more than 10 species of invertebrates became extinct in a year because of interspecific competition.
- **The prey defence mechanisms**
  (*a*) To avoid being detected easily by the predators, some species of insects and frogs are cryptically coloured (camouflaged).
  (*b*) The Monarch butterfly is highly distasteful to its predator (birds) because of a special chemical present in its body which is acquired by the butterfly by feeding on a poisonous weed in its caterpillar stage.
  (*c*) 25% of insects are phytophagous, *i.e.*, feed on plant sap and other parts of plants. So, some plants have thorns or spines for defence mechanism, *e.g.*, *Acacia*, cactus.
  (*d*) Some plants produce highly poisonous chemicals like cardiac glycosides, nicotine, caffeine, quinine, strychnine, opium, etc., are produced by plants actually as defences against grazers and browsers e.g. , *Calotropis* grows in abandoned fields.

(ii) Competition

- Competition is a type of interaction where both the species suffer. It may exist between some species (**interspecific competition**) or between individuals of same species (**intraspecific competition**).
- The competition occurs due to limited resources between closely related species.
- Some totally unrelated species could also compete for the same resource, *e.g.*, in some shallow South American lakes, visiting flamingoes and resident fishes compete for their common food, zooplanktons.
- In interspecific competition, the feeding efficiency of one species might be reduced due to the interfering and inhibitory presence of the other species, although the resources are abundant.
- For example, after the introduction of goats in Galapagos Islands, the Abingdon tortoise became extinct within a decade due to greater browsing efficiency of the goats.
- A species whose distribution is restricted to small geographical area because of presence of competitively superior species is found to expend its distributional range when competing species is removed. **Connell's Elegant field experiment** showed on rocky sea coasts of Scotland, larger and competitively superior barnacle *Balanus* dominates intertidal area and excludes smaller barnacle *Chathamalus* from that zone.
- **Competitive release** refers to the phenomenon of a species whose distribution is restricted to a small geographical area because of the presence of a competitively superior species, is found to expand its distributional range dramatically when the competing species is experimentally removed.
- Gause's competitive exclusion principle states that two closely related species competing for the same resource cannot coexist indefinitely and the competitively inferior one will be eliminated eventually by the superior one.
- **Resource partitioning:** It refers to the phenomenon in which species facing competition might evolve mechanisms that promote coexistence rather than exclusion. MacArthur showed that five closely related species of warblers living on the same tree were able to avoid competition and coexist due to behavioural differences in their foraging activities.
- Herbivores are more adversely affected by competition than carnivores.

(iii) Parasitism

- It is the mode of interaction between two species in which one species (parasite) depends on the other species (host) for food and shelter, and in this process damages the host. In this process one organism is benefited (parasite) while the other is being harmed (host).
- **Adaptation of parasite:**
  (*a*) The parasite have evolved to be host-specific in such a manner that both host and parasite tend to co-evolve.

(*b*) Loss of unnecessary sense organs as they do not interact with external environment [For example, eyes as they are found in an environment that lacks light.)

(*c*) Presence of adhesive organs or suckers to cling to host

(*d*) Loss of digestive system to absorb digested food from increase chances of survival.

(*e*) High reproductive capacity.

(*f*) Presence of adhesive.

(*g*) Loss of chlorophyll and leaves (*e.g.* cuscuta), to derive its nutrition from the host plant which it parasitises.

(*h*) Presence of more than one host to facilitate parasitisation of its primary host.

(*i*) Eggs resemble the host egg (*e.g.*, crow) in size and colour to reduce the chances of host bird (*i.e.*, *Koel*) detecting them.

- The life cycles of some parasites are complex, where one or more intermediate host or vectors to facilitate parasitisation are present.
  (*a*) The human liver fluke depends on two intermediate hosts, a snail and a fish, to complete its life cycle.
  (*b*) Malarial parasite (*Plasmodium*) needs a vector (mosquito) to complete its life cycle.
- Majority of parasites harm the host by reducing the survival, growth and reproduction of the host. They reduce its population density by making it physically weak.
- Parasites may be of two types: ectoparasites and endoparasites.

Table 13.2 Differences between endoparasite and ectoparasite

S. No.	Endoparasite	Ectoparasite
(*i*)	These are the parasites which live inside the host's body at different sites like liver, kidney, lungs, etc., for food and shelter.	These are the parasites which feed on the external surface of the host organism for food and shelter.
(*ii*)	Example, tapeworm, liver fluke, *Plasmodium*.	Example, lice on humans, ticks on dogs, copepods, *Cuscuta*.

- The phenomenon in which one organism (parasite) lays its eggs in the nest of another organism is called **brood parasitism**. Eggs of parasitic birds have evolved to resemble host's eggs in size and colour to reduce the chance of host bird detecting foreign eggs and remove them from nest. *e.g.*, Cuckoo lays eggs in Crow's nest.

(iv) Commensalism

- Commensalism is referred to as the interaction between two species where one species is benefited and the other is neither harmed nor benefited.
- **Few examples of commensalism:**
  (*a*) An orchid growing as an epiphyte on a mango tree. The orchid gets shelter and nutrition from mango tree while the mango tree is neither benefited nor harmed.
  (*b*) Barnacles growing on the back of whale. Barnacles are benefited to move to location for food as well as shelter while the whales are neither benefited nor harmed.
  (*c*) The egrets are in close association of grazing cattle. The cattle egrets are benefited by the cattle to detect insects because cattle stir up the bushes and insects are flushed out from the vegetation, to be detected by cattle egrets.
  (*d*) Commensalism is also found between sea anemones (that has stinging tentacles) and the clown fish. The fish is protected from predators and sea anemones are neither benefited nor harmed.

(v) Amensalism

- Amensalism is referred to as the interaction between two different species, in which one species is harmed and the other is neither benefited nor harmed.
- For example, the mould *Penicillium* secretes penicillin which kills bacteria but the mould is unaffected.

(vi) Mutualism

- Mutualism is referred to as the interspecific interaction in which both the interacting species are benefited.
- **Some examples of mutualism**
  - (*a*) Lichens represent close association between fungus and photosynthetic algae or cyanobacteria, where the fungus helps in the absorption of nutrients and provides protection while algae or cyanobacterium prepares the food.
  - (*b*) Mycorrhizae are close mutual association between fungi and the roots of higher plants, where fungi helps the plant for absorption of nutrients while the plant provides food, & protection for the fungus.
  - (*c*) Mutualism are found in plant–animal relationships. Plants take the help of animals for pollination and dispersal of their seeds and animals are rewarded in the form of nectar or edible pollen or oviposition (site for laying egg).
  - (*d*) Orchids have evolved to attract right pollinator insect (bees and bumble bees). Mediterranean orchid. *Ophrys muscifera* employs sexual deceit to get pollinated by bee species. One petal of flower resembles female bee in size, color and markings and male bee is attracted and pseudocopulates with it. During this process of pseudocopulation, the pollen grains are dusted on the body of male bees. With such pollen dusts, male bee pseudocopulates to another flower of the same species and pollination takes place. Here we see co-evolution, *i.e.*, if female bee's colour patterns change during evolution, orchid flower also co-evolves to maintain resemblance of petal to female bee.
  - (*e*) Co-evolution is also seen in many species of fig trees which are pollinated by specific species of wasp. Female wasp uses fruit for oviposition and also uses developing seeds within fruit for nourishing its larvae. Wasp pollinates the fig inflorescence while searching for suitable egg laying sites. In return, the fig offers the wasp some of its developing seeds as food for the developing wasp larvae.

NCERT Textbook Questions

Q. 1. How is diapause different from hibernation?

Ans. **Table 13.3 Differences between hibernation and diapause**

S. No.	Hibernation	Diapause
(*i*)	Under unfavourable conditions, the animals that fail to migrate, avoid the stress by escaping in time and showing winter sleep is called hibernation.	Under unfavourable conditions, many species in lakes and ponds are known to enter a stage of suspended development called diapause.
(*ii*)	It occurs usually in winters.	It occurs both in summers and winters.
(*iii*)	*Example*, bear goes into hibernation during winter.	*Example*, zooplanktons undergo diapause in lakes and ponds under unfavourable conditions.

Q. 2. If a marine fish is placed in a freshwater aquarium, will the fish be able to survive? Why or why not? ***[HOTS]***

Ans. A marine fish if kept in freshwater aquarium will not be able to survive because:

(*a*) water will enter the body of fish through endosmosis.

(*b*) it does not have mechanism of salt absorption as in freshwater fishes.

(*c*) its drinking water habit will cause excess of water to enter the body.

So, the marine fish will fail to maintain the osmolarity and hence will die.

Q. 3. Most living organisms cannot survive at temperature above 45°C. How are some microbes able to live in habitats with temperatures exceeding 100°C? ***[HOTS]***

Ans. Most living organisms cannot survive above 45°C because

(*a*) Above 45°C enzymes get denatured.

(*b*) Protoplasm precipitates at high temperature.

However, some microbes (Archaebacteria) are found at 100°C because of

(*a*) reduced fluidity of cell membrane due to presence of branched chain lipids in their cell membrane.

(*b*) presence of heat-tolerant enzymes.

Q. 4. List the attributes that populations, but not individuals possess.

Ans. The attributes that populations but not individuals possess are:

(*i*) Population density (*ii*) Population growth

(*iii*) Mortality or death rate (*iv*) Natality or birth rate

(*v*) Sex ratio (*vi*) Age distribution

Q. 5. If a population growing exponentially doubles in size in 3 years, what is the intrinsic rate of increase (r) of the population?

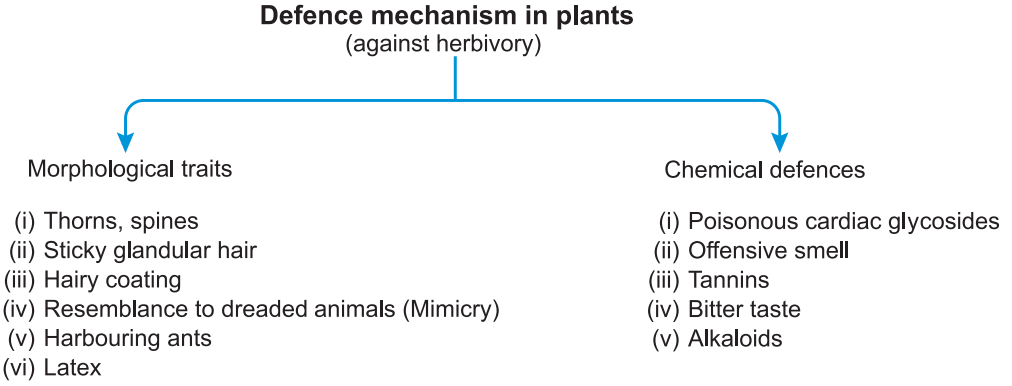
Ans. $$t = \frac{\log_2 N}{r}$$

or $$r = \frac{\log_2 N}{t} = \frac{0.7931}{3} = 0.2643$$

Intrinsic rate of increase = 0.2643 × 100 = 26.43%

Q. 6. Name important defence mechanisms in plants against herbivory.

Ans.



Q. 7. An orchid plant is growing on the branch of mango tree. How do you describe this interaction between the orchid and the mango tree?

Ans. The interaction between an orchid and the mango tree is commensalism, because orchid is benefited by getting shelter from mango tree whereas the mango tree is neither harmed nor benefited.

Q. 8. What is the ecological principle behind the biological control method of managing with pest insects?

Ans. The ecological principle operating in the biological control method of managing with pest insect is through their natural enemies, *i.e.*, predators and parasites.

Q. 9. Distinguish between the following:

(*a*) Hibernation and aestivation

(*b*) Ectotherms and endotherms

Ans. (*a*)

Table 13.4 Differences between hibernation and aestivation

S. No.	Hibernation	Aestivation
(*i*)	It is the condition of passing the winter in a resting or dormant condition.	It is the state of inactivity during hot dry summer.
(*ii*)	Animals rest in a warm place.	Animals rest in a cool and shady place.
(*iii*)	It lasts usually for the whole winter season.	It generally last for hot dry day-time because nights are often cooler.
(*iv*)	It is also called winter sleep.	It is also called summer sleep.

(b) **Table 13.5 Differences between ectotherms and endotherms**

S. No.	Ectotherms	Endotherms
(*i*)	They are also called cold-blooded animals.	They are also called warm-blooded animals.
(*ii*)	They are unable to regulate their body temperature, body temperature changes with temperature of environment.	They can regulate their body temperature.
(*iii*)	They exhibit both hibernation and aestivation.	Their activities are uncommon.
(*iv*)	They are less active animals.	They are more active animals.

Q. 10. Write a short note on:

(*a*) Adaptations of desert plants and animals

(*b*) Adaptations of plants to water scarcity

(*c*) Behavioural adaptations in animals

(*d*) Importance of light to plants

(*e*) Effect of temperature or water scarcity and the adaptations of animals.

Ans. **(*a*) Adaptations of desert plants are as follows:**

(*i*) Desert plants have cuticles to minimise transpiration.

(*ii*) In some desert plants, leaves are modified into spines to minimise loss of water.

(*iii*) They have long roots and adaptations to reduce transpiration, *e.g.*, *Acacia.*

(*iv*) Stomata are present in deeppits.

Adaptations of desert animals are as follows:

(*i*) Desert animals have concentrated their urine for minimum loss of water, *e.g.*, Kangaroo rat.

(*ii*) Desert animals absorb heat from the sun, when the body temperature drops below the comfort zone.

(*iii*) They live in burrows during hot season and have little water requirement, *e.g.*, camel.

(*iv*) Meet water requirement by interval fat oxidation.

(*b*) Adaptations of plants to water scarcity

(*i*) Some desert plants develop special photosynthetic pathway (CAM) to minimise the loss of water and close stomata during day.

(*ii*) Some desert plants have sunken stomata to minimise the loss of water.

(*iii*) Epidermis is thick walled with thick cuticles and often possess wax, thus, reducing the surface transpiration.

(*iv*) Roots are deep-seated, almost reaching the water table, *e.g.*, *Prosopis*.

(*v*) These xerophytes possess hard and pointed spines (modified leaves) to reduce transpiration.

(*c*) Behavioural adaptations in animals

(*i*) Desert lizards bask in the sun and absorb heat when their body temperature drops below the comfort zone, but move into shade when the ambient temperature starts increasing.

(*ii*) Some species are capable of burrowing into the soil to hide and escape from ground heat.

(*iii*) Hibernation and aestivation are quite common in ectothermal animals.

(*d*) Importance of light to plants

(*i*) Light is important for manufacturing food by the process of photosynthesis.

(*ii*) Duration of light determines flowering and fruit formation.

(*iii*) Light also determines the temperature which is associated with functioning of enzymes.

(*iv*) Light is essential for growth and development of plant because it provides organic materials.

(*e*) Effect of temperature or water scarcity and the adaptations of animals.

(*i*) Animals living in arid areas reduce water loss to minimum. For example, Kangaroo Rat feeds on dry seeds and seldom drink water.

(*ii*) The requirement of water is often compensated by food and metabolic water. Water loss is prevented by burrowing into the soil to hide and escape from the above ground heat, concentration of urine and solid faeces. Camel stops producing urine when water is not available and can remain without water for many days.

(*iii*) Animals protect themselves from excessive cold by deposition of fat, fur, etc. Bears undergo hibernation during winters.

Q. 11. List the various abiotic environmental factors.

Ans. **(*i*) Atmospheric factors:** Light, temperature, wind and water.

(*ii*) Lithosphere: Rock, soil.

(*iii*) Hydrosphere: Pond, river, lake and ocean.

(*iv*) Edaphic factors: Soil texture, soil water, soil air, soil micro-organisms, soil pH, minerals.

(*v*) Topographic factors: Slope, altitude, valley.

Q. 12. Give an example for:

(*a*) An endothermic animal **(*b*) Ectothermal animal**

(*c*) An organism of benthic zone.

Ans. (*a*) Monkey (*b*) Snake (*c*) Angler fish.

Q. 13. Define population and community.

Ans. **Population:** Population is a group of individuals of same species, which can reproduce among themselves and occupy a particular area in a given time.

Community: It is an assemblage of several populations in a particular area and time and exhibit interaction and interdependence through trophic relationships.

Q. 14. Define the following terms and give one example for each:

(*a*) Commensalism **(*b*) Parasitism** **(*c*) Camouflage**

(*d*) Mutualism **(*e*) Interspecific competition.**

Ans. **(*a*) Commensalism:** It is an interaction between two different species where one is benefited and other remains unaffected, *e.g.*, clown fish and sea anemone. Here, the clown fish gets protection from predators which stay away from stinging tentacles of anemone but anemone does not derive any benefit from fish.

(*b*) Parasitism: It is an interaction between two organisms in which one is benefited and the other is harmed, *i.e.*, one organism lives at the cost of other organism. *e.g.*, *Cuscuta*, a parasitic plant that is found growing on hedge plants, do not have chlorophyll and thus derives its nutrition from the host.

(*c*) Camouflage: It is a phenomenon of blending of an organism with the surrounding due to similar colour, marking and shape so as to avoid the predators, *e.g.*, leaf-like insect such as grasshopper.

(*d*) Mutualism: It is the interaction between two species in which both organisms are benefited to maintain the life process, *e.g.*, lichen (association between algae and fungi). Here, fungi helps in absorption of nutrients and water while the algal partner manufactures food.

(*e*) Interspecific competition: It is the competition among the members of different species for limited natural resources. The Abingdon tortoise in Galapagos Islands became extinct within a decade after goats were introduced on the Island, apparently due to the greater browsing efficiency of the goats.

Q. 15. With the help of suitable diagram describe the logistic population growth curve.

Ans. Refer to Basic Concepts Point 11(*ii*) and Fig. 13.4.

Q. 16. Select the statement which explains parasitism best.

(*a*) One organism is benefited.

(*b*) Both the organisms are benefited.

(*c*) One organism is benefited, other is not affected.

(*d*) One organism is benefited, other is affected.

Ans. (*d*).

Q. 17. List any three important characteristics of a population and explain them.

Ans. The three important characteristics of a population are as follows:

(*i*) Population density: Population density of a species is the number of individuals of a species per unit area or volume.

$$PD = \frac{N}{S}$$

where, PD = Population density

N = Number of individuals in a region

S = Number of unit area in a region.

(*ii*) Birth rate: It is expressed as the number of births per 1,000 individuals of a population per year.

(*iii*) Death rate: It is expressed as the number of deaths per 1,000 individuals of a population per year.

Multiple Choice Questions [1mark]

Choose and write the correct option in the following questions.

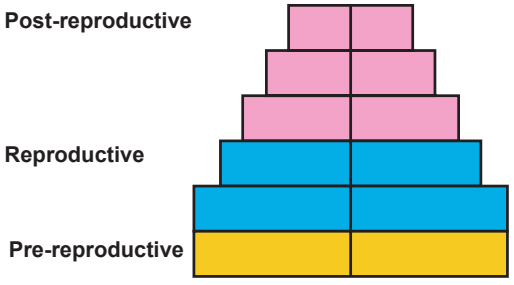
1. Reduction in vascular tissue, mechanical tissue and cuticle are characteristics of

(*a*) mesophytes (*b*) epiphytes (*c*) hydrophytes (*d*) xerophytes

2. Which of the following is a characteristic of biological community?

(*a*) Startification (*b*) Natality (*c*) Morality (*d*) Sex-ratio

3. What type of human population is represented by the following age pyramid?



(*a*) Vanishing population (*b*) Stable population

(*c*) Declining population (*d*) Expanding population

4. The logistics population growth is expressed by the equation

(*a*) $\frac{dt}{dN} = Nr\left(\frac{K - N}{K}\right)$ (*b*) $\frac{dN}{dt} = rN\left(\frac{K - N}{K}\right)$

(*c*) $\frac{dN}{dt} = rN$ (*d*) $\frac{dN}{dt} = rN\left(\frac{N - K}{N}\right)$

5. *Cuscuta* is an example of

(*a*) ectoparasitism (*b*) brood parasitims (*c*) predation (*d*) endoparasitims

6. A sedentary sea anemone gets attached to the shell lining of hermit crab. The association is

(*a*) commensalism (*b*) amensalism (*c*) ectoparasitism (*d*) symbiosis

7. Which of the following is the most accurate comment on Earth's carrying capacity (K)?

(*a*) K is smaller now than it was a thousand years ago.

(*b*) The human population is still a long way from K.

(*c*) Our technology has allowed us to keep increasing K.

(*d*) When it comes to humans, the concept of K is irrelevant.

8. Which of the following would be true of a species with an opportunistic life history?

(*a*) Members of the species take a relatively long time to reach reproductive age.

(*b*) They are regulated mostly by density-dependent factors.

(*c*) They produce large numbers of offspring.

(*d*) The population usually stabilizes near carrying capacity.

9. A particular species of tropical fish has only a few offspring and takes care of them for an extended period. We might also expect the fish population to

(*a*) be controlled mostly by density independent factors.

(*b*) show exponential growth.

(*c*) live in a harsh environment.

(*d*) be relatively stable near carrying capacity.

10. Ecological niche is **[*NCERT Exemplar*]**

(*a*) the surface area of the ocean

(*b*) an ecologically adapted zone

(*c*) the physical position and functional role of a species within the community

(*d*) formed of all plants and animals living at the bottom of a lake

11. When birth rate equals death rate,

(*a*) a population grows rapidly.

(*b*) the size of a population remains constant.

(*c*) density-dependent limiting factors do not affect the population.

(*d*) a population is in danger of extinction.

12. According to Allen's Rule, the mammals from colder climates have **[*NCERT Exemplar*]**

(*a*) shorter ears and longer limbs (*b*) longer ears and shorter limbs

(*c*) longer ears and longer limbs (*d*) shorter ears and shorter limbs

13. Salt concentration (Salinity) of the sea measured in parts per thousand is **[*NCERT Exemplar*]**

(*a*) 10 – 15 (*b*) 30 – 70 (*c*) 0 – 5 (*d*) 30 – 35

14. Formation of tropical forests needs mean annual temperature and mean annual precipitation as **[*NCERT Exemplar*]**

(*a*) 18–25°C and 150–400 cm (*b*) 5–15°C and 50–100 cm

(*c*) 30–50°C and 100–150 cm (*d*) 5–15°C and 100–200 cm

15. Which of the following forest plants controls the light conditions at the ground? **[*NCERT Exemplar*]**

(*a*) Lianas and climbers (*b*) Shrubs (*c*) Tall trees (*d*) Herbs

16. What will happen to a well growing herbaceous plant in the forest if it is transplanted outside the forest in a park? **[*NCERT Exemplar*]**

(*a*) It will grow normally

(*b*) It will grow well because it is planted in the same locality

(*c*) It may not survive because of change in its micro climate

(*d*) It grows very well because the plant gets more sunlight

17. If a population of 50 *Paramecium* present in a pool increases to 150 after an hour, what would be the growth rate of population? **[*NCERT Exemplar*]**

(*a*) 50 per hour (*b*) 200 per hour (*c*) 5 per hour (*d*) 100 per hour

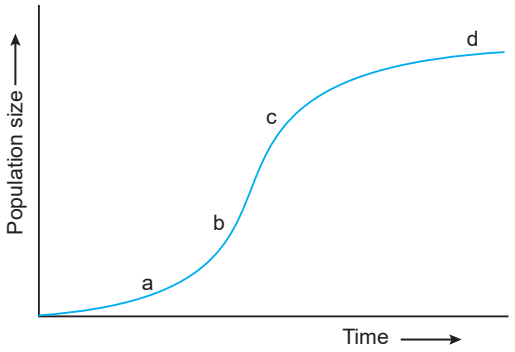
18. What would be the per cent growth or birth rate per individual per hour for the same population mentioned in the previous question (Question 17)? **[*NCERT Exemplar*]**

(*a*) 100 (*b*) 200 (*c*) 50 (*d*) 150

19. A population has more young individuals compared to the older individuals. What would be the status of the population after some years? *[NCERT Exemplar]*

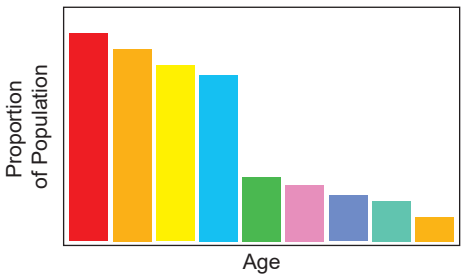
(*a*) It will decline
(*b*) It will stabilise
(*c*) It will increase
(*d*) It will first decline and then stabilise

20. At which point in the graph shown below would there be zero population growth (DN/Dt = 0)?



(*a*) a (*b*) b (*c*) c (*d*) d

21. For a population that is stable in size, the following age distribution indicates that



(*a*) The population's birth and death rates are both high.
(*b*) The population's birth and death rates are both low.
(*c*) The population's birth rate is low but its death rate is high.
(*d*) The population's birth rate is high but its death rate is low.

22. Amensalism is an association between two species where *[NCERT Exemplar]*

(*a*) one species is harmed and other is benefitted
(*b*) one species is harmed and other is unaffected
(*c*) one species is benefitted and other is unaffected
(*d*) both the species are harmed.

23. Lichens are association of *[NCERT Exemplar]*

(*a*) bacteria and fungus
(*b*) alga and bacterium
(*c*) fungus and alga
(*d*) fungus and virus

24. Which of the following is a partial root parasite? *[NCERT Exemplar]*

(*a*) Sandalwood
(*b*) Mistletoe
(*c*) Orobanche
(*d*) Ganoderma

25. The birth and death rates of four countries are given below. Which one will have the least population growth rate?

Country	Birth rate/1000	Death rate/1000
M	15	5
N	25	10
O	35	18
P	48	41

(*a*) M (*b*) N (*c*) O (*d*) P

26. According to population scientists, one of the factors responsible for limiting population is the

(*a*) availability of food. (*b*) daily variation of environmental temperature.

(*c*) time required for ecological succession. (*d*) life span of members of the population.

Answers

1. (*d*)	**2.** (*a*)	**3.** (*b*)	**4.** (*b*)	**5.** (*a*)	**6.** (*d*)	**7.** (*c*)	**8.** (*c*)	**9.** (*d*)	**10.** (*c*)
11. (*b*)	**12.** (*d*)	**13.** (*d*)	**14.** (*a*)	**15.** (*c*)	**16.** (*c*)	**17.** (*d*)	**18.** (*b*)	**19.** (*c*)	**20.** (*d*)
21. (*a*)	**22.** (*b*)	**23.** (*c*)	**24.** (*a*)	**25.** (*d*)	**26.** (*a*)				

Assertion-Reason Questions

In the following questions a statement of assertion followed by a statement of reason is given. Choose the correct answer out of the following choices.

(a) Assertion and reason both are correct statements and reason is correct explanation for assertion.

(b) Assertion and reason both are correct statements but reason is not correct explanation for assertion.

(c) Assertion is correct statement but reason is wrong statement.

(d) Assertion is wrong statement but reason is correct statement.

1. Assertion : Species are groups of potentially interbreeding natural populations which are isolated from other such groups.

Reason : Distinctive morphological features are displayed due to reproductive isolation.

2. Assertion : Leaf butterfly and stick insect show mimicry to dodge their enemies.

Reason : Mimicry is a method to acquire body colour blending with the surroundings.

3. Assertion : Small sized animals are rarely found in polar regions.

Reason : Small sized animal have larger surface area relative to their volume and have to spend energy to generate body heat.

4. Assertion : A stable population is depicted by bell-shaped age pyramid.

Reason : The proportion of individuals in reproductive age group is higher than those in pre reproductive age group.

5. Assertion : Plant-animal interactions do not generally involve co-evolution of the mutualist organisms.

Reason : Evolution of plants and animals go side by side.

6. Assertion : Predators are organisms which feed on other individuals.

Reason : Prey species have evolved various defences to lessen the impact of predation.

7. Assertion : Population pyramid (graphically) depicts the rate at which population will grow in future.

Reason : A triangular population pyramid depicts population size is stable.

8. Assertion : Epiphytes growing on branches of the tree exhibit commensalism.

Reason : In commensalism on organism benefits from the association while the other has no effect.

9. Assertion : Coral reefs are found in regions of West Bengal and Andhra Pradesh.

Reason : Coral reef require low fresh water inflow, high salinity and optimal temperature to propagate.

10. Assertion : Verhulst-Pearl Logistic growth curve is sigmoid in nature.

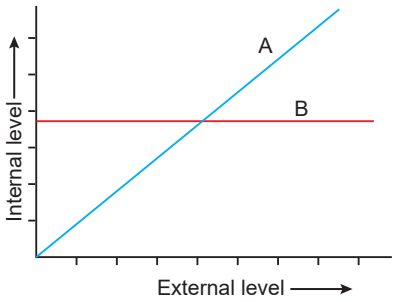
Reason : A population growing in habitat with limited resources shows an initial lag phase, followed by acceleration and deceleration and finally an asymptote.

Answers

1. (*b*)	**2.** (*a*)	**3.** (*a*)	**4.** (*c*)	**5.** (*d*)	**6.** (*b*)	**7.** (*c*)	**8.** (*a*)	**9.** (*d*)	**10.** (*b*)

Case-based/Source-based Question

1. The graph shown alongside represents the organismic response to a certain environmental condition (*e.g.*, temperature):



(*i*) Which one of these, 'A' or 'B', depicts conformers?

(*ii*) What does the other line graph depict?

(*iii*) How do these organisms differ from each other with reference to homeostasis?

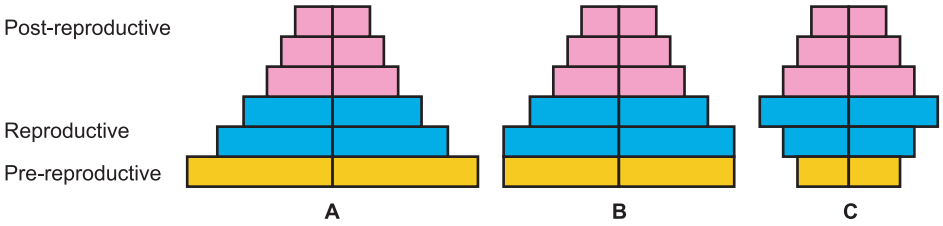
Ans. (*i*) 'A' depicts conformers.

(*ii*) The other line depicts response of the regulators.

(*iii*)

Conformers	Regulators
Aquatic animals and plants in which the osmotic concentration or body temperature of body fluids changes according to the ambient conditions or environment of water are called conformers.	Some organisms are able to maintain homeostasis by physiological means which ensures constant body temperature, constant osmotic concentration, etc.

2. Study the three different age pyramids for human population given below and answer the questions that follow:



(*i*) Write the names given to each of these age pyramids.

(*ii*) Mention the one which is ideal for human population and why.

(*iii*) What would be the growth rate pattern when the resources are unlimited?

Ans. (*i*) A — Expanding pyramid B — Stable pyramid
C — Declining pyramid

(*ii*) Stable pyramid is ideal for human population because it maintains the stability in all population phases.

(*iii*) Exponential.

Very Short Answer Questions [1 mark]

Q. 1. Write the basis on which an organism occupies a space in its community/natural surroundings. ***[CBSE (AI) 2013]***

Ans. Feeding relationships with other organisms.

Q. 2. Name a 'photoperiod' dependent process, one each in plants and in animals. ***[CBSE (F) 2013]***

Ans. In plants, flowering and in animals, migration/foraging are photoperiod dependent processes.

Q. 3. Between amphibians and birds, which will be able to cope with global warming? Give reasons. ***[HOTS]***

Ans. Birds being eurythermals can tolerate a wide range of temperature and thus will be able to cope with global warming more efficiently.

Q. 4. Why are green algae not likely to be found in the deepest strata of the ocean? ***[CBSE (AI) 2013]*** ***[HOTS]***

Ans. The wavelength of light at the deepest strata is unsuitable for growth of green algae.

Q. 5. Why are some organisms called as eurythermals and some others as stenohaline? ***[CBSE (F) 2011]*** ***[HOTS]***

Ans. Eurythermals are organisms that can tolerate and thrive in a wide range of temperature, whereas stenohalines can tolerate a narrow range of salinities.

Q. 6. Which one of the two, stenothermals or eurythermals, shows wide range of distribution on earth and why?

Ans. Eurythermals show a wide range of distribution on earth, as they show tolerance for wide range of temperatures.

Q. 7. What are ectotherms?

Ans. Ectotherms are those animals whose body temperature changes and matches with that of the environment in which they are living. They are also called cold-blooded animals.

Q. 8. Species that tolerate wide range of salinity are called _____. ***[NCERT Exemplar]***

Ans. Euryhaline.

Q. 9. Mention the effect of global warming on the geographical distribution of stenothermals like amphibians. ***[CBSE (F) 2012]***

Ans. Due to global warming, stenothermals would either migrate or die due to change in the temperature.

Q. 10. When and why do some animals go into hibernation?

Ans. When the animals are not able to tolerate the stressful conditions like low temperature, they hibernate to avoid the stress by escaping in time since they can not migrate.

Q. 11. When and why do some animals like snails go into aestivation?

Ans. Snails undergo aestivation if they are unable to migrate in order to avoid stressful condition of high temperature.

Q. 12. Why are mammals the most successful animals on earth? ***[HOTS]***

Ans. The mammals are most successful animals on earth because they can maintain a constant body temperature with high range of tolerance whether in Antarctica or in Sahara desert.

Q. 13. Why do people living in high altitude have more haemoglobin/high RBC count? ***[HOTS]***

Ans. To acclimatise at high altitude, the people have more haemoglobin/high RBC count to compensate for the low oxygen availability.

Q. 14. What is a tree line? ***[NCERT Exemplar]*** ***[HOTS]***

Ans. When we go up the altitude, beyond a particular height no tree are found and the vegetation comprise only of shrubs and herbs. The altitude beyond which no tree is seen is known as tree line.

Q. 15. Why has life history of variation evolved? ***[HOTS]***

Ans. (*a*) Life history of variation has evolved.

(*b*) In order to maximise reproductive fitness of individual.

Q. 16. State Gause's Competitive Exclusion principle. ***[CBSE (AI) 2014]***

Ans. Gause's Competitive Exclusion Principle states that two closely related species competing for same resources, cannot coexist indefinitely, (the inferior will be eliminated) by the superior one.

Q. 17. What does nature's carrying capacity for a species indicate? ***[CBSE (F) 2016]***

Ans. In nature, a given habitat has enough or limited resources to support a maximum possible number of population and nature's carrying capacity indicates that how much growth is possible in a population.

Q. 18. Name two organisms (one plant and one animal) which breed only once in their life time.

Ans. Pacific salmon fish and bamboo.

Q. 19. What is Allen's rule?

Ans. According to Allen's rule, mammals in colder climate have shorter ears and shorter limbs to minimise heat loss.

Q. 20. Why do predators avoid eating Monarch butterfly? How does the butterfly develop this protective feature? **[*CBSE (F) 2010*]**

Ans. The Monarch butterfly is highly distasteful to its predator (birds) because of a special chemical present in its body. It acquires this chemical during its caterpillar stage by feeding on a poisonous weed.

Q. 21. Give two reasons as to why a weed such a *Calotropis* flourishes in abandoned fields. **[*CBSE 2019 (57/2/1)*]**

Ans. *Calotropis* flourishes in abandoned fields because of:
(*i*) It has dry hairy seeds which help in dissemination (*ii*) Its have xerophytic adaptations like thick hair on leaves and stems. (*iii*) It is not grazed by animals as it produces poisonous substances like cardiac glycosides. (*Any two*)

Q. 22. Why are cattle and goats not seen browsing on *Calotropis* growing in the fields? **[*CBSE (F) 2011*] [*HOTS*]**

Ans. *Calotropis* produces highly poisonous cardiac glycosides. Therefore, cattle and goats do not browse on them.

Q. 23. If 8 individuals in a laboratory population of 80 fruit flies died in a week, then what would be the death rate of population for the said period? **[*CBSE Delhi 2010*] [*HOTS*]**

Ans. $$\text{Death rate} = \frac{\text{Number of individuals dead}}{\text{Total number of individual}} = \frac{8}{80} = 0.1$$

The death rate will be 0.1 individuals per week.

Q. 24. In a pond there were 20 *Hydrilla* plants. Through reproduction 10 new *Hydrilla* plants were added in a year. Calculate the birth rate of the population. **[*CBSE Delhi 2010*] [*HOTS*]**

Ans. $$\text{Birth rate} = \frac{\text{Number of individuals born}}{\text{Total number of individuals}} = \frac{10}{20} = 0.5$$

Birth rate is 0.5 plants per year.

Q. 25. What does J-shaped growth curve of a population indicate?

Ans. The J-shaped growth curve indicates the minimum or absence of environmental resistance.

Q. 26. What does sigmoid growth curve of a population indicate?

Ans. Sigmoid growth curve of a population indicates following characteristics:

(*i*) Initially the growth is slow.

(*ii*) The growth becomes rapid and the curve becomes steady due to environmental resistance.

Q. 27. Pollinating species of wasps show mutualism with specific fig plants. Mention the benefits the female wasps derive from the fig trees from such an interaction. **[*CBSE (AI) 2011*] [*HOTS*]**

Ans. The wasp uses the fruit as oviposition, *i.e.*, egg laying and the developing seeds for nourishing its larvae.

Q. 28. Give an example of an organism that enters 'diapause' and why. **[*CBSE Delhi 2014*] [*HOTS*]**

Ans. Many species of Zooplankton under unfavourable conditions enters diapause which delay overall development and hence they can pass unfavourable conditions.

Q. 29. Name the type of association that the genus *Glomus* exhibits with higher plants. **[*CBSE (AI) 2014*] [*HOTS*]**

Ans. Symbiosis/Mycorrhizae/Mutualism.

Q. 30. Name the interaction between a whale and the barnacles growing on its back. **[*CBSE (F) 2012*]**

Ans. Commensalism

Q. 31. Name the interaction between sea anemone and the hermit crab that grows on it. [*CBSE (F) 2012*]

Ans. Commensalism

Q. 32. What is the interaction called between *Cuscuta* and shoe flower bush? [*CBSE Delhi 2012*]

Ans. Parasitism

Q. 33. What is an interaction called when an orchid grows on a mango plant? [*CBSE Delhi 2012*]

Ans. Commensalism

Q. 34. What do phytophagous insects feed on? [*CBSE Delhi 2012*]

Ans. Phytophagous insects feed on plant sap and other parts of plant.

Q. 35. What is mycorrhiza? [*NCERT Exemplar*]

Ans. Mycorrhiza is a symbiotic association between a fungus and the roots of higher plants.

Q. 36. Give one function of aerenchyma in aquatic plants. [*HOTS*]

Ans. Aerenchyma gives buoyancy to the aquatic plants due to presence of air chambers.

Short Answer Questions [2 marks]

Q. 1. Explain the response of all communities to environment over time. [*CBSE (AI) 2011*] [*HOTS*]

Ans. Environmental factors like temperature, water, light, soil, etc., may influence the members of communities in varying degrees. Organisms in response to these factors try to adapt according to their capacities, by maintaining a constant internal environment through homeostasis or migration to a less stressful environment or suspending activities till favourable conditions return.

Q. 2. Categorise the following plants into hydrophytes, xerophytes, halophytes and mesophytes. Write the type of plant against the following examples.

(*a*) *Salvinia* (*b*) *Opuntia

(*c*) *Rhizophora* (*d*) *Mangifera* [*NCERT Exemplar*]

Ans. (*a*) Hydrophyte (*b*) Xerophyte

(*c*) Halophyte (*d*) Mesophyte

Q. 3. In a pond, we see plants which are free-floating, rooted-submerged, rooted emergent, rooted with floating leaves. Write the type of plants against each of them.

(*a*) *Hydrilla*, (*b*) *Typha*, (*c*) *Nymphaea*, (*d*) *Lemna*, (*e*) *Vallisnaria* [*NCERT Exemplar*]

Ans. (*a*) Submerged (*b*) Rooted emergent

(*c*) Rooted with floating leave (*d*) free-floating

(*e*) Rooted Submerged

Q. 4. The density of a population in a habitat per unit area is measured in different units. Write the unit of measurement against the following:

(*a*) Bacteria, (*b*) Grass, (*c*) Banyan, (*d*) Deer, (*e*) Fish [*NCERT Exemplar*]

Ans. (*a*) Numbers/volume (*b*) Coverage/area

(*c*) Biomass/area (*d*) Numbers/area

(*e*) Weight/area or Number/area

Q. 5. Explain relationship between biotic potential and environmental resistance.

Ans. Biotic potential is defined as the maximum inherent capacity of an organism to reproduce or increase the number of individuals. Whereas the environmental resistance is the biotic and abiotic factors of the environment, that do not allow the population of organisms to grow unlimited and keeps the population size in control.

Q. 6. "Snow leopards are not found in Kerala forests and tuna fish are rarely found beyond tropical latitude in the ocean". Study the above two cases and state the possible reasons for the same. [*HOTS*]

Ans. Change in temperature from their established habitats affects the kinetics of the enzymes and through it, the basal metabolism, activity and other physiological functions of the organism.

Q. 7. Why are coral reefs not found from West Bengal to Andhra Pradesh but found in Tamil Nadu on the east coast of India? ***[NCERT Exemplar]*** ***[HOTS]***

Ans. High salinity, optimal temperature and less siltation are essential to colonise corals. If siltation and fresh water inflow are very high, the corals don't colonise. In contrast when the siltation and fresh water in flow by the rivers are very less, the corals do colonise.

Q. 8. In a sea shore, the benthic animals live in sandy, muddy and rocky substrata and accordingly developed the following adaptations. Find the suitable substratum against each adaptation.

(*a*) Burrowing _____

(*b*) Building cubes _____

(*c*) Holdfasts/peduncle _____ ***[NCERT Exemplar]*** ***[HOTS]***

Ans. (*a*) Sandy, (*b*) Muddy, (*c*) Rocky.

Q. 9. Name two basic types of competition found amongst organisms. Which one of them is more intense and why?

Ans. The two basic types of competitions are:

(*i*) Interspecific competition

(*ii*) Intraspecific competition

The intraspecific competition is more intense because the requirement of the individual of the species are similar.

Q. 10. Mention four adaptive features that help cacti survive in xeric environment. ***[CBSE (F) 2010]***

Ans. Adaptation in desert plants:

(*i*) Desert plants have thick waxy coating on leaf called cuticle for minimum loss of water, through transpiration.

(*ii*) They have special photosynthetic pathway (CAM) that enables minimum loss of water during day time because stomata remain closed.

(*iii*) Some desert plants develop spines instead of leaf and photosynthetic function is carried out by the flattened stem.

(*iv*) Stomata are arranged in deep pits to minimise loss, through transpiration.

Q. 11. In certain seasons we sweat profusely while in some other season we shiver. Explain. ***[CBSE Delhi 2016]***

Ans. Human beings maintain a constant body temperature of 37°C.

- **In summers:** The outside temperature is much higher than our body temperature. Therefore, we sweat profusely. This results in evaporative cooling and our body temperature is brought down to normal (37°C).
- **In winters:** The outside temperature is much lower than our body temperature. Therefore, we start to shiver; this action (of shivering) is a kind of exercise (work) that produces heat and raises the body temperature.

Q. 12. Why are small animals rarely found in the polar regions? Explain.

OR ***[CBSE Delhi 2013; (F) 2010]***

Why are small birds like humming birds not found in polar regions? Explain. ***[CBSE (F) 2012]***

Ans. Small animals like humming birds have a large surface area relative to their volume. So they tend to lose body heat very fast when it is cold outside. Then, these animals have to use their energy (generated by metabolic reactions) to generate body heat. That is the reason why small sized animals are rarely found in the polar regions.

Q. 13. Why the plants that inhabit a desert are not found in a mangrove? Give reasons. ***[CBSE Delhi 2016]***

Ans. In mangroves the soil is oxygen deficit because of excess water present. Plants in mangroves develop special roots called breathing roots or pneumatophores for respiration. This adaptation

is not present in desert plants because of which they cannot survive in mangroves.

Q. 14. Bear hibernates whereas some species of zooplanktons enter diapause to avoid stressful external conditions. How are these two ways different from each other? [*CBSE (F) 2011*]

Ans. Hibernation is the winter sleep, seen in cold-blooded animals in polar regions, in which they suspend their metabolic activities when external temperature becomes unfavourable. Whereas, diapause is the phenomenon seen in insects during their developmental stages, in which metabolic activities are suspended due to unfavourable conditions.

Q. 15. Many fresh water animals cannot survive in marine environment. Explain. [*CBSE Delhi 2015*] [*HOTS*]

Ans. Marine environment has high salt concentration. These fresh water animals in such hypertonic surroundings suffer from osmotic problems. Their bodies start losing water by exosmosis.

Q. 16. How do seals adapt to their natural habitat? Explain. [*CBSE (F) 2010*]

Ans. Seals adapt to the cold climate by developing a thick layer of fat (blubber) below their skin that acts as an insulator and reduce excess loss of body heat.

Q. 17. Some organisms suspend their metabolic activities to survive in unfavourable conditions. Explain with the help of any four examples. [*CBSE Delhi 2012*]

Ans. **(*i*) Polar bear:** They hibernate during winter to escape the cold weather.

(*ii*) Snails/fishes: They go into aestivation during summer to avoid heat related problems and desiccation.

(*iii*) Seeds of higher plants/spores of bacteria/fungi: They become dormant in unfavourable conditions and in case of *Amoeba* cyst formation takes place.

(*iv*) Some species of zooplankton: They undergo diapause.

Q. 18. Plants that inhabit a rain-forest are not found in a wetland. Explain. [*CBSE Delhi 2016*]

Ans. Plants in wetland are adapted differently. The soil in wetland lacks oxygen. So, for respiration the roots have to grow above the soil. These roots are called breathing roots or pneumatophores. This feature is not present in roots of plants growing in rainforest.

Q. 19. How does our body adapt to low oxygen availability at high altitudes? [*CBSE (F) 2011*]

Ans. Our body adapts to low oxygen availability by increasing red blood cell production, decreasing the binding capacity of haemoglobin and by increasing breathing rate.

Q. 20. How does a desert plant adapt to the dry, warmer environmental conditions? [*CBSE (F) 2015*]

Ans. Adaptations of a desert plant:

(*i*) Leaf surface has a thick cuticle.

(*ii*) Stomata are situated in deep pits.

(*iii*) Stem is flattened and performs photosynthesis.

(*iv*) Leaves are modified into spines as in *Opuntia*. (*Any two*)

Q. 21. (*a*) Explain "birth rate" in a population by taking a suitable example.

(*b*) Write the other two characteristics which only a population shows but an individual cannot. [*CBSE (AI) 2013*]

Ans. (*a*) Birth rate is expressed as the number of births per 1,000 individuals of a population per year. For example, in a pond there were 200 frogs and 40 more were born in a year. Then, the birth rate of the population will be 40/200 = 0.5 frogs per year.

(*b*) Sex ratio, age distribution, population density, population growth. (*Any two*)

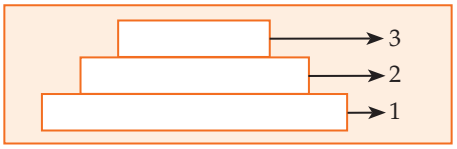
Q. 22. Construct an age pyramid which reflects an expanding growth status of human population. [*CBSE (AI) 2014*] [*HOTS*]

Ans. Refer to Fig. 13.3.

Q. 23. Construct an age pyramid which reflects a stable growth status of human population. [*CBSE Delhi 2014*] [*HOTS*]

Ans. Refer to Fig. 13.3.

Q. 24.



(*a*) Label the three tiers 1, 2, 3 given in the above age pyramid.

(*b*) What type of population growth is represented by the above age pyramid?

[*NCERT Exemplar*] [*HOTS*]

Ans. (*a*) 1 represents Pre-reproductive age group
2 represents Reproductive age group
3 represents Post-reproductive age group

(*b*) Expanding population.

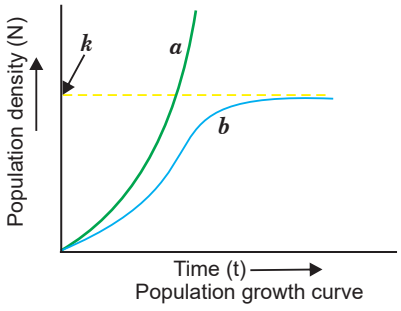
Q. 25. (*a*) What is "r" in the population equation given: dN/dt = rN?

(*b*) How does the increase and the decrease in the value of 'r' affect the population size?

Ans. (*a*) 'r' is called intrinsic rate of natural increase.

(*b*) Population size increases with increase in 'r' and it decreases with decrease in 'r'.

Q. 26. Identify the curves '*a*' and '*b*' shown in the graph given below. List the conditions responsible for growth patterns '*a*' and '*b*'. [*HOTS*]



Ans. Curve '*a*' is exponential growth curve. When the resources (food + space) are unlimited, this type of growth curve appears.

Curve '*b*' is logistic growth curve. When the resources become limited at certain point of time, this type of growth curve appears.

Q. 27. Explain Verhulst-Pearl Logistic Growth of a population. [*CBSE (F) 2014*]

Ans. According to Verhulst–Pearl Logistic growth, a population growing in a habitat with limited resources initially shows a lag phase, followed by phases of acceleration and deceleration and finally an asymptote when the population density reaches the carrying capacity. It is given by the following equation:

$$\frac{dN}{dt} = rN\left[\frac{K - N}{K}\right]$$

where, N = population density at time t, r = intrinsic rate of natural increase, K = carrying capacity.

Q. 28. Co-evolution is a spectacular example of mutualism between an animal and a plant. Describe co-evolution with the help of an example. [*CBSE (F) 2016*]

OR

Describe the mutual relationship between fig tree and wasp and comment on the phenomenon that operates in their relationship. [*CBSE (AI) 2014*]

Ans. Co-evolution can be observed in Fig (plant) and wasp (animal). The female wasp uses the fruit for oviposition or egg laying. It also uses developing seeds within the fruit for nourishing its larvae. The wasp in turn pollinates the fig inflorescence. The given Fig species can be pollinated by its 'partner' wasp species and no other species.

Q. 29. Egrets are often seen along with grazing cattle. How do you refer to this interaction? Give a reason for this association.

Ans. The interaction between them can be referred to as commensalism. Egrets always forage close to where the cattle are grazing because the cattle, as they move stir up and flush out insects from the vegetation which otherwise might be difficult for the egrets to find and catch.

Q. 30. Explain brood parasitism with the help of an example. ***[CBSE (AI) 2012]***

Ans. *Koel* is a parasitic bird (which has lost the instinct to make its own nest to lay eggs), has evolved the technique of laying eggs in the nest of a crow.

Its eggs bear resemblances to those of crow.

Q. 31. Explain parasitism and co-evolution with the help of one example of each. ***[CBSE (AI) 2016]***

Ans. Mode of interaction between two species in which one species (parasite) depends on the other species (host) for food and shelter is called parasitism. In this one organism is benefitted and the other is harmed.

For example, Human liver fluke or Malarial parasite or *Cuscuta.*

Co-evolution is the relationship between two interacting organisms where an organisms fails to survive in the absence of the other.

For example, Fig and fig wasp or *Ophrys* and bumble bee.

Q. 32. What is mutualism? Mention any two examples where the organisms involved are commercially exploited in agriculture. ***[CBSE (AI) 2015]***

Ans. Interaction between two species in which both are benefited is called mutualism.

(*i*) Rhizobium in the roots (nodules) of legumes.

(*ii*) Mycorrhiza → Glomus living with the roots of higher plants.

Q. 33. How does the Mediterranean orchid *Ophrys* ensure its pollination by bees?

Ans. The petals of the *Ophrys* resembles the female of a bee species in size, colour and odour, etc. Male bee mistakes the *Ophrys* for female bee and tries to copulate. Few pollen grains adhered with the body of the male bee fall over stigma of the flower thereby leading to pollination.

Q. 34. How do plants benefit from having mycorrhizal symbiotic association? ***[CBSE (F) 2010]***

Ans. Mycorrhizal association is found between fungi and the roots of higher plants. The fungi help the plant in the absorption of essential nutrients from the soil while plant in turn provides energy-yielding carbohydrates to fungi.

Q. 35. (*a*) How is *Cuscuta* adapted to be a parasitic plant?

(*b*) Why do cattle avoid browsing on *Calotropis* plants? Explain.

Ans. (*a*) *Cuscuta* has lost its chlorophyll and leaves during evolution and thus it derives its nutrition from host plant, thus, it is a parasitic plant.

(*b*) Cattle avoid browsing on *Calotropis* plants because it produces poisonous cardiac glycosides.

Q. 36. Why do clown fish and sea anemone pair up? What is this relationship called? ***[CBSE Delhi 2012]***

Ans. The clown fish gets protection from predators which stay away from stinging tentacles of anemone but anemone does not derive any benefit from the fish. This relationship is called commensalism.

Q. 37. Besides acting as 'conduits' for energy transfer across trophic levels, predators play other important roles. Justify. ***[CBSE Sample Paper 2016]***

Ans. Besides acting as 'conduits' of energy transfer across trophic levels, predators play other important roles like

(*i*) They keep prey population under control.

(*ii*) Predators also help in maintaining species diversity in a community by reducing the intensity of competition among competing prey species.

Q. 38. An organic farmer relies on natural predation for controlling plant pests and diseases. Justify giving reasons why this is considered to be a holistic approach. ***[CBSE (F) 2010] [HOTS]***

Ans. Besides acting as 'conduits' for energy transfer across trophic levels, predators are used in biological control of plant pests. This ability of the predator is based on its regulating the prey population. The natural predators reduce interspecific competition and do not harm the crop

plants. For example, in an area the invasive cactus can be brought under control by cactus-feeding predator (a moth). Using natural predation, the ecosystem is kept stable without harming any of the trophic levels.

Q. 39. Apart from being part of the food chain, predators play other important roles. Mention any two such roles supported by examples. ***[CBSE Delhi 2014] [HOTS]***

Ans. (*i*) Keeps prey population under control. For example, the invasive prickly. Pear cactus in Australia was brought under control only after a cactus feeding predator (a moth) was introduced in the country.

(*ii*) Maintains species diversity by reducing intensity of competition among prey species. For example, when the starfish *Pisaster* was removed from its community of American Pacific Coast, more than 10 species of invertebrates became extinct.

Long Answer Questions–I [3 marks]

Q. 1. (*a*) Write the importance of measuring the size of a population in a habitat or an ecosystem.

(*b*) Explain with the help of an example how the percentage cover is a more meaningful measure of population size than mere numbers. ***[CBSE (AI) 2013]***

Ans. (*a*) By measuring the size of a population, following can be predicted:

(*i*) Status of the population in a habitat.

(*ii*) Outcome of competition with other species.

(*iii*) Impact of predator or pesticides.

(*iv*) Increase or decrease of population size.

(*iv*) Effect of pesticide application (*Any two*)

(*b*) **Example:** Banyan tree and *Parthenium* plants.

When 1 banyan tree is compared with 100 *Parthenium* plants, the population of banyan in terms of number is very much low as compared to *Parthenium*. But in terms of percentage cover or biomass, the banyan tree provides a much larger cover in comparison to 100 *Parthenium* plants. Thus, the percentage cover or biomass is a more meaningful measure of population size.

Q. 2. (*a*) List any three ways of measuring population density of a habitat.

(*b*) Mention the essential information that can be obtained by studying the population density of an organism. ***[CBSE (AI) 2012]***

Ans. (*a*) By physical counting, percent cover or total biomass, from relative density, counting pugmarks, counting faecal pellets. (*Any three*)

(*b*) Status of habitat, whether competition for survival exists or not, whether population is increasing or declining, natality, mortality, emigration, immigration.

Q. 3. (*a*) List the biotic components an organism interacts with in its natural habitat.

(*b*) Mention how have organisms optimised their survival and reproduction in a habitat. ***[CBSE (F) 2013]***

Ans. (*a*) Plants, animals and microorganisms.

(*b*) (*i*) Some organisms regulate to maintain homeostasis by physiological and behavioural means.

(*ii*) In some animals and plants the osmotic concentration of the body fluids change with that of the ambient water osmotic concentration (Conform).

(*iii*) Some animals migrate to avoid unfavourable conditions.

(*iv*) Some bacteria, fungi and lower plants, under unfavourable conditions slow down metabolic rate and form thick-walled spores to overcome stressful conditions (Suspend).

Q. 4. How do organisms which cannot migrate, tend to overcome adverse environmental conditions? Explain taking one example each from vertebrates and angiosperms respectively.

Ans. Organisms which cannot migrate tend to overcome adverse environmental conditions by developing several methods/features. For example, some vertebrates escape the stress caused by

unfavourable environmental conditions by escaping in time like bears go into hibernation during the winter months. In angiosperms, seeds and some other vegetative reproductive structures serve as means to tide over periods of stress. They reduce their metabolic activity and go into an inactive, *i.e.*, 'dormant' state. They germinate to form new plant when the favourable conditions return.

Q. 5. Explain with the help of suitable examples the three different ways by which organisms overcome their stressful conditions lasting for short duration. ***[CBSE Delhi 2016]***

Ans. If the stressful conditions remain for short duration, the organism has following alternatives, *i.e.*, either conform, migration, suspension.

(*i*) Conform: In some animals called conformers, osmotic concentration of body fluids change with that of the ambient water osmotic concentration. For example, small animals have larger surface area relative to their volume. They lose body heat very fast in low temperature. So, they expand energy to generate body heat through metabolism.

(*ii*) Migration: The temporary movement of organism from the stressful habitat to a more hospitable area and return when stressful period is over is called migration. For example, migratory birds from Siberia come to Keoladeo National Park (Bharatpur) in every winter.

(*iii*) Suspend: Those animals who fail to migrate, might avoid the stress by escaping in time. Hibernation of bears during winter or aestivation of snails and fish to avoid summer are examples of this phenomenon.

Q. 6. Explain with the help of an example each, any two ways by which the animals cope with the stressful conditions lasting for a short period in their habitat. ***[CBSE 2019 (57/3/3)]***

Ans. Refer to Basic Concepts Point 7.

Q. 7. How do organisms like fungi, zooplanktons and bears overcome the temporary short-lived climatic stressful conditions? Explain. ***[CBSE (AI) 2010]***

Ans. **Fungi** form thick-walled spores which help them survive in unfavourable conditions. On availability of suitable environment, these germinate.

Zooplanktons in lakes and ponds under unfavourable conditions, enter diapause, a stage of suspended development.

Bears in extreme low temperatures, escape winter time by hibernating.

Q. 8. How do organisms cope with stressful external environmental conditions which are localised or of short duration? ***[CBSE (AI) 2011]***

Ans. The following methods are employed by organisms to cope with stressful conditions:

(*i*) Migrate temporarily from the stressful habitat to a hospitable area,
(*ii*) suspend activities,
(*iii*) form thick walled spores,
(*iv*) form dormant seeds,
(*v*) hibernate during winter,
(*vi*) aestivate during summer,
(*vii*) planktons undergo diapause. (*Any six*)

Q. 9. (*a*) State how the constant internal/environment is beneficial to organisms.

(*b*) Explain any two alternatives by which organisms can overcome stressful external conditions. ***[CBSE (AI) 2014]***

Ans. (*a*) Constant internal environment permits all biochemical reaction and physiological functions to proceed with maximal efficiency and thus enhance the overall fitness of the species.

(*b*) Organisms can overcome stressful external conditions with the following ways:

(*i*) Regulation: Maintaining internal environment by maintaining constant body temperature or osmotic concentration.

(*ii*) Suspend (conform): By suspending metabolic activities through hibernation or aestivation or diapause.

(*iii*) Migration: Organisms migrate temporarily to more hospitable areas.

Q. 10. Different animals respond to changes in their surroundings in different ways. Taking one example each, explain "some animals undergo aestivation while some others hibernate". How do fungi respond to adverse climatic conditions? ***[CBSE (AI) 2017]***

Ans. Some animals go into aestivation to avoid summer problems like, heat and dessication. For example, snails and fish.

Some animals go into hibernation to avoid winter related problem like, extreme cold. For example, bear.

Fungi form thick walled spores and suspend their activities to respond to adverse climatic conditions.

Q. 11. Water is very essential for life. Write any three features both for plants and animals which enable them to survive in water scarce environment.

[CBSE (AI) 2011, CBSE Sample Paper 2014]

Ans. **Plants:** Ephemeral mode (complete life cycle in short period); deep tap roots; deciduous leaves; waxy cuticle; sunken stomata; succulence to store water; C_4 or CAM pathway of photosynthesis. (*Any three*)

Animals: No sweating; uricotelic; deposition of fat in sub-epidermal layer; burrowing nature; thick skin; body covered with scales. (*Any three*)

Q. 12. How do kangaroo rats and desert plants adapt themselves to survive in their extreme habitat? Explain. ***[CBSE (AI) 2017]***

Ans. Kangaroo rats are capable of meeting its water requirements through its internal fat oxidation in which water is a by product. It also has the ability to concentrate its urine so that minimal volume of water is used to remove excretory products.

Desert plants have a thick cuticle on their leaf surface and have their stomata arranged in deep pits to minimise water loss. They also have leaves reduced to spines and deep roots to absorb more water. They have a special photosynthetic pathway (CAM).

Q. 13. Describe the specific adaptation of xerophytes with respect to root system, stem and leaves.

Ans. (*i*) The root system is deep-rooted, that help to reach up to the level of water table.

(*ii*) Stem become modified into fleshy, spongy flat and green structure called phylloclade. Stem can perform photosynthesis and store water.

(*iii*) Leaves have waxy layer called cuticle, contain sunken stomata and leaves are modified into hard pointed spines to reduce transpiration. Leaves become fleshy in succulents.

Q. 14. (*a*) "Organisms may be conformers or regulators." Explain this statement and give one example of each.

(*b*) Why are there more conformers than regulators in the animal world? ***[CBSE (AI) 2017]***

Ans. (*a*) Conformers are organisms which cannot maintain a constant internal environment under varying external environmental conditions. They change body temperature and osmotic concentration with change in external environment. For example, all plants, fishes, amphibians etc.

Regulators are organisms which can maintain homoeostasis (by physiological means or behavioural means) *i.e.*, they maintain constant body temperature and osmotic concentration. For example, birds and mammals.

(*b*) Thermoregulation is energetically expensive for animals. Therefore, more conformers are found.

Q. 15. Explain mutualism with the help of any two examples. How is it different from commensalism? ***[CBSE Delhi 2013]***

Ans. Refer to Basic Concepts Point 13 (*vi*).

In commensalism, one species benefits and the other is neither benefitted nor harmed whereas in mutualism both the species are benefitted.

Q. 16. Study the graph given alongside and answer the questions which follow:

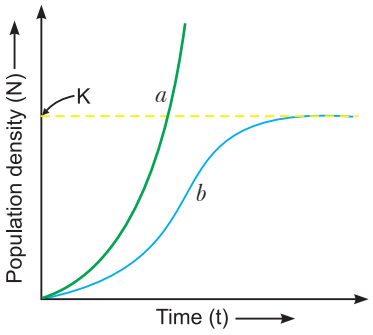
(*i*) The curve '*b*' is described by the following equation:

$$\frac{dN}{dt} = rN\left\{\frac{K - N}{K}\right\}$$

What does 'K' stand for in this equation? Mention its significance.

(*ii*) Which one of the two curves is considered a more realistic one for most of the animal populations?

(*iii*) Which curve would depict the population of a species of deer if there are no predators in the habitat? Why is it so?



Ans. (*i*) 'K' stands for carrying capacity. Carrying capacity is defined as the maximum number of individuals of a population that can be sustained by the given habitat/environment.

(*ii*) Curve '*b*' is more realistic.

(*iii*) Curve '*a*'. When the predators are absent, the prey population grows exponentially.

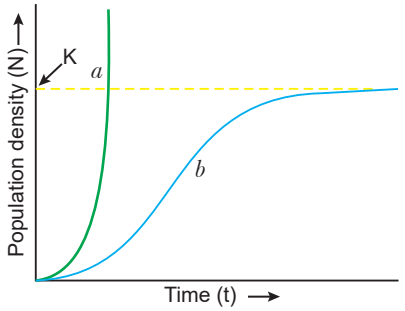
Q. 17. Study the population growth curves in the graph given below and answer the questions that follow:

(*i*) Identify the growth curves '*a*' and '*b*'.

(*ii*) Which one of them is considered a more realistic one and why?

(*iii*) If $\frac{dN}{dt} = rN\left\{\frac{K - N}{K}\right\}$ is the equation of the logistic growth curve, what does K stand for?

(*iv*) What is symbolised by N?



Ans. (*i*) *a* is exponential growth curve or J-shaped curve.

b is logistic growth curve or S-shaped curve.

(*ii*) Logistic growth curve (*b*) is considered more realistic because unlimited resources are never available in an ecosystem or in a habitat.

(*iii*) K stands for carrying capacity.

(*iv*) N indicates population density, which is the number of species of a population per unit area.

Q. 18. When do you describe the relationship between two organisms as mutualistic, competitive and parasitic? Given one example of each type. ***[CBSE (F) 2017]***

Ans. Mutualism is referred to as the interspecific interaction in which both the interacting species are benefited from each other. For example, lichens represent close association between fungus and Algae.

Competition is a type of interaction due to limited resources between closely related species where they compete for the same resource and both species suffer. For example, In South American lakes, visiting flamingos and resident fishes compete for zooplanktons.

Parasitism is the mode of interaction between two species, in which one species (parasite) depends on the other species (host) for food and shelter, and in the process damages the host. For example, human liver fluke depends on two hosts, a snail and a fish, to complete its life cycle.

Q. 19. Name the type of interaction seen in each of the following examples:

(*i*) *Ascaris* worms living in the intestine of humans

(*ii*) Wasp pollinating fig inflorescence

(*iii*) Clown fish living among the tentacles of sea-anemone

(*iv*) Mycorrhizae living on the roots of higher plants

(*v*) Orchid growing on a branch of a mango tree

(*vi*) Disappearance of smaller barnacles when *Balanus* dominated in the coast of Scotlan(d) **[*CBSE Delhi 2011*]**

Ans. (*i*) Parasitism (*ii*) Mutualism
(*iii*) Commensalism (*iv*) Mutualism
(*v*) Commensalism (*vi*) Competition

Q. 20. Predation is usually referred to as a detrimental association. State any three positive roles that a predator plays in an ecosystem. **[*CBSE (AI) 2016*]**

Ans. (*i*) They predators act as conduits for energy transfer across trophic levels.
(*ii*) They keep prey populations under control.
(*iii*) They help in maintaining species diversity in a community by reducing the intensity of competition among prey species.

Q. 21. Explain co-evolution with reference to parasites and their hosts. Mention any four special adaptive features evolved in parasites for their parasitic mode of life. **[*CBSE (AI) 2015*]**

Ans. If the host evolves special mechanism for rejecting or resisting the parasite. The parasite has to (simultaneously) evolve/co-evolve the mechanism to counter act and neutralise them & *i.e.* called co-evolution.

(*a*) Parasitic adaptation in Animals

Refer to Basic concept 13 (*iii*) (Adaptation of parasite)

(*b*) Parasitic adaptation in plants

(*i*) Haustoria in *Cuscuta*
(*ii*) Loss of chlorophyll
(*iii*) Loss of leaves/foliage

Q. 22. Differentiate between mutualism, parasitism and commensalism. Provide one example for each of them. **[*CBSE (F) 2015*]**

Ans. Refer to Basic Concepts Point 13 (*iii*), (i*v*) & (*vi*).

Q. 23. Differentiate between commensalism and mutualism by taking one example each from plants only. **[*CBSE (F) 2014*]**

Ans. **Table 13.7 Differences between commensalism and mutualism**

S. No.	Commensalism	Mutualism
(*i*)	It is an interspecific interaction in which one species is benefited and other is neither harmed nor benefited.	It is an interspecific interaction in which both the species (individuals) are mutually benefited.
(*ii*)	The two individuals may be physically associated.	The two individuals may be physically or physiologically associated.
(*iii*)	*E.g.*, Sucker fish and shark.	*E.g., Rhizobium* and the legume plants.

Q. 24. (*a*) Explain any two defence mechanisms plants have evolved against their predators.
(*b*) How does predation differ from parasitism? **[*CBSE (F) 2016*]**

Ans. (*a*) Plants have developed the following defence mechanisms:
(*i*) Thorns as means of defence.
(*ii*) Plants may produce chemicals such as nicotine, caffeine, quinine, strychnine, opium for defence.

(*b*) **Table 13.8 Differences between predation and parasitism**

S. No.	Predation	Parasitism
(*i*)	The predator only feeds on prey.	The parasite lives and feeds on the host.
(*ii*)	The predator is not prey specific.	The parasite is host specific.
(*iii*)	The predator keeps a check on prey population.	The parasite coevolves with the host.

Q. 25. Highlight the differences and a similarity between the following population interactions: Competition, predation and commensalism. ***[CBSE (F) 2017]***

Ans. **Table 13.9 Differences between competition, predation and commensalism**

S. No.	Competition	Predation	Commensalism
(*i*)	In this type of interaction both the species suffer.	In this type of interaction the predator kills and consumes the prey.	In this type of interaction one species is benefited and the other is neither harmed nor benefited.
(*ii*)	It occurs due to limited resources between closely related species.	It is the nature's way of transferring energy to higher trophic level.	It is not particularly for any gain of energy or resources.
(*iii*)	For example, In American lakes visiting flamingos and resident fish.	For example, tiger (predator) and deer (prey).	For example, sucker fish and shark.

Similarity: All these interactions leads to evolution as the fittest organism survives.

Q. 26. Highlight the differences between the population interactions given below. Given an example of each.

(*a*) Parasitism (*b*) Amensalism (*c*) Mutualism ***[CBSE (F) 2017]***

Ans. **Table 13.10 Differences between parasitism, amensalism and mutualism**

S. No.	Parasitism	Amensalism	Mutualism
(*i*)	In this interaction one species (parasite) depends on the other species (host) for food and shelter.	In this interaction one species is harmed and the other is neither benefited nor harmed.	In this interaction both the interacting species are benefited.
(*ii*)	The interacting species co-evolve.	No evolution is observed.	The interacting species co-evolve.
(*iii*)	For example, Cuscuta is commonly found growing on hedge plants.	For example, the mould Penicillium secretes penicillin which kills bacteria but the mould is unaffected.	For example, *Rhizobium* and the legume plants.

Q. 27. Interspecific interactions of two species of any population may be beneficial, detrimental or neutral. Explain each of them with the help of suitable examples. ***[CBSE Sample Paper 2014]***

Ans. **Population interactions:**

Species A	Species B	Name of interaction
+	+	Mutualism
–	–	Competition
+	–	Predation
+	–	Parasitism
+	0	Commensalism

(*i*) + = Beneficial; – Detrimental; 0 Neutral. Both species benefit in mutualism, *e.g.* lichens

(*ii*) Both species lose in competition, *e.g.* (detrimental)

(*iii*) In predation and parasitism the predator and the parasite gets benefit but it is detrimental to the other species (host and prey respectively)

(*iv*) In commensalism one species is benefitted but the other is neither harmed nor benefitted.

Long Answer Questions–II [5 marks]

Q. 1. **(*a*) List the different attributes that a population has and not an individual organism.**

(*b*) What is population density? Explain any three different ways the population density can be measured, with the help of an example each. **[*CBSE (AI) 2015*]**

Ans. (*a*) **Attributes of population**

Birth rate, death rate, sex ratio, age pyramids/age distribution. (*Any two*)

(*b*) **Population density:** Number of individuals per unit area at a given time/period

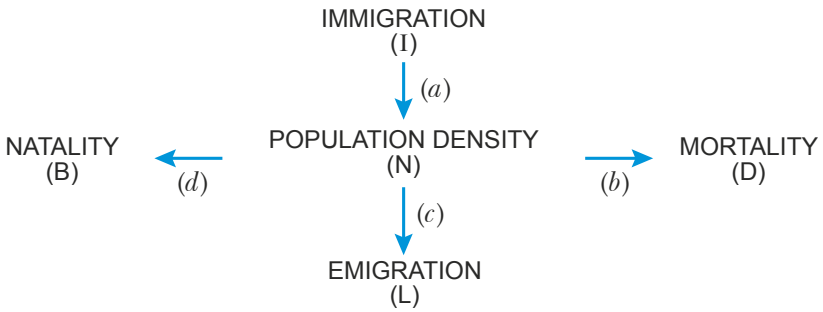
(*i*) **Biomass/%Cover,** *e.g.*, Hundred Parthenium plants and 1 huge banayan tree

(*ii*) **Relative Density,** *e.g.*, Number of fish caught per trap from a lake

(*iii*) **Numbers,** *e.g.*, Human population

(*iv*) **Indirect estimation,** *e.g.*, without actually counting/seeing them, *e.g.*, tiger census based on pug marks and faecal pellets. (*Any three*)

Q. 2.



(*a*) Which of the above represents the increase or decrease of population?

(*b*) If N is the population density at time t, then what would be its density at time (t+1)? Give the formula.

(*c*) In a barn there were 30 rats. 5 more rats enter the barn and 6 out of the total rats were eaten by the cats. If 8 rats were born during the time period under consideration and 7 rats left the barn, find out the resultant population at time (t+1).

(*d*) If a new habitat is just being colonized, out of the four factors affecting the population growth, which factor contributes the most? **[*CBSE Sample Paper 2016*]**

Ans. (*a*) *a* and *d* represents increase of population and *b* and *c* represent decrease of population.

(*b*) $N_{t+1} = N_t + [(B + I) - (D + E)]$

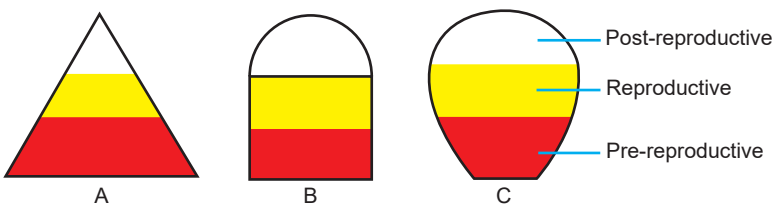
(*c*) Here, $N_t = 30$; I = 5; E = 7 ; D = 6; B = 8

Putting the value in $N_{t+1} = N_t + [(B + I) - (D + E)]$

$$N_{t+1} = 30 + [(8 + 5) - (6 + 7)]$$
$$= 30 + [13 - 13]$$
$$= 30 + 0$$
$$= 30 \text{ rats}$$

(*d*) Immigration contributes the most.

Q. 3. **The following diagrams are the age pyramids of different populations. Comment on the status of these populations.** **[*NCERT Exemplar*] [*HOTS*]**

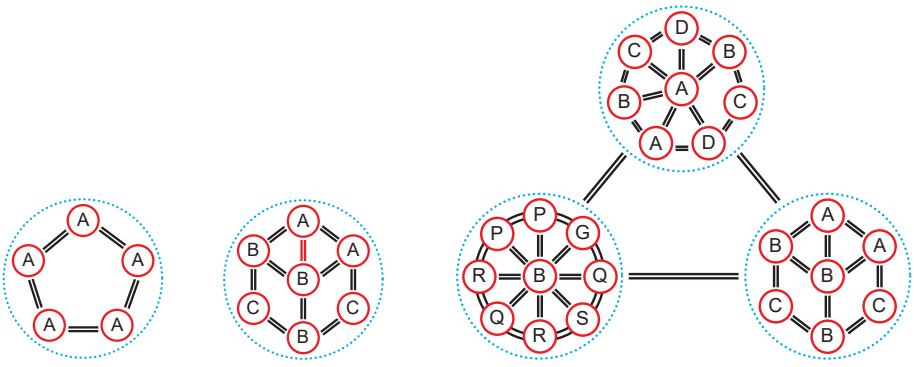


Ans. **Fig. A:** It is a 'pyramid' shaped age pyramid. In this figure, the base, *i.e.*, pre-reproductive stage is very large as compared with the reproductive and post-reproductive stages of the population. This type of age structure indicate that the population would increase rapidly.

Fig. B: It is an 'inverted bell' shaped pyramid. In this figure, the pre-reproductive and reproductive stages are same. This type of age structure indicates that the population is stable.

Fig. C: It is 'urn' shaped pyramid. In this figure, the pre-reproductive and reproductive stages are less than the post-reproductive stage of this population. In this population more older people are present. This type of age structure indicates that the population definitely is declining.

Q. 4. Comment on the following diagrams:
A, B, C, D, G, P, Q, R, S are species. **[*NCERT Exemplar*] [*HOTS*]**



I **II** **III**

Ans. **Fig. I:** It is a single population and all individuals are of the same species, *i.e.*, A individuals interact among themselves and their environment.

Fig. II: It is a community and it contains three populations of species A, B and C. They interact with each other and their environment.

Fig. III: It is a biome. It contains three communities of which one is in climax and other two are in different stage of development. All three communities are in the same environment and they interact with each other and their environment.

Q. 5. (*a*) Following are the responses of different animals to various abiotic factors. Describe each one with the help of an example.
(*i*) Regulate **(*ii*) Conform**
(*iii*) Migrate **(*iv*) Suspend**
(*b*) If 8 individuals in a population of 80 butterflies die in a week, calculate the death rate of population of butterflies during that period.

Ans. (*a*) Refer to Basic Concepts Point 7.

(*b*) $\text{Death rate} = \frac{\text{Number of individuals dead}}{\text{Total population}}$

$= \frac{8}{80} = 0.1$ individuals per butterfly per week

Q. 6. (*a*) Explain giving reasons why the tourists visiting Rohtang Pass or Mansarovar are advised to resume normal 'active life' only after a few days of reaching there.
(*b*) It is impossible to find small animals in the polar regions. Give reasons. **[*CBSE (AI) 2012*]**

Ans. (*a*) Initially the person suffers from altitude sickness/nausea, fatigue and heart palpitation because of low oxygen availability and low atmospheric pressure. Gradually the body increases RBC production, decreasing binding capacity of Hb and increases the breathing rate to get acclimatised.

(*b*) Small animals have larger surface area relative to their volume, so they lose heat much faster, & have to spend more energy to generate body heat.

Q. 7. (*a*) List any three parameters used by ecologists under different situations to measure the population size in a habitat.

(*b*) Mention what do the following stand for in the equation given below:

(*i*) N_{t+1}, (*ii*) B and (*iii*) E.

$$N_{t+1} = N_0 + [(B + I) - (D + E)]$$

Give an explanation for the above equation.

Ans. Refer to Basic Concepts Point 10.

Q. 8. Draw and explain a logistic curve for a population of density (N) at time (t) whose intrinsic rate of natural increase is (r) and carrying capacity is (K).

Ans. Refer to Basic Concepts Point 11(*ii*)

For diagram refer to Fig. 13.4.

Q. 9. (*a*) Explain with the help of a graph the population growth curve when resources are

(*i*) limiting and (*ii*) not limiting.

(*b*) "Nature has a carrying capacity for a species." Explain. ***[CBSE (F) 2010]***

Ans. (*a*) Refer to Basic Concepts Point 11, for graph refer to Fig. 13.4.

(*b*) (*i*) The resources become limited at certain point of time, so no population can grow exponentially.

(*ii*) Every ecosystem or environment or habitat has limited resources to support a particular maximum number of individuals called its carrying capacity (K).

Q. 10. (*a*) Name the two growth models that represent population growth and draw the respective growth curves they represent.

(*b*) State the basis for the difference in the shape of these curves.

(*c*) Which one of the curves represent the human population growth at present? Do you think such a curve is sustainable? Give reason in support of your answer. ***[CBSE (AI) 2016]***

Ans. (*a*) Exponential growth curve and logistics growth curve

For graph refer to Fig. 13.4.

(*b*) The difference in the shape of the curve is due to the amount of resources available for the given population. When resources are unlimited, each species realises its innate potential to grow in number and result in a J-shaped curve in exponential growth while in logistics growth no population has unlimited resources leading to competition for resources and show S-shaped curve.

(*c*) Logistic growth represents human population growth at present. Such a curve is not sustainable because with growing population natural resources are getting depleted and its availability is not increasing enough.

Q. 11. (*a*) Represent diagrammatically three kinds of age-pyramids for human populations.

(*b*) How does an age pyramid for human population at given point of time helps the policy-makers in planning for future. ***[CBSE Delhi 2016]***

Ans. (*a*) Refer to Fig. 13.3.

(*b*) Age pyramid helps in planning the healthcare programmes, the education policies and the infrastructure of the area Analysis of age pyramid of a population can give the correct information about the status of the people in the area and their requirements.

Q. 12. "Analysis of age-pyramids for human population can provide important inputs for long-term planning strategies." Explain. ***[CBSE Delhi 2015]*** ***[HOTS]***

Ans. Refer to Basic Concepts Point 9 (last 4 points) and Figure 13.3.

Through analysis of the age pyramids of a population proper planing of health, education, transport, infra-structure, finance, food and employment can be done.

Thus, long-term management of resources can be done so that maximum benefits can be provided to the population.

Q. 13. (*a*) Why are herbivores considered similar to predators in the ecological context? Explain.

(*b*) Differentiate between the following interspecific interactions in a population:

(*i*) Mutualism and Competition (*ii*) Commensalism and Amensalism [*CBSE (AI) 2010*]

Ans. (*a*) Herbivores are animals feeding on plants. Although they are classed differently they are considered predators. Like predators, for transfer of energy across trophic levels, herbivores also do the same. Besides this, they also keep the population of their prey under control. For example, when the prickly pear cactus was introduced in Australia in early 1920s, they spread rapidly, causing havoc. Their population was controlled by introducing cactus-feeding predator (a moth).

(*b*) (*i*)

Table 13.11: Differences between mutualism and competition

S.No.	Mutualism	Competition
(*i*)	This interaction benefits both the interacting species.	In this interaction, both the interacting species suffer negatively.
(*ii*)	The two individuals may be physically or physiologically associated.	There is no physical association between the competitors.
(*iii*)	*E.g.*, Lichens represent mutualism between fungus and algae where fungus absorbs nutrition and provides protection, and algae prepares food.	*E.g.*, In some American Lakes, visiting flamingoes and resident species compete for their common food.

(*ii*) Commensalism and ammensalism

Refer to Basic concept 13 (*iv*) and 13 (*v*)

Self-Assessment Test

Time allowed: 1 Hour **Max. marks: 30**

1. Choose and write the correct option in the following questions. **(3×1 = 3)**

(i) Autecology is the

(a) relation of heterogenous populations to its environment

(b) relation of an individual to its environment

(c) relation of a community to its environment

(d) relation of a biome to its environment

(ii) Ecotone is

(a) a polluted area

(b) the bottom of a lake

(c) a zone of transition between two communities

(d) a zone of developing community

(iii) An ecologist would suspect that a population is growing rapidly if it

(a) contains many more pre-reproductive than reproductive individuals.

(b) is near its carrying capacity.

(c) is limited only by density-dependent factors.

(d) shows a clumped pattern of dispersion

2. In the following questions a statement of assertion followed by a statement of reason is given. Choose the correct answer out of the following choices. **(3×1 = 3)**

(a) Assertion and reason both are correct statements and reason is correct explanation for assertion.

(b) Assertion and reason both are correct statements but reason is not correct explanation for assertion.

(c) Assertion is correct statement but reason is wrong statement.

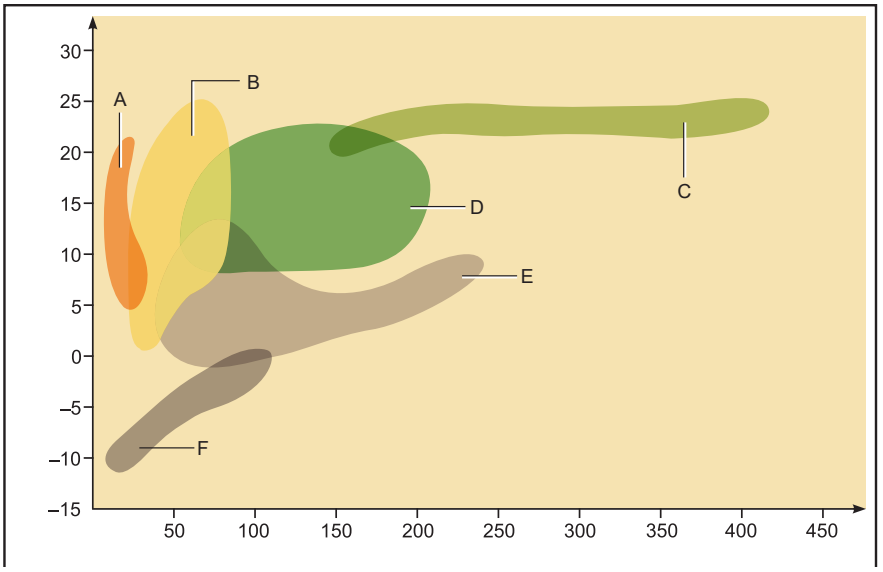
(d) Assertion is wrong statement but reason is correct statement.

(i) **Assertion :** Logistic growth model is more realistic in nature.
Reason : No population growth can sustain indefinitely due to finite resources.

(ii) **Assertion :** Ectoparasites line inside the host's body at different sites.
Reason : Parasites are host specific and both parasite and host co-evolve.

(iii) **Assertion :** Euryhaline organisms can tolerate a wide range of salinity.
Reason : Fresh water animals will not survive in marine water due to osmotic problems.

3. Define carrying capacity. **(1)**
4. What is Allen's rule? **(1)**
5. Explain why very small animals are rarely found in polar region. **(2)**
6. Name the interaction in each of the following:
   (i) Clown fish living among the tentacles of sea anemone.
   (ii) Sucker fish lives attached to the shark.
   (iii) Smaller barnacles disappeared when *Balanus* dominated in the coast of Scotland.
   (iv) Wasp pollinating fig inflorescence. **(2)**
7. How does Monarch butterfly defend itself from predators? Explain. **(2)**
8. How does the human body maintains constant temperature both in summers and winters? Explain. **(2)**
9. Distinguish between hibernation and aestivation. Give one example of each. **(3)**
10. The graph given below shows the distribution of biomes: **(3 × 1 = 3)**



   (i) What do the 'X' and 'Y' axes represent?
   (ii) Identify the 'grassland' and 'coniferous forest' biomes, from the above figure.
   (iii) Why is 'F' located at the given position in the graph?
11. How does mutualism differ from commensalism? Give one example of each. **(3)**
12. (i) What is an age-pyramid?
   (ii) Name three representative kinds of age-pyramids for human population and list the characteristics for each one of them. **(5)**

Answers

1. (*i*)—(*b*), (*ii*)—(*c*), (*iii*)—(*a*) **2.** (*i*)—(*a*), (*ii*)—(*d*), (*iii*)—(*b*)

Chapter–14

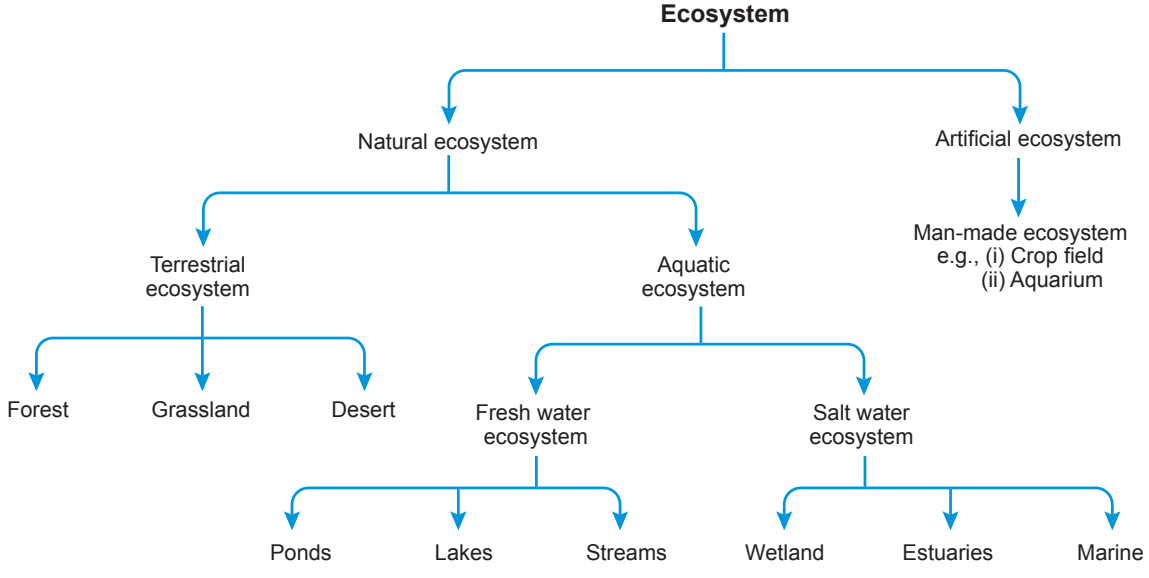
Ecosystem

basic concepts

1. Ecosystem

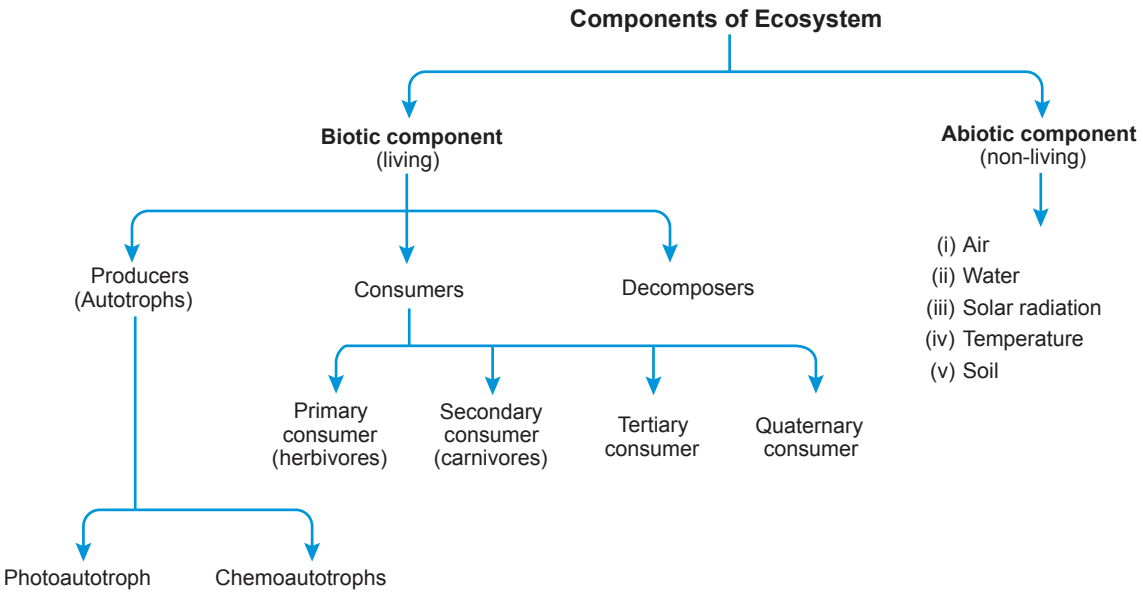
- The term ecosystem was coined by **Sir A.G. Tansley** (1935).
- An ecosystem is the basic functional ecological unit in which living organisms interact among themselves and with their surrounding physical environment.
- The size of the ecosystem varies from small pond to a large forest or sea.

2. Classification of Ecosystem



3. Ecosystem Structure and Function

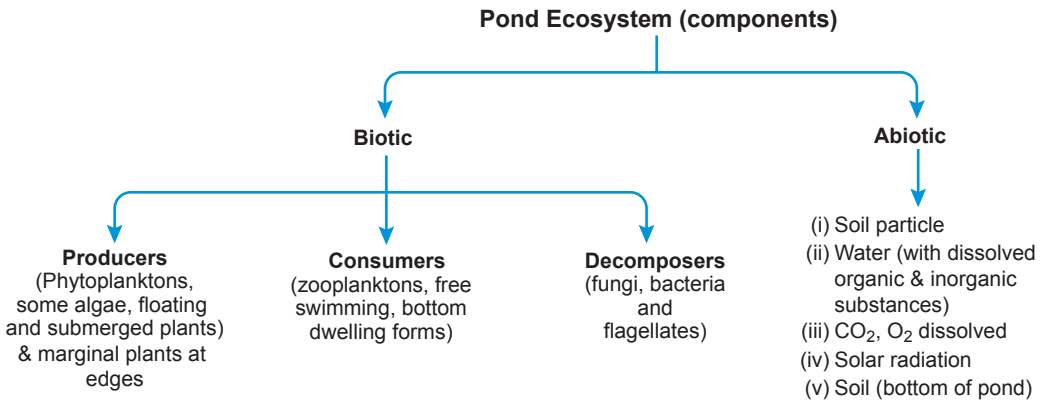
- The ecosystem consists of biotic and abiotic components and their interaction with each other resulting in a physical structure.
- The flow of energy takes place within these components of the ecosystem.
- The identification and enumeration of plant and animal species in an ecosystem gives it species composition.



- Vertical distribution of different species occupying different levels is called **stratification**, *e.g.*, in a forest ecosystem, trees occupy top vertical strata or layer, shrubs the second, and herbs and grasses occupy the bottom layers.
- The major functions of an ecosystem include
  (*i*) Productivity (*ii*) Decomposition
  (*iii*) Energy flow (*iv*) Nutrient cycling

4. Pond Ecosystem

- It is a self-sustainable unit. A pond is a shallow water body with all the biotic and abiotic components.



- The inorganic and organic materials are conversed with the help of the radiant energy of sun by the autotrophs.
- Heterotrophs consume autotrophs.
- Decomposers decompose the dead organic matter to release minerals back for reuse by the autotrophs.
- The matter and minerals are recycled between biotic and abiotic components.
- The energy flow is unidirectional.
- Solar input, cycle of temperature, day length and other climatic conditions regulate rate of function of entire pond.

5. Productivity

- The rate of biomass or organic matter production per unit area, over a time period, by plant during photosynthesis is called **productivity**.
- It is expressed in kcal m^{-2} yr^{-1} or $g/m^2/yr$ or g m^{-2} y^{-1}.
- The amount of biomass or organic matter produced per unit area over a time period in plants during photosynthesis is called **primary production**. It is expressed in terms of weight (g m^{-2}) or energy (kcal m^{-2}).
- The rate of formation of new organic matter by consumers is called **secondary productivity**.

Aspects of Primary Productivity

Primary Productivity

Gross Primary Productivity (GPP)

- It is the rate of production of organic matter during photosynthesis in an ecosystem.
- Some of GPP is utilised by plants for respiration and some is passed to the next trophic level.

Net Primary Productivity (NPP)

- It is the available biomass for the consumption of heterotrophs.
- It is the weight of the organic matter stored by the producers in a unit area/volume per unit time. It is given by

  NPP = GPP – R

  where R = Respiration losses
- NPP is utilised by heterotrophs (herbivores & decomposers)

6. Factors Affecting Primary Productivity

- Plant species inhabiting a particular area.
- **Environmental factors:**
  - (*i*) **Sunlight:** The sunlight directly regulates the primary productivity because the plants perform photosynthesis with the help of sunlight. As tropical region receives maximum sunlight so it exhibits higher productivity.
  - (*ii*) **Temperature:** Temperature regulates the activity of enzyme. So, optimum temperature is required for proper functioning of enzyme.
  - (*iii*) **Moisture:** Rain (humidity) is required for higher primary productivity. Deserts have the lowest primary productivity as the soil is deficient in moisture.
- **Availability of nutrients:** Greater nutrients ensure greater primary productivity.
- **Photosynthetic efficiency:** Some plants have more efficiency to trap sunlight (sugarcane), so they accumulate more primary productivity.
- Annual Net Primary Productivity of whole biosphere is approx. 170 billion tons (dry weight) of organic matter. Of this, oceans occupy 70% of surface, productivity of oceans are only 55 billion tons. Rest if from land.

7. Decomposition

- The process of breaking down complex organic matter into inorganic substances like CO_2, water and nutrients is called **decomposition**.
- The raw materials for decomposition including dead plant remains like leaves, bark, flowers, and animal remains and their faecal matter are called **detritus**.

Steps in Decomposition

(*i*) **Fragmentation:** The process of breaking down of detritus into smaller particles is called fragmentation, *e.g.*, as done by earthworm (= farmer's friend).

(*ii*) **Leaching:** The process by which water-soluble inorganic nutrients go down into the soil horizon and get precipitated as unavailable salts is called leaching.

(*iii*) **Catabolism:** The enzymatic process by which bacterial and fungal enzymes degrade detritus to simpler inorganic substances is called catabolism.

(*iv*) **Humification:** The process of accumulation of a dark coloured amorphous substance, called **humus**, that is highly resistant to microbial action and undergoes decomposition at an extremely slow rate is called humification. Humus being colloidal is reservoir of nutrients.

(*v*) **Mineralisation:** The process by which humus is further degraded by some microbes to release inorganic nutrients is called mineralisation.

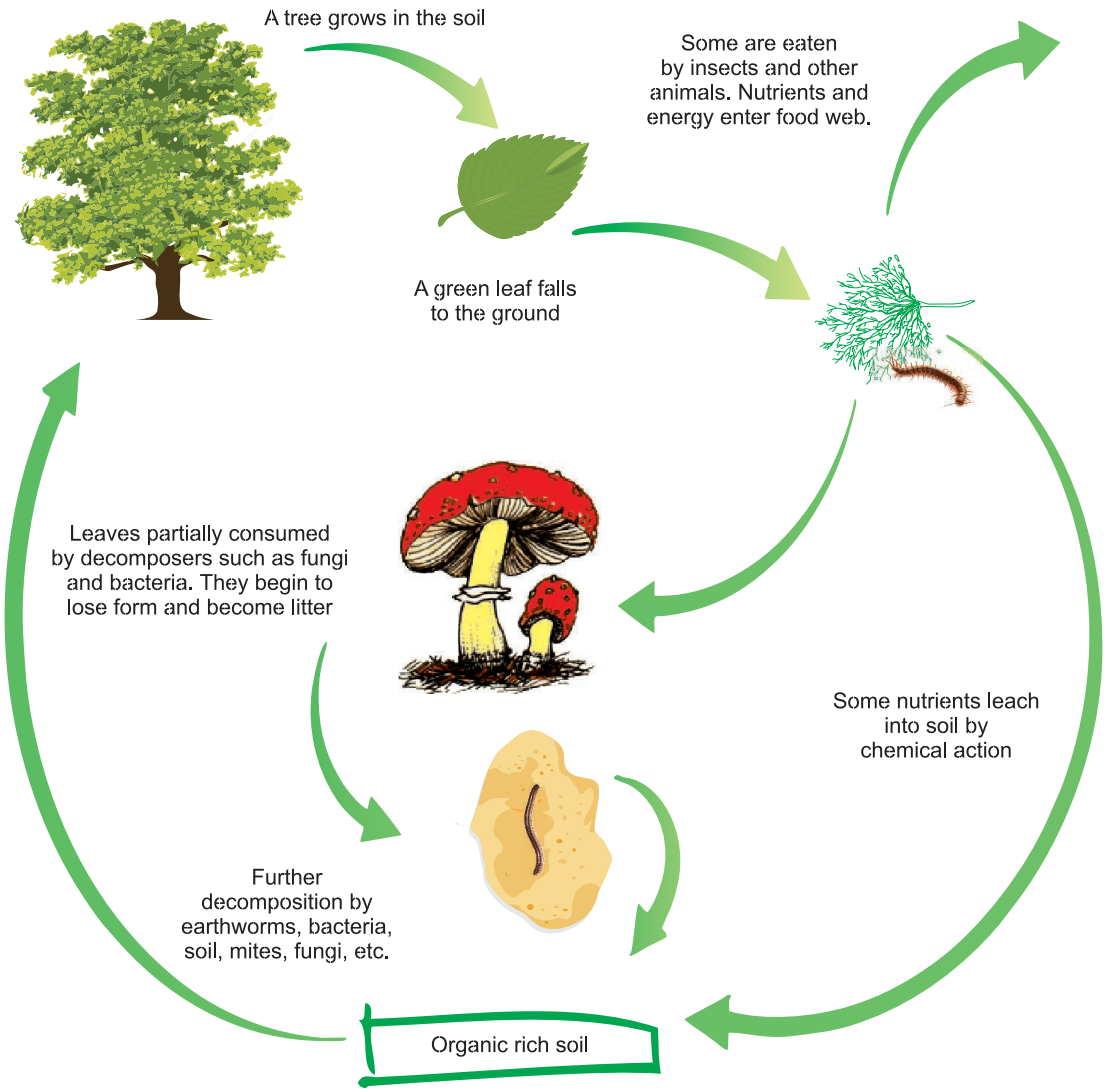


Fig. 14.1 Diagrammatic representation of decomposition cycle in a terrestrial ecosystem

8. Factors Affecting Decomposition

(i) Chemical composition of detritus

- The decomposition rate is slow if detritus is rich in lignin and chitin.
- The decomposition rate is higher when detritus is rich in nitrogen and water-soluble substances like sugars.

(ii) Climatic factors

- Warm and moist environment favours decomposition.
- Low temperature and anaerobiosis inhibit decomposition.

Table 14.1: Differences between food chain and food web

S. No.	Food chain	Food web
(*i*)	The transfer of energy from producers to top consumers through a series of organisms is called food chain.	A number of food chains are inter-connected with each other, forming a web-like pattern is called food web.
(*ii*)	One organism holds only one position.	One organism can hold more than one position.
(*iii*)	The flow of energy can be easily calculated.	The flow of energy is very difficult to calculate.
(*iv*)	It is always straight and proceed in a progressive straight line.	Instead of straight line it is a series of branching lines.
(*v*)	Competition is limited to members of same trophic level.	Competition is amongst members of same and different trophic levels.

9. Types of Food Chains

- Two types of food chains can be observed in the ecosystem:

  (*i*) Grazing Food Chain (GFC), *e.g.*,

  (1) Grass ⟶ Rabbit ⟶ Lion

  (2) Grass ⟶ Goat ⟶ Man

  (Producer) (Pr. Consumer) (Sec. Consumer)

  (*ii*) Detritus Food Chain (DFC), *e.g.*, Dead leaves ⟶ Woodlouse ⟶ Blackbird

- In an aquatic ecosystem, GFC is the major conduit for energy flow.
- In terrestrial ecosystem, DFC may be connected with GFC at some levels. Some of the organisms of DFC are prey to GFC animals in a natural ecosystem. Some animals like cockroaches, crows, etc. are omnivores.

Table 14.2: Differences between grazing food chain (GFC) and detritus food chain (DFC)

S. No.	Grazing food chain (GFC)	Detritus food chain (DFC)
(*i*)	It starts with green plants called producers as first trophic level.	It begins with dead organic matter and decomposers called saprophytes as first trophic level. Decomposers secrete digestive enzymes that breakdown dead and waste into simple, inorganic materials which are absorbed by them.
(*ii*)	A much less fraction of energy flows through this type of food chain.	A much large fraction of energy flows through this type of food chain.
(*iii*)	Energy for food chain comes from sun.	Energy for the food chain comes from organic remain or detritus.

10. Trophic Level

- In an ecosystem, an organism occupies a specific place in the food chain called **trophic level**.
- Each trophic level has a certain mass of living material at a particular time called the **standing crop**.
- The standing crop is measured as the biomass of living organisms (biomass), or the number in a unit area. Biomass is expressed interms of fresh or dry weight.

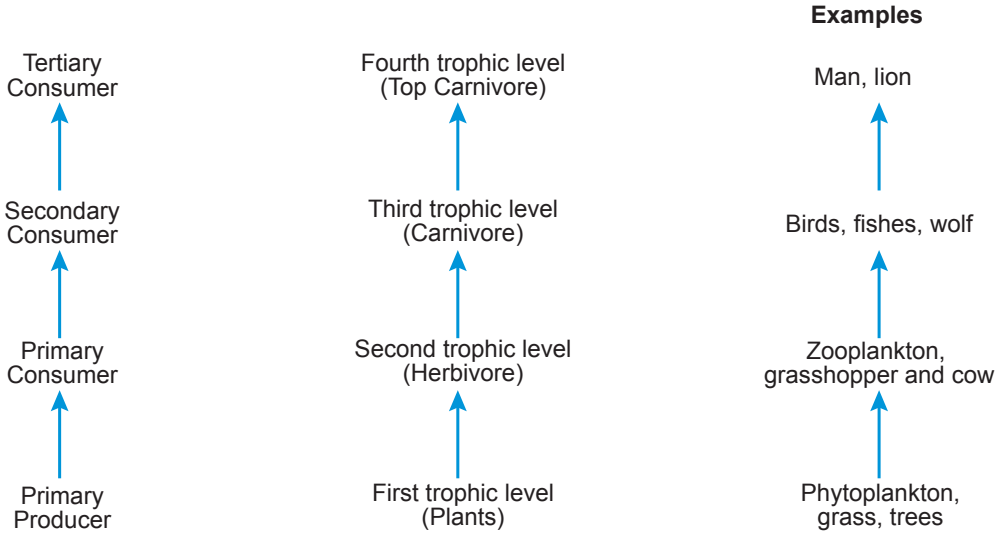


Fig. 14.2 Diagrammatic representation of trophic levels in an ecosystem

11. Energy Flow

- The sun is the only source of energy for all ecosystems on earth.
- Out of the total incident solar radiation, only 50 per cent of it is **photosynthetically active radiation (PAR)**.
- Plants capture only 2–10 per cent of the PAR and this small amount of energy sustains the entire living world. So, there is unidirectional flow of energy from the sun to producers and then to consumers.

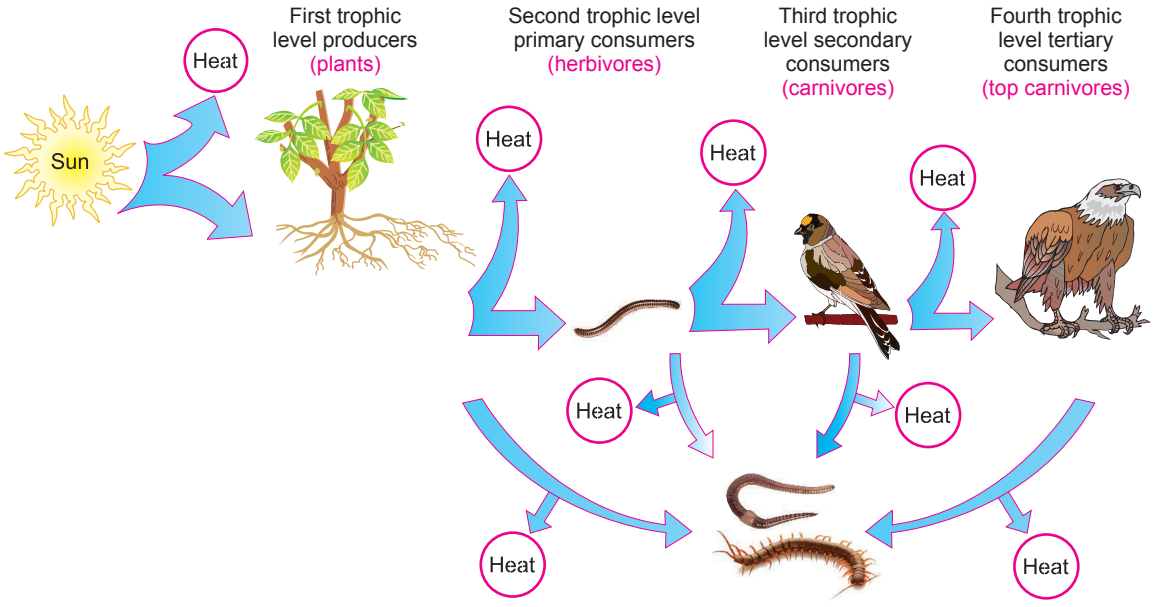


Fig. 14.3 Energy flow through different trophic levels

- The energy is transferred in an ecosystem, in the form of food which is degraded and lose major part of food energy as heat during metabolic activities and only a very small fraction becomes stored as biomass.
- This is correlated to second law of thermodynamics, *i.e.*, ecosystems need a constant supply of energy to synthesize molecules they require, to counteract universal tendency towards increasing disorderliness.
- The green plants in the ecosystem which can trap solar energy to convert it into chemical bond energy are called **producers**.
- All the animals that depend for food on plants are called **consumers** or **heterotrophs**.
- Consumers are divided into the following categories:
  - (*i*) **Primary consumers:** Animals which feed directly on plants, *i.e.*, herbivores.
  - (*ii*) **Secondary consumers:** Consumers that feed on primary consumers, *i.e.*, carnivores.
  - (*iii*) **Tertiary consumers:** Consumers that feed on secondary consumers.
- **Lindeman's 10 per cent law:** At each step of food chain, when food energy is transferred from one trophic level to the next higher trophic level, only about 10 per cent of energy is passed on to the next trophic level. This is known as Lindeman's 10 per cent law given by Lindeman in 1942.

12. Ecological Pyramid

- The relationship between producers and consumers at different trophic levels in an ecosystem can be graphically represented in the form of a pyramid called **ecological pyramid**.
- **Structure:** The base always represents the producers or the first trophic level and the apex represents top level consumer or the last trophic level.
- Ecological pyramids are of three types:
  (*i*) Pyramid of number (*ii*) Pyramid of biomass
  (*iii*) Pyramid of energy
  - (*i*) **Pyramid of number:** The relationship between producers and consumers in an ecosystem can be represented in the form of a pyramid in terms of number of organisms at different trophic levels called pyramid of number.

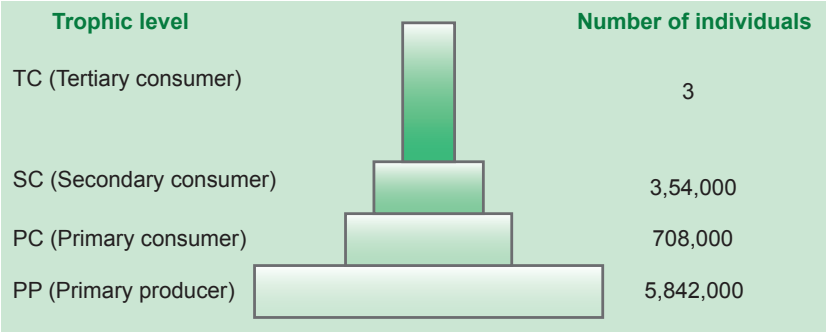


Fig. 14.4 Pyramid of numbers in a grassland ecosystem

It is inverted, when you count number of insects feeding on a big tree.

- (*ii*) **Pyramid of biomass:** The relationship between producers and consumers in an ecosystem can be represented in the form of a pyramid in terms of biomass called pyramid of biomass. It can be
  (*a*) Upright, *e.g.*, in case of grassland ecosystem; or
  (*b*) Inverted, *e.g.*, in case of pond ecosystem as biomass of fishes for exceeds that of phytoplanktons.

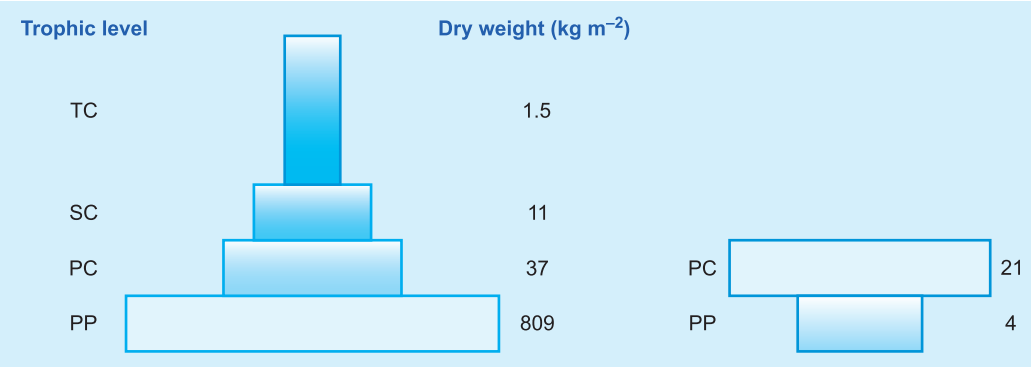


Fig. 14.5 Pyramid of biomass shows a sharp decrease in biomass at higher trophic levels

Fig. 14.6 Inverted pyramid of biomass: Small standing crop of phytoplankton supports large standing crop of zooplankton

(*iii*) **Pyramid of energy:** The relationship between producers and consumers in an ecosystem can be represented in the form of a pyramid, in terms of flow of energy called pyramid of energy. It is always upright because energy is always lost as heat at each step and as it follow 10% law.

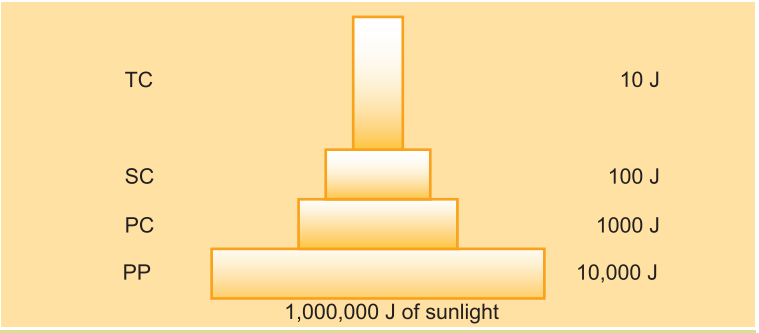


Fig. 14.7 An ideal pyramid of energy

- **Limitations of ecological pyramids:**
  - (*i*) It never takes into account the same species belonging to two or more trophic levels.
  - (*ii*) It assumes a simple food chain, which never exists in nature. It does not accommodate a food web.
  - (*iii*) In spite of the vital role played by saprophytes/decomposers, they are not given any position in ecological pyramids.

13. Ecological Succession

- The sequential, gradual and predictable changes in the species composition in an area are called succession or **ecological succession**.
- It mainly focuses on changes in vegetation that in turn affect types of animals.
- The entire sequence of communities that successively changes in a given area are called sere(s).
- The individual transitional communities are termed as seral stages or **seral communities**.
- The community that is in near equilibrium with the environment is called a **climax community**.
- The species that invade a bare area are called **pioneer species**.
- The changes that occur in successive seral stages to reach a climax community are:
  - (*i*) changes in the diversity of species of organisms.
  - (*ii*) increase in the total biomass.
  - (*iii*) increase in the number of species and organisms.

- Ecological succession is of two types:
  - (*i*) **Primary succession:** It begins in areas where no living organisms ever existed. Therefore, the establishment of a biotic community is very slow, *e.g.*, newly cooled lava, bare rock, newly created pond or reservoir. It takes natural processes several hundred to thousand years to produce fertile soil on bare rock.
  - (*ii*) **Secondary succession:** It begins in areas where natural biotic communities have been destroyed, *e.g.*, abandoned farm lands, buried or cut forests. Since soil is available, it is a faster process. The species that invade depend on the condition of soil, available of water, environment and seeds or other propagules present.

14. Succession of Plants

- The plant succession is of two types:
  - (*i*) **Hydrarch succession:** The plant succession which takes place in wet area or water, leading to successional series, progress from hydric to the mesic conditions.
  - (*ii*) **Xerarch succession:** The plant succession which takes place in a dry area, leading to successional series from xeric to mesic conditions.

(i) Primary succession in water

- The pioneer species are phytoplanktons.
- The phytoplanktons are replaced by free-floating angiosperms.

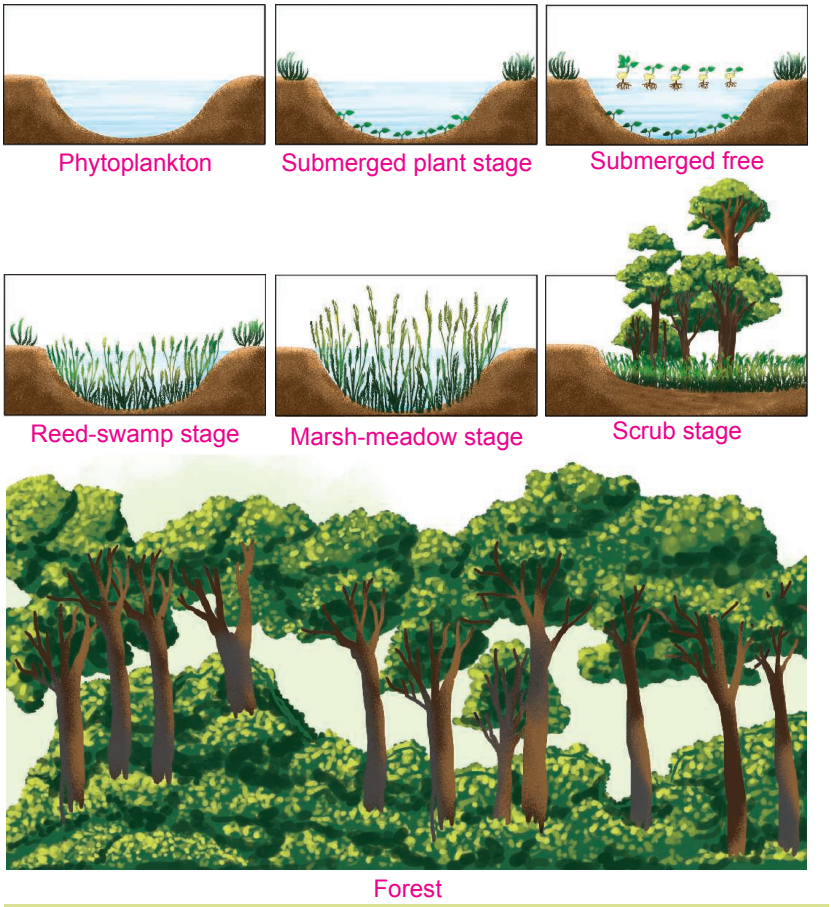


Fig. 14.8 Diagrammatic representation of primary succession

- Then, rooted angiosperms invade sedges, grasses and finally the trees.
- At last, a stable climax forest is formed.
- An aquatic habitat is converted into mesic habitat.

(ii) Primary succession on rocks

- Lichens are the pioneer species on a bare area.
- The lichen secretes some acids to dissolve rock and help in weathering and soil formation.
- Later, some small bryophytes invade and hold the small amount of soil.
- The bryophytes are succeeded by herbs, shrubs and ultimately big trees.
- At last, a stable climax forest is formed.
- The xerophytic habitat gets converted into a mesophytic one.

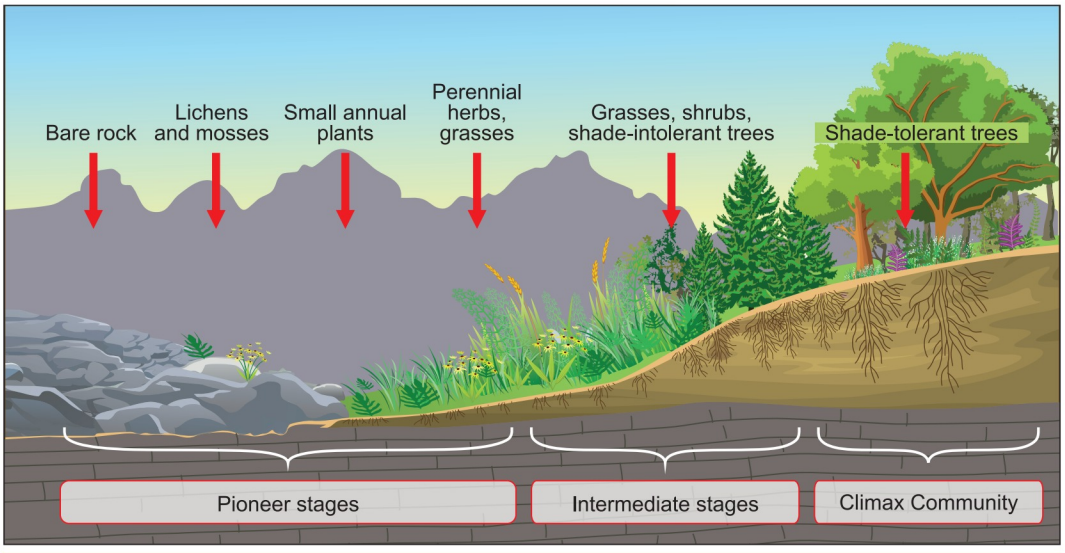


Fig. 14.9 Biotic succession on a bare rock

15. Nutrient Cycle

- The movement of nutrient elements through various components (abiotic + biotic) of an ecosystem is called **nutrient cycling** or **biogeochemical cycle**.
- The total amount of nutrients like carbon, phosphorus, calcium, etc., present in soil at any time is called **standing state**.
- Standing state varies with the kind of ecosystem and season.
- The nutrient reservoir meets the deficit arising due to imbalance in the rate of influx and efflux.
- Soil, moisture, PH, temperature regulate the rate of release of nutrients into the atmosphere.
- The nutrient cycles are of two types:
  (*i*) Gaseous cycle
  (*ii*) Sedimentary cycle.

Table 14.3: Differences between gaseous cycle and sedimentary cycle

S. No.	Gaseous cycle	Sedimentary cycle
(*i*)	The reservoir is the atmosphere.	The reservoir is the earth crust.
(*ii*)	The nutrient occurs as gas or vapour.	The nutrient is non-gaseous.
(*iii*)	It is comparatively quick or fast.	It is quite slow.
(*iv*)	For example, carbon cycle, nitrogen cycle.	For example, phosphorus cycle, sulphur cycle.

16. Carbon Cycle

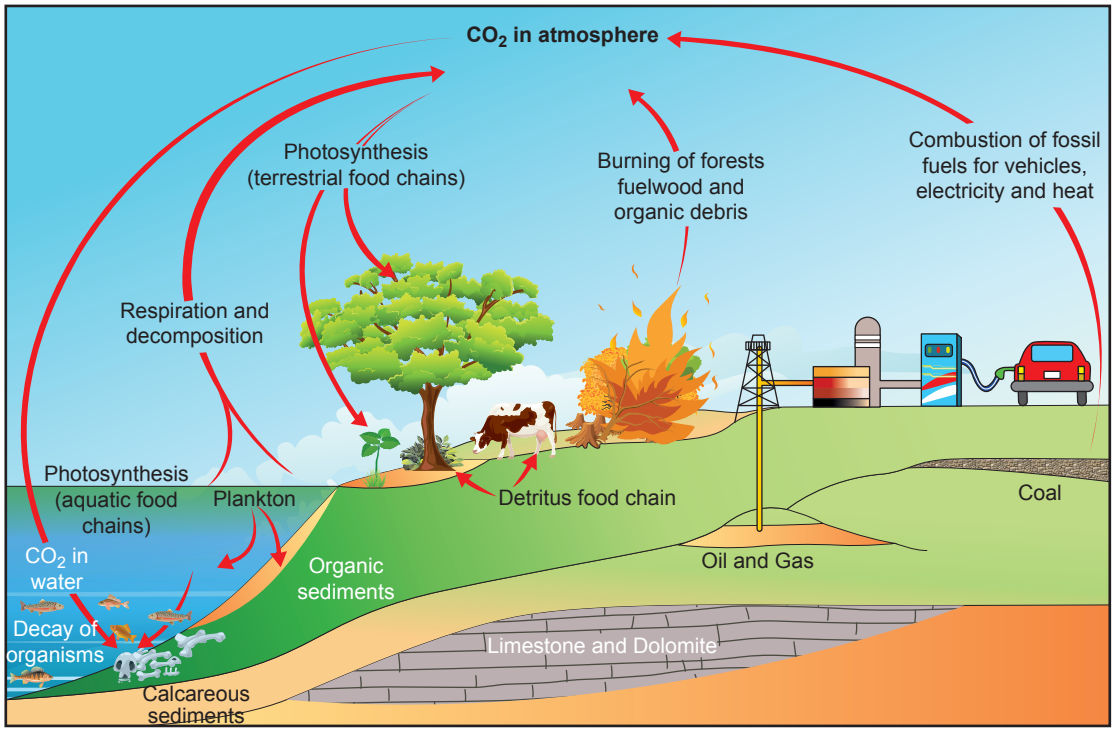


Fig. 14.10 Simplified model of carbon cycle in the biosphere

- Carbon constitutes 49 per cent of dry weight of an organism.
- 71 per cent of the carbon is found dissolved in oceans which is responsible for its regulation in atmosphere.
- The carbon cycle occurs through atmosphere, oceans and through living and dead organisms.
- It is estimated that 4×10^{13} kg of carbon is fixed in the biosphere through photosynthesis annually.
- Carbon is returned to atmosphere as CO_2 by animals and plants through respiration and the activities of decomposers.
- Some amount of fixed carbon is lost as sediments and removed from circulation.
- Burning of wood, forest fire, volcanic activity and combustion of organic matter and fossil fuels are some additional sources for releasing CO_2 in the atmosphere.
- Human activities like deforestation and vehicular burning of fossil fuels have caused an increase in the amount of CO_2 in atmosphere.

17. Phosphorus Cycle

- Importance of phosphorus:
  - (*i*) It is a major constituent of biological membranes, nucleic acids and cellular energy transfer systems.
  - (*ii*) It is required for making shells, bones and teeth.
- Rocks are the natural reservoirs of phosphorus.
- During weathering of rocks, minute amounts of these phosphates dissolve in soil solution and are absorbed by plants through roots.
- Herbivores and carnivores obtain this element from plants directly or indirectly.
- The waste products and the dead organisms are decomposed by phosphate-solubilising bacteria and in turn release phosphorus.

- Gaseous exchange of phosphorus between organisms and environment are negligible.

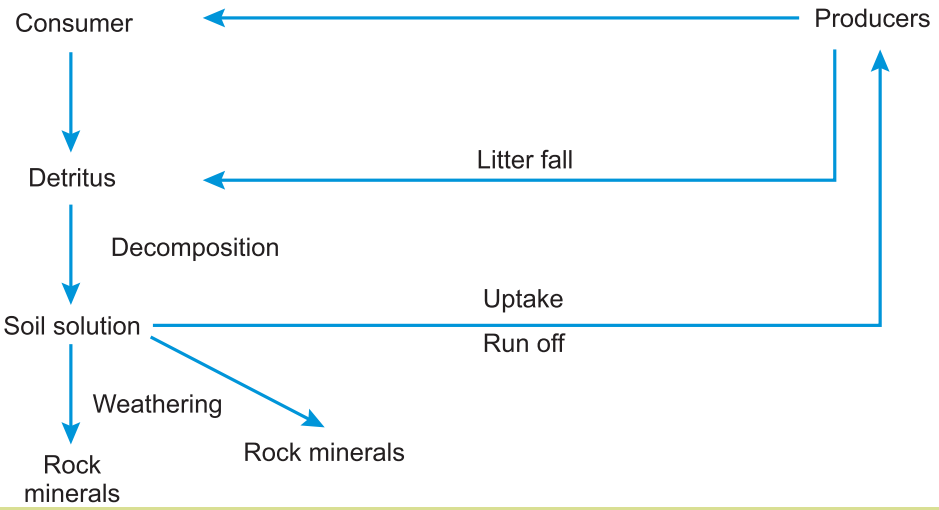


Fig. 14.11 A simplified model of phosphorus cycling in a terrestrial ecosystem

18. Ecosystem Services

- The products of ecosystem processes (economic, environmental and aesthetic) are called **ecosystem services**.
- Forests are the major source of ecosystem services. They
  (*i*) purify air and water, (*ii*) mitigate droughts and floods,
  (*iii*) cycle nutrients, (*iv*) generate fertile soils,
  (*v*) provide wildlife habitat, (*vi*) maintain biodiversity,
  (*vii*) pollinate crops, (*viii*) provide storage site for carbon,
  (*ix*) provide aesthetic, cultural and spiritual values.
- **Robert Constanza** and his colleagues tried to put price tags on nature's life-support services which came up to US$ 33 trillion a year which are taken for granted. This is nearly twice the value of the global gross national product, (GNP) which is US $18 trillion.
- Out of the total cost of various ecosystem services, the soil formation accounts for 50%; recreation and nutrient cycling contribute less than 10% each. Cost of climate regulation and wildlife habitat are about 6% each.

NCERT Textbook Questions

Q. 1. Fill in the blanks.

(*a*) Plants are called as _____ because they fix carbon dioxide.
(*b*) In an ecosystem dominated by trees, the pyramid (of numbers) is _____ type.
(*c*) In aquatic ecosystems, the limiting factor for the productivity is _____.
(*d*) Common detritivores in our ecosystem are _____.
(*e*) The major reservoir of carbon on earth is _____.

Ans. (*a*) producers (*b*) inverted
(*c*) light (*d*) earthworm, ants and mites.
(*e*) oceans (71% dissolved carbon)

Q. 2. Which one of the following has the largest population in a food chain?

(*a*) Producers (*b*) Primary consumers
(*c*) Secondary consumers (*d*) Decomposers

Ans. (*a*) Producers (decomposers can be maximum but they are excluded from the food chain).

Q. 3. The second trophic level in a lake is

(*a*) Phytoplankton (*b*) Zooplankton (*c*) Benthos (*d*) Fishes

Ans. (*b*) Zooplankton

Q. 4. Secondary producers are

(*a*) Herbivores (*b*) Producers (*c*) Carnivores (*d*) None of the above

Ans. (*b*) Herbivores

Q. 5. What is the percentage of photosynthetically active radiation (PAR), in the incident solar radiation?

(*a*) 100% (*b*) 50% (*c*) 1–5% (*d*) 2–10%

Ans. (*b*) 50%

Q. 6. Distinguish between

(*a*) Grazing food chain and detritus food chain
(*b*) Production and decomposition
(*c*) Litter and detritus
(*d*) Upright and inverted pyramid
(*e*) Food chain and food web
(*f*) Primary and secondary productivity

Ans. **(*a*) Grazing food chain and detritus food chain:** Refer to Basic Concepts Point 10.

(*b*)

Table 14.4: Differences between production and decomposition

S. No.	Production	Decomposition
(*i*)	It is the process of formation of fresh biomass from inorganic matter by producers (plants) using sunlight.	It is the process of degradation of waste biomass into its constituents by decomposers.
(*ii*)	It traps energy.	It releases energy.
(*iii*)	It needs sunlight.	It does not require sunlight.
(*iv*)	It is an anabolic process.	It is a catabolic process.

(*c*)

Table 14.5: Differences between litter and detritus

S. No.	Litter	Detritus
(*i*)	It is made of dried fallen plant matter.	It is freshly deposited organic matter, *i.e.*, remains of plants and animals.
(*ii*)	It is found above the ground.	It is found both above and below the ground.

(*d*)

Table 14.6: Differences between upright and inverted pyramid

S. No.	Upright pyramid	Inverted pyramid
(*i*)	The base bar comprises of producers in large number.	The base bar comprises producers in smallest number.
(*ii*)	The number of consumers decrease and become least in top consumer level.	The number of consumers increase and become largest in top consumer level.
(*iii*)	Pyramid of energy is always upright.	Pyramid of number and biomass may be inverted.

(*e*) Food chain and food web: Refer to Table 14.1.

(*f*)

Table 14.7: Differences between primary and secondary productivity

S. No.	Primary productivity	Secondary productivity
(*i*)	It is the rate at which organic matter is built up by producers.	It is the rate at which organic matter is built up by consumers.
(*ii*)	It is the result of synthesis of fresh organic matter from inorganic materials.	It is the result of synthesis of organic matter from plant organic matter.

Q. 7. Describe the components of an ecosystem.

Ans. An ecosystem consists of two types of components, *i.e.*, biotic or living and abiotic or non-living. There are three main types of biotic components on the basis of mode of obtaining their food—producers, consumers and decomposers.

(*i*) Producers (autotrophs): They are photosynthetic or autotrophic plants that synthesise their own organic food from inorganic raw materials with the help of solar radiations. Common producers are algae, plants and photosynthetic bacteria. Phytoplanktons are the producers of aquatic ecosystems.

(*ii*) Consumers (heterotrophs): They are animals which feed on other organisms or producers for obtaining their nourishment. Common consumers are deer, goat, etc.

(*iii*) Decomposers: They are saprotrophs which obtain nourishment from organic remains. They release digestive enzymes to digest the organic matter. Common decomposers are detritivores, *e.g.*, earthworm. Abiotic component of ecosystem consists of non-living substances and factors which are as follows:

(*a*) Temperature (*b*) Light
(*c*) Wind (*d*) Humidity
(*e*) Precipitation (*f*) Water, etc.

Q. 8. Define ecological pyramids and describe with examples, pyramids of number and biomass.

Ans. Refer to Basic Concepts Point 12.

Q. 9. What is primary productivity? Give brief description of factors that affect primary productivity.

Ans. Primary productivity is the rate of synthesis of biomass by producers, per unit time, per unit area through the process of photosynthesis.

For factors affecting primary productivity, refer to Basic Concepts Point 6.

Q. 10. Define decomposition and describe the process and products of decomposition.

Ans. Refer to Basic Concepts Point 7.

Decomposition produces a dark coloured nutrient rich substance called humus which on degradation releases CO_2, water and other nutrients in the soil.

Q. 11. Give an account of energy flow in an ecosystem.

Ans. Refer to Basic Concepts Point 11.

Q. 12. Write important features of a sedimentary cycle in an ecosystem.

Ans. Sedimentary cycle is circulation of non-gaseous biogeochemical nutrients between abiotic and biotic components of ecosystem with reservoir pool being lithosphere or sediments of earth.

Important features of a sedimentary cycle in an ecosystem are:

(*i*) Input: Weathering of rocks, industrial processing and mining adds the nutrient to the cycling pool.

(*ii*) Internal cycling: Nutrients contained in the cycling pool are picked up by producers and the process is called uptake. Organic matter with nutrients is then passed to the next trophic levels. Wastes and dead remains of organisms give rise to detritus which undergoes decomposition.

(*iii*) Output: It is the loss of nutrients from cycling pool. It occurs through soil erosion, run-off water, etc.

Q. 13. Outline salient features of carbon cycling in an ecosystem.

Ans. Refer to Basic Concepts Point 16.

Multiple Choice Questions [1mark]

Choose and write the correct option in the following questions.

1. Mass of living matter at a trophic level in an area at any time is called
(*a*) standing crop (*b*) detritus (*c*) humus (*d*) standing state

2. Which one of the following is not a gaseous biogeochemical cycle in ecosystem?
(*a*) Oxygen cycle (*b*) Phosphorus cycle (*c*) Nitrogen cycle (*d*) Carbon cycle

3. Identify the possible link "A" in the following food chain.
Plant → insect → frog → "A" → eagle
(*a*) rabbit (*b*) wolf (*c*) cobra (*d*) parrot

4. Which one of the following is not a functional unit of an ecosystem?
(*a*) Energy flow (*b*) Decomposition (*c*) Productivity (*d*) Stratification

5. The upright pyramid of number is absent in
(*a*) pond (*b*) forest (*c*) lake (*d*) grassland

6. The rate of formation of new organic matter by rabbit in a grassland, is called
(*a*) net productivity (*b*) second productivity
(*c*) net primary productivity (*d*) gross primary productivity

7. Decomposers like fungi and bacteria are *[NCERT Exemplar]*
(*i*) autotrophs **(*ii*) heterotrophs**
(*iii*) saprotrophs **(*iv*) chemo-autotrophs**
(*a*) (*i*) and (*iii*) (*b*) (*i*) and (*iv*) (*c*) (*ii*) and (*iii*) (*d*) (*i*) and (*ii*)

8. The process of mineralisation by microorganisms helps in the release of *[NCERT Exemplar]*
(*a*) inorganic nutrients from humus
(*b*) both organic and inorganic nutrients from detritus
(*c*) organic nutrients from humus
(*d*) inorganic nutrients from detritus and formation of humus.

9. Productivity is the rate of production of biomass expressed in terms of *[NCERT Exemplar]*
(*i*) (kcal m^{-3}) yr^{-1} **(*ii*) g^{-2} yr^{-1}**
(*iii*) g^{-1} yr^{-1} **(*iv*) (kcal m^{-2}) yr^{-1}**
(*a*) (*ii*) (*b*) (*iii*) (*c*) (*ii*) and (*iv*) (*d*) (*i*) and (*iii*)

10. An inverted pyramid of biomass can be found in which ecosystem? *[NCERT Exemplar]*
(*a*) Forest (*b*) Marine (*c*) Grass land (*d*) Tundra

11. What is the difference between a community or group of communities and an ecosystem?
(*a*) A community and the abiotic environment comprise an ecosystem.
(*b*) An ecosystem is a type of community.
(*c*) A biome includes only the plant community or communities present in an environment.
(*d*) An ecosystem includes only the abiotic aspects of a particular environment.

12. Which of the following ecosystems is most productive in terms of net primary production? *[NCERT Exemplar]*
(*a*) Deserts (*b*) Tropical rain forests
(*c*) Oceans (*d*) Estuaries

13. Pyramid of numbers is *[NCERT Exemplar]*
(*a*) always upright (*b*) always inverted
(*c*) either upright or inverted (*d*) neither upright nor inverted

14. Of the total amount of energy that passes from one trophic level to another, about 10% is
(*a*) respired and becomes heat (*b*) passed out as faces or urine
(*c*) stored as body tissue (*d*) recycled to autotrophs

15. During the process of ecological succession the changes that take place in communities are [NCERT Exemplar]

(*a*) orderly and sequential (*b*) random
(*c*) very quick (*d*) not influenced by the physical environment.

16. Climax community is in a state of [NCERT Exemplar]

(*a*) non-equilibrium (*b*) equilibrium (*c*) disorder (*d*) constant change.

17. Among the following bio-geo-chemical cycles which one does not have losses due to respiration? [NCERT Exemplar]

(*a*) Phosphorus (*b*) Nitrogen (*c*) Sulphur (*d*) All of the above

18. The sequence of communities of primary succession in water is [NCERT Exemplar]

(*a*) phytoplankton, sedges, free-floating hydrophytes, rooted hydrophytes, grasses and trees.
(*b*) phytoplankton, free-floating hydrophytes, rooted hydrophytes, sedges, grasses and trees.
(*c*) free-floating hydrophytes, sedges, phytoplankton, rooted hydrophytes, grasses and trees.
(*d*) phytoplankton, rooted submerged hydrophytes, floating hydrophytes, reed swamp, sedges, meadow and trees.

19. The reservoir for the gaseous type of bio-geo chemical cycle exists in [NCERT Exemplar]

(*a*) stratosphere (*b*) atmosphere (*c*) ionosphere (*d*) lithosphere

20. If the carbon atoms fixed by producers already have passed through three species, the trophic level of the last species would be: [NCERT Exemplar]

(*a*) scavenger (*b*) tertiary producer (*c*) tertiary consumer (*d*) secondary consumer

21. Humans benefit from ecosystems because ecosystems provide

(*a*) buffers from natural disasters such as floods.
(*b*) maintenance of a clean water supply.
(*c*) climate moderation.
(*d*) All of the above

22. Which of the following type of ecosystem is expected in an area where evaporation exceeds precipitation, and mean annual rainfall is below 100 mm? [NCERT Exemplar]

(*a*) Grassland (*b*) Shrubby forest (*c*) Desert (*d*) Mangrove

23. The zone at the edge of a lake or ocean which is alternatively exposed to air and immersed in water is called: [NCERT Exemplar]

(*a*) pelagic zone (*b*) benthic zone (*c*) lentic one (*d*) littoral zone

24. Edaphic factor refers to: [NCERT Exemplar]

(*a*) water (*b*) soil (*c*) relative humidity (*d*) altitude

25. Which of the following is an ecosystem service provided by a natural ecosystem? [NCERT Exemplar]

(*a*) Cycling of nutrients
(*b*) Prevention of soil erosion
(*c*) Pollutant absorption and reduction of the threat of global warming
(*d*) All of the above

26. A succession of communities on barren land, is known as

(*a*) secondary succession (*b*) primary succession
(*c*) tertiary succession (*d*) none of these

Answers

1. (*a*)	**2.** (*b*)	**3.** (*c*)	**4.** (*d*)	**5.** (*b*)	**6.** (*a*)	**7.** (*c*)	**8.** (*a*)	**9.** (*c*)	**10.** (*b*)
11. (*a*)	**12.** (*b*)	**13.** (*c*)	**14.** (*c*)	**15.** (*a*)	**14.** (*b*)	**17.** (*d*)	**18.** (*b*)	**19.** (*b*)	**20.** (*c*)
21. (*d*)	**22.** (*c*)	**23.** (*d*)	**24.** (*b*)	**25.** (*d*)	**26.** (*b*)				

Assertion-Reason Questions

In the following questions a statement of assertion followed by a statement of reason is given. Choose the correct answer out of the following choices.

(a) Assertion and reason both are correct statements and reason is correct explanation for assertion.

(b) Assertion and reason both are correct statements but reason is not correct explanation for assertion.

(c) Assertion is correct statement but reason is wrong statement.

(d) Assertion is wrong statement but reason is correct statement.

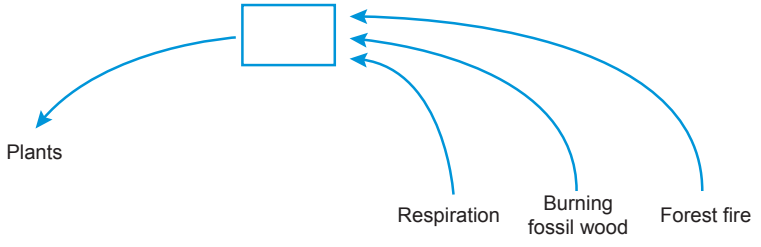
1. **Assertion :** A network of food chains existing together in an ecosystem is known as a food web.
   Reason : An animal like kite cannot be part of a food web.
2. **Assertion :** In open water zone upto the depth to which light can penetrate is called photic zone.
   Reason : The photic zone contains autotrophs.
3. **Assertion :** In a food chain the members of the successive trophic levels are fewer.
   Reason : Number of organisms at any trophic level is independent of the availability of organisms which serve as food at the lower level.
4. **Assertion :** Vertical distribution of different species occupying different levels is called stratification.
   Reason : Trees occupy top vertical strata, shrub the second, herbs and grasses occupy the bottom layers.
5. **Assertion :** Primary succession takes very long time.
   Reason : Soil is absent at the time of beginning of primary succession.
6. **Assertion :** Pyramid of energy is always upright.
   Reason : When energy flows from a particular trophic level to the next trophic level, some energy is always lost at heat at each step.
7. **Assertion :** Ecological succession occurs when older communities of plants and animals are replaced by newer communities.
   Reason : The natural process of replacement of one vegetation community in a given habitat by the other vegetation community.
8. **Assertion :** The decomposers feed on detritus, or decaying organic matter, derived from all levels.
   Reason : At each level of energy flow in the food web, energy is lost to respiration.
9. **Assertion :** In a terrestrial ecosystem, detritus food chain is the major conduit for energy flow.
   Reason : Solar energy is the direct source for energy supply in a detritus food chain.
10. **Assertion :** Net primary productivity is gross primary productivity minus respiration.
    Reason : Secondary productivity is produced by heterotrophs.

Answers

1. (*c*) **2.** (*b*) **3.** (*d*) **4.** (*b*) **5.** (*a*) **6.** (*a*) **7.** (*a*) **8.** (*b*) **9.** (*c*) **10.** (*b*)

Case-based/Source-based Question

1. **Study the diagram given below and answer the questions that follow.**



(*i*) Name the biogeochemical (nutrient) cycle shown above.

(*ii*) Name an activity of the living organisms not depicted in the cycle by which this nutrient is returned to the atmosphere.

(*iii*) How would the flow of the nutrient in the cycle be affected due to large scale deforestation? Explain giving reasons.

Ans. (*i*) The biogeochemical cycle shown is carbon cycle.

(*ii*) Volcanic activity and mining/Microbial decomposition of organic matter.

(*ii*) Due to large scale deforestation, the flow of carbon in the environment will be disturbed because plants are the major consumers which utilise carbon for photosynthesis. This would lead to accumulation of carbon in the atmosphere.

Very Short Answer Questions [1 mark]

Q. 1. Name the basic requirement of any ecosystem to function and sustain properly.

Ans. A constant input of solar energy is the ultimate source of all energy and requirement of any ecosystem to function and sustain properly.

Q. 2. What is detritus?

Ans. Dead organic matter or remains of plant such as leaves, bark, flower and dead remain of animals, including faecal matter constitute detritus.

Q. 3. What is net primary productivity?

Ans. The amount of energy or biomass remaining in a producer after meeting the cost of its respiration and is passed on to next trophic level is called the net primary productivity.

Q. 4. Why is the rate of assimilation of energy at the herbivore level called secondary productivity? **[*NCERT Exemplar*] [*HOTS*]**

Ans. It is because the biomass available to the consumer for consumption is a resultant of the primary productivity from plants.

Q. 5. All the primary productivity is not available to a herbivore. Give one reason. **[*HOTS*]**

Ans. All the primary productivity is not available to a herbivore because a considerable amount is utilised by the plant by respiration.

Q. 6. Write the equation that helps in deriving the net primary productivity of an ecosystem. **[*CBSE Delhi 2013*] [*HOTS*]**

Ans. GPP – R = NPP

Q. 7. Write a difference between net primary productivity and gross productivity. **[*CBSE (AI) 2011*] [*HOTS*]**

Ans. Gross productivity (GPP) is the rate of production of organic matter during photosynthesis. Net primary productivity (NPP) is the available biomass for the consumption by heterotrophs. GPP – R = NPP

Q. 8. What is secondary productivity?

Ans. Secondary productivity is defined as the rate of formation of new organic matter by consumers.

Q. 9. State what does 'standing crop' of a trophic level represent. **[*CBSE (AI) 2013*]**

Ans. Standing crop represents the mass of living material (biomass) at a particular time.

Q. 10. List any two ways of measuring the standing crop of a trophic level. **[*CBSE (F) 2010*]**

Ans. Standing crop is measured as the biomass or the number of plant in a unit area.

Q. 11. Differentiate between standing state and standing crop in an ecosystem. **[*CBSE (F) 2010*]**

Ans. In an ecosystem, standing crop is the mass of living material in each trophic level at a particular time. Whereas standing state refers to the amount of nutrients in the soil at any given time.

Q. 12. Why is a food web formed in nature? [*HOTS*]

Ans. Many organisms occupy positions in different food chains and several food chains become interconnected to form a food web.

Q. 13. Name an omnivore which occurs in both grazing food chain and the decomposer food chain. [*NCERT Exemplar*] [*HOTS*]

Ans. Sparrow/crow

Q. 14. Standing crop and biomass are related to each other, how? [*CBSE Sample Paper 2014*]

Ans. The standing crop is measured as the mass of living organisms or the number of plants in a unit area. The biomass of a species is expressed in terms of fresh or dry weight.

Q. 15. What is a detritus food chain made up of? How do they meet their energy and nutritional requirements? [*CBSE (AI) 2013*]

Ans. Dead plant and animal remains and their faecal matter constitute Detritus. DFC includes decomposers which obtain energy by decomposing the dead materials.

Q. 16. Why is the pyramid of biomass inverted in a pond ecosystem? [*HOTS*]

Ans. The pyramid of biomass is inverted in a pond ecosystem because the biomass of fish (top consumer) is far larger than the producers (phytoplanktons).

Q. 17. Mention the role of pioneer species in primary succession on rocks. [*CBSE (F) 2012*]

Ans. The pioneer species invade a bare area and pave way for other species.

Q. 18. Why green plants are not found beyond a certain depth in the ocean? [*CBSE Delhi 2011* [*HOTS*]

Ans. Beyond a certain depth in the ocean, sunlight is not able to penetrate. Due to which green plants cannot photosynthesise and thus, do not survive.

Q. 19. Why is an earthworm called a detritivore? [*CBSE (F) 2012*] [*HOTS*]

Ans. This is because earthworm breaks down detritus into smaller particles.

Q. 20. "Man can be a primary as well as a secondary consumer." Justify this statement. [*CBSE (F) 2015*] [*HOTS*]

Ans. Man has a varied diet. When on vegetarian diet, they are primary consumers and when on non-vegetarian diet, they are secondary consumers.

Q. 21. How is 'stratification' represented in a forest ecosystem? [*CBSE Delhi 2014*] [*HOTS*]

Ans. Stratification in the vertical distribution of species at different levels. Trees occupy top vertical strata, shrubs the second layer and herbs/ grasses occupy the bottom layers.

Q. 22. Define primary production.

Ans. It is defined as the amount of biomass or organic matter produced per unit area over a certain time period by plants during photosynthesis.

Q. 23. What is meant by humification?

Ans. The process of formation of humus from detritus or dead organic matter is called humification.

Q. 24. Define mineralisation.

Ans. It is the process in which the humus is degraded by certain microbes and thus inorganic nutrients are released in the soil.

Q. 25. Climax stage is achieved quickly in secondary succession as compared to primary succession. Why? [*NCERT Exemplar*] [*HOTS*]

Ans. The rate of succession is much faster in secondary succession as the substratum (soil) is already present as compared to primary succession where the process starts from a bare area (rock).

Q. 26. Under what conditions would a particular stage in the process of succession revert back to an earlier stage? [*NCERT Exemplar*] [*HOTS*]

Ans. Natural or human induced disturbances like fire, deforestation, etc.

Q. 27. Arrange the following as you observe in vertical stratification of a forest—Grass, Shrubby plants, Teak, *Amaranthus*. **[*NCERT Exemplar*] [*HOTS*]**

Ans. Grass, *Amaranthus*, Shrubby plants, Teak.

Q. 28. Name the pioneer species:

(*i*) on a bare rock

(*ii*) in a water body

Ans. (*i*) Lichens

(*ii*) Phytoplanktons

Short Answer Questions [2 marks]

Q. 1. How are productivity, gross productivity, net primary productivity and secondary productivity interrelated? **[*CBSE Delhi 2015*]**

Ans. Productivity is the rate of biomass production. GPP is rate of production of organic matter during photosynthesis.

$$GPP - R = NPP = 1$$

Where NPP is biomass available to consumers for secondary productivity. Secondary productivity is rate of formation of new organic matter by consumers.

Q. 2. "It is possible that a species may occupy more than one trophic level in the same ecosystem at the same time." Explain with the help of one example. **[*CBSE (AI) 2013*]**

Ans. For example, sparrow is an omnivore. When it eats seeds, fruits or any other plant products, it occupies the primary trophic level. Whereas, when it eats worms and any other insect, it occupies the secondary trophic level. Thus, it occupies more than one trophic level in the same ecosystem.

Q. 3. Justify the importance of decomposers in an ecosystem. **[*CBSE (F) 2015*]**

Ans. Decomposers which are heterotrophic organisms, mainly fungi and bacteria, break down complex organic matter into inorganic substances like carbon dioxide, water and nutrients. They meet their energy and nutrient requirements by degrading dead organic matter or detritus. These are also known as saprotrophs. Decomposers secrete digestive enzymes that breakdown dead and waste materials into simple, inorganic materials, which are subsequently absorbed by them.

Q. 4. Why is earthworm considered a farmer's friend? Explain humification and mineralisation occurring in a decomposition cycle. **[*CBSE (F) 2015*]**

Ans. Earthworms help in breakdown of complex organic matter as well as loosening of the soil. This helps in the proper growth of the crops. Therefore, they are considered farmer's friend.

Refer to Basic Concepts Point 7(*iv*) and (*v*).

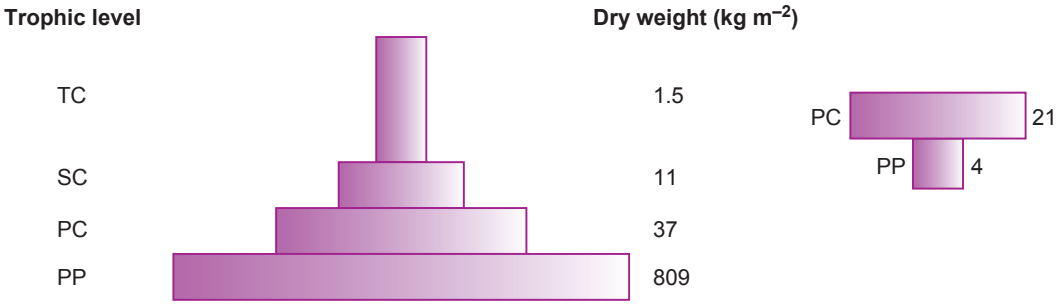
Q. 5. What is an incomplete ecosystem? Explain with the help of a suitable example. **[*NCERT Exemplar*]**

Ans. An ecosystem is a functional unit with biotic and abiotic factors interacting with one another resulting in a physical structure. Absence of any component will make an ecosystem incomplete as it will hinder the functioning of the ecosystem. Examples of such an ecosystem can be a fish tank or deep aphotic zone of the oceans where producers are absent.

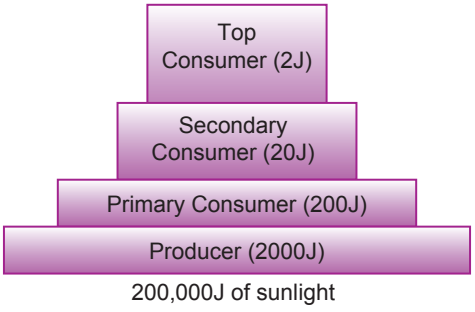
Q. 6. Primary productivity varies from ecosystem to ecosystem. Explain. **[*NCERT Exemplar*] [*HOTS*]**

Ans. Primary productivity varies from ecosystem to ecosystem because it depends on the plant species inhabiting the area and their photosynthetic activity. It also depends on various environmental factors, which vary in different ecosystems.

Q. 7. Compare the two ecological pyramids of biomass given below and explain the situations in which this is possible. Also, construct an ideal pyramid of energy, if 200,000 joules of sunlight is available. ***[CBSE Sample Paper 2016]***



Ans. The first pyramid of biomass corresponds to a terrestrial ecosystem. Second pyramid refers to a small standing crop of phytoplankton supporting a large standing crop of zooplankton or an aquatic ecosystem.



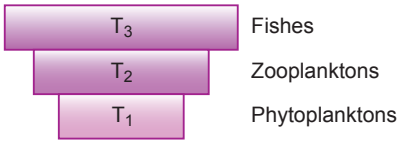
Q. 8. Differentiate between two different types of pyramids of biomass with the help of one example of each. ***[CBSE (AI) 2013]***

Ans. **Table 14.8: Differences between upright and inverted pyramids of biomass**

S. No.	Upright pyramid of biomass	Inverted pyramid of biomass
(*i*)	The biomass of producers is more than that of consumers.	The biomass of the producers (phytoplankton) is less than that of consumers (fish).
(*ii*)	For example, forest ecosystem.	For example, aquatic ecosystem.

Q. 9. Construct a pyramid of biomass starting with phytoplanktons. Label three trophic levels. Is the pyramid upright or inverted? Why?

Ans.



The pyramid is inverted because the biomass of fishes is much more than that of the phytoplanktons.

Q. 10. "In a food-chain, a trophic level represents a functional level, not a species." Explain. ***[CBSE Delhi 2016]*** ***[HOTS]***

Ans. A given species may occupy more than one trophic level in the same ecosystem (in different food chains) at the given time. If the function of the mode of nutrition of species changes, its position shall change in the trophic levels. The same species can be at primary consumer level in one food chain and at secondary consumer level in another food chain in the same ecosystem at the given time.

Q. 11.

Identify the type of the given ecological pyramid and give one example each of pyramid of number and pyramid of biomass in such cases. ***[CBSE (AI) 2011]*** ***[HOTS]***

Ans. The given ecological pyramid is the inverted pyramid.

Inverted pyramid of biomass in a lake: Phytoplankton → Zooplankton → fishes.

Inverted pyramid of number: Tree → insects → birds.

Q. 12. **Apart from plants and animals, microbes form a permanent biotic component in an ecosystem. While plants have been referred to as autotrophs and animals as heterotrophs, what are microbes referred to as? How do these microbes fulfil their energy requirements?** ***[NCERT Exemplar]***

Ans. Microbes are referred to as heterotrophs and saprotrophs. They fulfil their energy requirement by feeding on dead remains of plants and animals through the process of decomposition.

Q. 13. **What could be the reason for the faster rate of decomposition in the tropics?** ***[NCERT Exemplar]*** ***[HOTS]***

Ans. The rate of decomposition is regulated by climatic factors like temperature and soil moisture as they have an effect on the activities of soil microbes. The tropics with its hot and humid climatic condition provides an environment which is ideal for the microbes to speed up the process of decomposition.

Q. 14. **"Decomposition is an oxygen requiring process" Comment.** ***[HOTS]***

Ans. Detritus is rich in nitrogen and sugars. For oxidation of nitrogen and sugars oxygen is required by a class of aerobic microbes.

Q. 15. **State the difference between the first trophic levels of detritus food chain and grazing food chain.**

Ans. **Table 14.9: Differences between first trophic level of detritus food chain and grazing food chain**

S. No.	First trophic level of detritus food chain	First trophic level of grazing food chain
(*i*)	Decomposers are the first trophic level.	Producers are the first trophic level.
(*ii*)	They break down the complex organic matter into simpler form by secreting enzymes.	They prepare complex organic molecules from simple inorganic material with the help of sunlight.

Q. 16. **Differentiate between a detritivore and a decomposer giving an example of each.**

Ans. **Table 14.10: Differences between detritivore and decomposer**

Detritivore	Decomposer
They are organisms which feed on detritus and break them into smaller particles, *e.g.*, earthworm.	They are organisms which by secreting enzymes break down complex organic matter into inorganic substances, *e.g.*, some bacteria and fungi.

Q. 17. **Construct a grazing food chain and detritus food chain using the following, with 5 links each: Earthworm, bird, snake, vulture, grass, grasshopper, frog, decaying plant matter.**

Ans. **Grazing food chain:**

Grass → Grasshopper → Frog → Snake → Vulture

OR

Grass → Grasshopper → Bird → Snake → Vulture

Detritus food chain:

Decaying plant matter ⟶ Earthworm ⟶ Bird ⟶ Snake ⟶ Vulture

Q. 18. Explain with the help of two examples, how the pyramid of number and the pyramid of biomass can look inverted. ***[CBSE (F) 2011]***

Ans. The pyramid of biomass in sea is generally inverted because the biomass of fishes far exceeds that of phytoplankton and the number of big fishes eating the small fishes is also greater than the small ones. Also in pyramid of number, the number of insects feeding on a big tree is far greater than the number of trees. Now the number of small birds depending on the insects and the number of larger birds eating the smaller ones also increases in the order.

Q. 19. What would happen to the successive trophic levels in the pyramid of energy, if the rate of reproduction of phytoplanktons was slowed down? Suggest two factors which could cause such a reduction in phytoplankton reproduction. ***[HOTS]***

Ans. If the rate of reproduction of phytoplanktons slows down then the net primary productivity decrease. As a result, flow of energy will also decrease in the successive trophic level.

The following two factors cause reduction in phytoplankton reproduction:

(*i*) Less water availability

(*ii*) Less nutrient availability.

Q. 20. What are the shortcomings of ecological pyramids in the study of ecosystem? ***[NCERT Exemplar]*** ***[HOTS]***

Ans. The ecological pyramid assumes a simple food chain and does not accommodate food webs. Thereby, it does not take into account the fact that species may belong to two or more trophic levels at a time. Also saprophytes despite their vital role in ecosystem are given no place in the ecological pyramids.

Q. 21. Sometimes due to biotic/abiotic factor the climax remain in a particular seral stage (pre-climax) without reaching the climax. Do you agree with this statement. If yes, give a suitable example. ***[NCERT Exemplar]*** ***[HOTS]***

Ans. It is true that any change in the abiotic/biotic factor will arrest a particular seral stage leading to a pre-climax condition before the climax stage is achieved. This can happen in cases of forest fires, landslide, change in soil characteristics, increase in herbivore population leading to over-grazing.

Q. 22. How does primary succession start in water and lead to the climax community? Explain. ***[CBSE (F) 2012]***

Ans. Refer to Basic Concepts Point 14(*i*).

Q. 23. Name the pioneer and the climax species in a water body. Mention the changes observed in the biomass and the biodiversity of the successive seral communities developing in the water body.

Ans. Pioneer species — Phytoplanktons

Climax species — Forest or trees

Biomass will be gradually increased and phytoplanktons are replaced by free-floating angiosperms then by rooted hydrophytes followed by different seral communities thus, biodiversity also increases.

Q. 24. Explain the function of 'reservoir' in a nutrient cycle. List the two types of nutrient cycles in nature. ***[CBSE (F) 2011]***

Ans. The function of the reservoir is to meet the deficit of nutrients which occurs due to imbalance in the rate of influx and efflux.

The two types of nutrient cycles are:

(*i*) Gaseous, and (*ii*) Sedimentary

Long Answer Questions–I [3 marks]

Q. 1. Describe the inter-relationship between productivity, gross primary productivity and net productivity. ***[CBSE (F) 2016]***

Ans. Productivity is the rate of biomass production per unit area over a period of time.

Gross primary productivity is the rate of production of organic matter during photosynthesis in an ecosystem.

Net productivity is the gross primary productivity minus respiration losses.

Q. 2. Draw a pyramid of biomass and pyramid of energy in sea. Give your comments on the type of pyramids drawn. ***[CBSE (F) 2016]***

Ans. Refer to Fig. 14.6 and Fig. 14.7.

The pyramid of biomass in sea is inverted.

The pyramid of energy in sea is upright.

Q. 3. (*a*) Construct a pyramid of numbers by taking suitable examples for each trophic level in an ecosystem.

(*b*) Explain why a progressive decline is seen in the population size from the first to the fourth trophic level in the above pyramid. ***[CBSE (F) 2015]*** ***[HOTS]***

Ans. (*a*) Refer to Fig. 14.4

(*b*) Amount of energy decreases at successive trophic levels resulting into decreasing in number of organisms as per 10% law.

Q. 4. Name the pioneer species on a bare rock. How do they help in establishing the next type of vegetation? Mention the type of climax community that will ultimately get established.

OR

Explain how does a primary succession start on a bare rock and reach a climax community. ***[CBSE Delhi 2012]***

Ans. Refer to Basic Concepts Point 14(*ii*).

Q. 5. (*a*) Describe primary succession that occurs on bare rock.

(*b*) Differentiate between xerarch and hydrarch successions. ***[CBSE (F) 2013]***

Ans. (*a*) Refer to Basic Concepts Point 14(*ii*).

(*b*) Refer to Basic Concepts Point 14.

Q. 6. Differentiate between primary and secondary succession. Provide one example of each. ***[CBSE (AI) 2016]***

Ans.

Table 14.11: Differences between primary and secondary succession

S. No.	Primary Succession	Secondary Succession
(*i*)	It begins with areas where no living organisms ever existed.	It begins in areas where natural biotic communities have been destroyed.
(*ii*)	Establishment of a biotic community is very slow.	Establishment of a biotic community is faster.
(*iii*)	**Example:** Newly cooled-lava/barerocks/newly created ponds or reservoir.	**Example:** Abandoned farm lands/burnt or cut forests/ lands that have been flooded.

Q. 7. Name the type of food chains responsible for the flow of larger fraction of energy in an aquatic and a terrestrial ecosystem, respectively. Mention one difference between the two food chains. ***[CBSE Delhi 2010]***

Ans. In aquatic system, grazing food chain and in terrestrial ecosystem, detritus food chain is responsible for flow of larger fraction of energy.

For difference, refer to Basic Concepts Point 9.

Q. 8. (*a*) Name the type of detritus that decomposes faster. List any two factors that enhance the rate of decomposition.

(*b*) Write the different steps taken in humification and mineralisation during the process of decomposition. ***[CBSE 2019 (57/3/1)]***

Ans. (*a*) ● Detritus rich in nitrogen decomposes faster. These are water-soluble substances like sugar.

● Factors enhancing rate of decomposition: Warm temperature, moist environment, availability of oxygen.

(*b*) **Humification:** Accumulation of dark coloured amorphous substance called humus which is resistant to micorbial action and undergoes decomposition at a very slow rate.

Mineralisation: Humus is further degraded by microbes releasing inorganic nutrients.

Q. 9. Explain xerarch succession highlighting the xeral communities.

Ans. The series of development stages of biotic succession in an arid area are is termed as xeroseres while biological succession on an arid area is called xerarch.

For explanation, refer to Basic Concepts Point 14(*ii*).

Q. 10. Name the kind of organisms which constitute the pioneer community of xerarch and hydrarch succession, respectively.

Ans. Xerarch succession—Lichens and Hydrarch succession—Phytoplanktons

Q. 11. (*a*) What is meant by ecological succession? Explain how it occurs.

(*b*) What properties distinguish a pioneer community from a climax community?

Ans. (*a*) Refer to Basic Concepts Point 13.

(*b*) **Table 14.12: Differences between pioneer community and climax community**

S. No.	Pioneer community	Climax community
(*i*)	The species which invade a bare area or land to initiate succession is called pioneer community.	The last or final stage in a succession constitute the climax community.
(*ii*)	The pioneer species have high reproductive rate.	The climax species have low reproductive rate.
(*iii*)	The pioneer species have short life span.	The climax species have long life span.
(*iv*)	They are replaceable.	They are stable and not replaced.

Q. 12. Fill in the missing stages in the given primary hydrarch succession.

Phytoplankton → (*a*) → (*b*) → (*c*) → Submerged free-floating → (*d*) → Forest plant stage

What is common between hydrarch and xerarch succession?

Ans. (*a*) Reed-swamp stage

(*b*) Submerged plant stage

(*c*) Marsh-meadow stage

(*d*) Scrub stage

Both the hydrarch and xerarch lead to mesic conditions of forest.

Q. 13. Where and how does the primary succession occur? Explain.

Ans. Primary succession occurs on newly cooled lava or bare rocks or newly created pond or reservoir. (*Any two*)

Refer to Basic Concepts Point 14(*i*) or (*ii*).

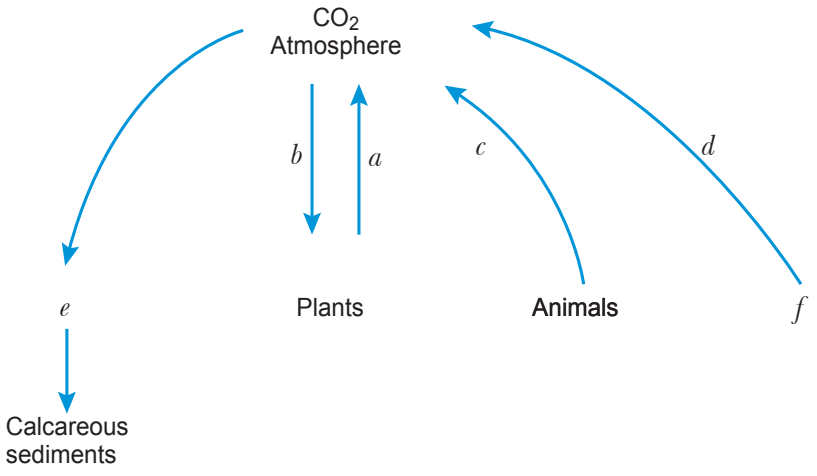
Q. 14. Define ecological succession. Give three differences between seral stages and climax community during succession.

Ans. The sequential, gradual and predictable changes in the species composition in an area are called succession or ecological succession.

Table 14.13: Differences between seral stages and climax community

S. No.	Seral stage	Climax community
(*i*)	It is the sequential replacement and establishment of species in the process of succession.	It is the community which gets established at the terminal stage of succession.
(*ii*)	The species composition changes from time to time.	The species are stable and species composition do not change.
(*iii*)	Simple food chains and food webs are found.	Complex food chains and food webs are found.

Q. 15. Draw and complete the following model of carbon cycle filling *a, b, c, d, e* and *f*.



Ans. (*a*) Respiration
(*b*) Photosynthesis
(*c*) Respiration
(*d*) Combustion of fossil fuels
(*e*) Aquatic food chain
(*f*) Coal, oil.

Q. 16. Why is the length of a food chain in an ecosystem generally limited to 3–4 trophic levels? Explain with an example.

Ans. The amount of energy flow decreases with successive trophic levels as only 10% of energy is transferred from one trophic level to the next successive level. The energy is lost in the form of respiration and other vital activities to maintain life. If more trophic levels are present, the residual energy will be limited and decreased to such an extent that it cannot further support any trophic level by the flow of energy. So, the food chain is generally limited to 3–4 trophic levels only.

For, *e.g.*,

Sun (30,000 J) —1% absorbed→ Plants (300 J) —10% transferred→ Deer (30 J) —10% transferred→ Tiger (3 J)

—10% transferred→ IV Trophic Level (0.3 J) —10% transferred→ V Trophic Level (0.03 J)

Q. 17. What are the limitations of ecological pyramids?

Ans. Refer to Basic Concepts Point 12 (Limitations of Ecological Pyramids)

Q. 18. (*a*) State any two differences between phosphorus and carbon cycles in nature.

(*b*) Write the importance of phosphorus in living organisms. **[*CBSE (F) 2015*]**

Ans. (*a*)

Table 14.14: Differences between phosphorus and carbon cycles

	Phosphorus cycle	Carbon cycle
(*i*)	It is a sedimentary cycle.	It is a gaseous cycle.
(*ii*)	Atmospheric inputs through rainfall are much smaller.	Atmospheric inputs through rainfall are more.
(*iii*)	Gaseous exchange of phosphorus between organism and environment is nil.	Gaseous exchange of carbon between organism and environment is much more.

(*b*) Phosphorus is a major constituent of biological membranes, nucleic acids and cellular energy transfer system.

Q. 19. Describe the effects of human activities in influencing natural ecosystem cycles with special reference to carbon cycle. **[*CBSE (F) 2017*]**

Ans. Human activities have significantly influenced the carbon cycle. Rapid deforestation and massive burning of fossil fuels for energy and transport have significantly increased the rate of release of carbon dioxide into the atmosphere. Carbon dioxide is a greenhouse gas which allows the solar radiations to enter but prevent the escape of heat radiations of longer wavelength. The absorbed radiations again come to earth's surface and heat it up. Thereby increasing the average temperature of surface of the earth, *i.e.*, global warming.

Q. 20. State the function of a reservoir in a nutrient cycle. Explain the simplified model of carbon cycle in nature. **[*CBSE (AI) 2014*]**

Ans. The function of a reservoir is to meet the deficit of nutrient which occurs due to imbalance in the rate of influx and efflux.

For Carbon Cycle, Refer to Fig. 14.10.

Long Answer Questions–II [5 marks]

Q. 1. (*a*) Explain primary productivity and the factors that influence it.

(*b*) Describe how do oxygen and chemical composition of detritus control decomposition. **[*CBSE Delhi 2011*]**

Ans. (*a*) Refer to Basic Concept Points 5 and 6.

(*b*) Decomposition of detritus is slow if it contains lignin, chitin, tannins and cellulose, whereas it is quicker if detritus is made up of nitrogenous compounds and water-soluble substances like sugars. This is because the latter are easy to degrade.

Oxygen is required for the activity of decomposers and detritivores. Therefore, a reduced oxygen amount will slow down the process of decomposition.

Q. 2. Describe the process of decomposition of detritus under the following heads: Fragmentation; leaching; catabolism; humification and mineralisation. **[*CBSE Delhi 2010*]**

Ans. The process of breaking down complex organic matter into inorganic substances like—, water and nutrients is called decomposition. The raw material for decomposition is called detritus. They are dead remains of plants and animals.

Steps in decomposition:

(*a*) Fragmentation: The process of breaking down of detritus into smaller particles is called fragmentation, *e.g.*, as done by earthworm.

(*b*) Leaching: The process by which water-soluble inorganic nutrients go down into the soil horizon and get precipitated as unavailable salts.

(*c*) **Catabolism:** The enzymatic process by which degraded detritus is converted into simple inorganic substances is called catabolism.

(*d*) **Humification:** The process of accumulation of a dark coloured amorphous substance called humus, that is, highly resistant to microbial action and undergoes decomposition at an extremely slow rate.

(*e*) **Mineralisation:** The process by which humus is further degraded by some microbes and release inorganic nutrients is called mineralisation.

Q. 3. Carbon cycle in nature is a biogeochemical event. Explain.

OR

Explain the carbon cycle with the help of a simplified model. ***[CBSE Delhi 2012]***

Ans. Refer to Basic Concepts Point 16 and fig 14.10.

Q. 4. (*a*) Draw the pyramids of biomass in a sea and in a forest. Explain giving reasons why the two pyramids are different.

(*b*) "Pyramid of energy is always upright." Explain. ***[CBSE (F) 2010]***

Ans. (*a*) Refer to Fig. 14.6 and 14.5, respectively.

The pyramid of biomass in sea is inverted because the biomass of fish far exceeds that of phytoplankton. Whereas the pyramid of biomass in a forest ecosystem is upright, because the biomass decreases as the trophic level increases.

(*b*) Pyramid of energy is never inverted because when energy flows from a particular trophic level to the next trophic level, some energy is always lost as heat at each step and only 10% is passed on to next trophic level. Each bar in the energy pyramid indicates the amount of energy present at each trophic level at a given time.

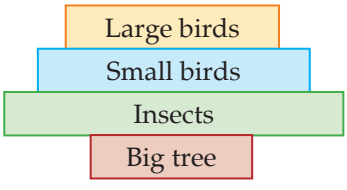
Q. 5. "It is often said that the pyramid of energy is always upright. On the other hand, the pyramid of biomass can be both upright and inverted." Explain with the help of examples and sketches. ***[CBSE (AI) 2015]***

Ans. Refer to Basic Concepts Point 12(*ii*) and (*iii*).

Q. 6. (*a*) Draw a 'pyramid of numbers' of a situation where a large population of insects feed upon a very big tree. The insects in turn, are eaten by small birds which in turn are fed upon by big birds.

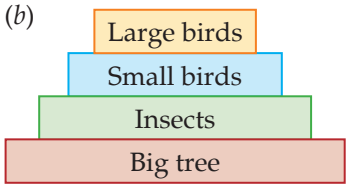
(*b*) Differentiate giving reason, between the pyramid of biomass of the above situation and the pyramid of numbers that you have drawn. ***[CBSE Delhi 2012]***

Ans. (*a*)



Pyramid of number

(*b*)



Pyramid of biomass

The pyramid of biomass is upright at the first two trophic levels because the biomass of a single tree is much more than total population of insects. Whereas, the pyramid of number is inverted at the first two trophic levels because the number of insects is much more than the number of trees.

Q. 7. (*a*) With suitable examples, explain the energy flow through different trophic levels. What does each bar in this pyramid represent?

(b) Write any two limitations of ecological pyramids. ***[CBSE Delhi 2014]***

Ans. (*a*) In an ideal energy pyramid, the primary producers use only 1% of the energy in the sunlight available to them. The subsequent trophic levels pass on 10% of the energy received from previous trophic level to the next trophic level.

Refer to Fig. 14.7.

Each bar or level in the pyramid represents the amount of energy transferred to the next trophic level.

(*b*) (*i*) It does not take into account the same species belonging to two trophic levels.

(*ii*) It assumes simple food chain and not food web.

(*iii*) Saprophytes are not considered. (*Any two*)

Q. 8. (*a*) What is a trophic level in an ecosystem? What is 'standing crop' with reference to it?

(*b*) Explain the role of the 'first trophic level' in an ecosystem.

(*c*) How is the detritus food chain connected with the grazing food chain in a natural ecosystem? ***[CBSE 2018]***

Ans. (*a*) The specific places occupied by an organism in the food chain is called trophic level.

Each trophic level has a certain mass of living material at a particular time which is called as the standing crop.

(*b*) The first trophic level is comprised by the producers which trap solar energy to convert it into chemical bond energy of food. They serve as food for subsequent trophic levels.

(*c*) The organisms of the detritus food chain (DFC) are the prey to the grazing food chain (GFC) organisms. The dead remains of GFC are decomposed into simple inorganic materials. These materials are then absorbed by DFC organisms.

Q. 9. (*a*) Differentiate between primary and secondary ecological successions.

(*b*) Explain the different steps of xerarch succession occurring in nature. ***[CBSE (F) 2014]***

Ans. **(*a*) Primary succession:** It begins in areas where no living organisms ever existed. Therefore, the establishment of a biotic community is very slow, *e.g.*, newly cooled lava, bare rock, newly created pond or reservoir.

Secondary succession: It begins in areas where natural biotic communities have been destroyed, *e.g.*, abandoned farm lands, buried or cut forests. Since soil is available, it is a faster process.

(*b*) Xerarch Succession in Nature:

- Lichens are the pioneer species on a bare area.
- The lichen secretes some acids to dissolve rocks and help in weathering and soil formation.
- Later, some small bryophytes invade and hold the small amount of soil.
- The bryophytes are succeeded by herbs, shrubs and ultimately big trees.
- At last, a stable climax forest is formed.
- The xerophytic habitat gets converted into a mesophytic one.

Q. 10. Describe the advantages for keeping the ecosystems healthy. ***[CBSE Delhi 2015]***

Ans. By keeping the ecosystem healthy we can take advantage of the ecosystem services which are the products of ecosystems.

Following are the economic and environmental goods that we obtain from the ecosystem. They

(*i*) Purify air and water

(*ii*) Mitigate drought and floods

(*iii*) Cycle nutrients

(*iv*) Generate fertile soil

(*v*) Provide wildlife habitat

(*vi*) Maintain biodiversity

(*vii*) Pollinate crops

(*viii*) Provide storage site for carbon

(*ix*) Provide aesthetic, cultural and spiritual value

(*x*) Provide stable food chain

(*xi*) Provide economically useful forest products

(*xii*) Provide sustainable biological legacy to future generations.

Q. 11. (*a*) Draw a simplified model of phosphorus cycling in a terrestrial ecosystem.

(*b*) Write the importance of such cycles in ecosystems. **[*CBSE (AI) 2014*]**

Ans. (*a*) Refer to Fig. 14.11.

(*b*) Such cycles recycle nutrients again and again and maintain the balance in ecosystem.

Q. 12. What will happen to an ecosystem if

(*a*) All producers are removed;

(*b*) All organisms of herbivore level are eliminated; and

(*c*) All top carnivore population is removed. **[*NCERT Exemplar*] [*HOTS*]**

Ans. (*a*) Reduction in primary productivity. No biomass available for consumption by higher trophic levels/heterotrophs and hence heterotrophs also die of starvation.

(*b*) Increase in primary productivity and biomass of producers. Carnivore population will subsequently dwindle due to food shortage.

(*c*) Increase in number of herbivores which leads to over-grazing by herbivores, finally resulting in desertification.

Q. 13. Citing lake as an example of a simple aquatic ecosystem, interpret how various functions of this ecosystem are carried out. Make a food chain that is functional in this ecosystem.

[*CBSE Sample Paper 2015, 2017, 2018*] [*HOTS*]

Ans. **(*i*) Productivity:** Conversion of inorganic into organic material with the help of solar energy by the autotrophs.

(*ii*) Energy flow: Unidirectional movement of energy towards higher trophic level (and its dissipation and loss as heat to the environment).

(*iii*) Decomposition: Fragmentation, leaching, catabolism, humification, mineralization by bacteria, fungi and flagellates (abundant at the bottom of lake).

(*iv*) Nutrient cycling: Decomposition of dead matter to release the nutrients back to be re-used by the autotrophs.

Food chain in aquatic ecosystem (lake):

Phytoplanktons → Zooplanktons → Small fish → Big fish (*Any other appropriate example*).

Q. 14. (*a*) Colonisation of a rocky terrain is a natural process. Mention the group of organisms which invade this area first. Give an example.

(*b*) Over the years, it has been observed that some of the lakes are disappearing due to urbanisation. In absence of human interference, depict by making a flow chart, how do the successional series progress from hydric to mesic condition.

(*c*) Identify the climax community of hydrarch and xerarch succession.

[*CBSE Sample Paper 2015, 2017, 2018*] [*HOTS*]

Ans. (*a*) Pioneer species invade the area first. For example, lichen

(*b*) Phytoplankton – (hydric) → Submerged plant stage → Submerged free floating plant stage → Reed swamp stage → Marsh – meadow stage → Scrub stage → Forest stage (Mesic condition)

(*c*) Forest is the climax community for both successions.

Self-Assessment Test

Time allowed: 1 Hour **Max. marks: 30**

1. Choose and write the correct option in the following questions. **(3×1 = 3)**

(i) Which of the following is not a producer?

(a) *Spirogyra* (b) *Agaricus* (c) *Volvox* (d) *Nostoc*

(ii) Among the following, where do you think the process of decomposition would be the fastest?

(a) Tropical rain forest (b) Antarctic (c) Dry arid region (d) Alpine region

(iii) How much of the net primary productivity of a terrestrial ecosystem is eaten and digested by herbivores?

(a) 1% (b) 10% (c) 40% (d) 90%

2. In the following questions a statement of assertion followed by a statement of reason is given. Choose the correct answer out of the following choices. **(3×1 = 3)**

(a) Assertion and reason both are correct statements and reason is correct explanation for assertion.

(b) Assertion and reason both are correct statements but reason is not correct explanation for assertion.

(c) Assertion is correct statement but reason is wrong statement.

(d) Assertion is wrong statement but reason is correct statement.

(i) Assertion : Energy always flows from the Sun to producers.

Reason : No energy that is trapped into an organism remains in it forever.

(ii) Assertion : The climax community remains stable as long as the environment remains unchanged.

Reason : Lichens are the climax community in primary succession on rocks.

(iii) Assertion : A trophic level represents a species level.

Reason : Biomass is the mass of living organisms in terms of fresh or dry weight.

3. What is meant by 10% law? **(1)**

4. What is the primary productivity of an ecosystem and how is it expressed? **(1)**

5. Distinguish between the biotic community and an ecosystem. **(2)**

6. What are decomposers? Name any two kinds of decomposers. **(2)**

7. Distinguish between pioneer community and climax community. **(2)**

8. What is meant by saying that the energy flow in an ecosystem is unidirectional? **(2)**

9. Given below is a representation of trophic levels in an ecosystem. Answer the questions based on the representation. **(3 × 1 = 3)**

(i) Justify the pitcher plant as a producer.

(ii) Name any two organisms which occupy more than one trophic level in an ecosystem.

(iii) What is common to earthworm, mushroom, soil mites and dung beetle in an ecosystem?

10. Draw a simplified model of phosphorus cycle and label all its parts. **(3)**

11. How does primary succession start in water and lead to the climax community? Explain. **(3)**

12. What will happen to an ecosystem if

(i) All producers are removed?

(ii) All organisms of herbivore level are eliminated?

(iii) All top carnivore population is removed? **(5)**

Answers

1. (*i*)—(*b*), (*ii*)—(*a*), (*iii*)—(*b*) **2.** (*i*)—(*b*), (*ii*)—(*c*), (*iii*)—(*d*)

Chapter–15

Biodiversity and Conservation

basic concepts

1. Biodiversity

- The occurrence of different types of genes, gene pools, species, habitats and ecosystems in a particular place and various parts of earth is called **biodiversity**.
- The term 'biodiversity' was given by **Edward Wilson**.
- Biodiversity is divided into three levels of biological organisation:

(i) Genetic diversity

- It is the measure of variety in genetic information contained in the organisms over its distributional range.
- It enables a population to adapt to its environment.
- For example, medicinal plant *Rauwolfia vomitoria* growing in Himalayan ranges shows variation in potency and concentration of the active chemical reserpine that it produces.
- There are more than 50,000 genetically different strains of rice and 1,000 varieties of mango in India.

(ii) Species diversity

- It is a measure of the variety of species and their relative abundance present within a region.
- For example, the Western Ghats have a greater amphibian species diversity than the Eastern Ghats.

(iii) Ecological diversity

- It is a measure of the diversity at community and ecosystem levels. They represent the local, unique habitat and regional components of species diversity.
- For example, ecological diversity is greater in India than a Scandavian country like Norway due to presence of large number of ecosystems like deserts, rainforests, coral reefs, wetlands, estuaries and alpine meadows.

2. Global Species Diversity

- According to the International Union for Conservation of Nature and natural resources or IUCN (2004), the total number of plant and animal species is over 1.5 million.
- A more conservative and scientifically sound estimate made by Robert May, places the global species diversity at about 7 million.
- More than 70 per cent of all the species are animals, while plants account for about 22 per cent of the total.

- Amongst animals, insects comprise more than 70 per cent that means, out of every 10 animals on this planet, 7 are insects on this earth.
- India has only 2.4 per cent of world's land area and 8.1 per cent global species diversity. There are nearly 45,000 plants and twice as many animals. So, India is one of 12 megadiversity countries of the world.
- Large number of species are facing threat of becoming extinct even before we discover them.
- We cannot estimate diversity of prokaryotes because conventional taxonomic methods are not suitable for identifying microbial species and many species are simply not culturable under laboratory conditions. If we accept biochemical or molecular criteria for delineating species of prokaryotes, then their diversity might run into millions.

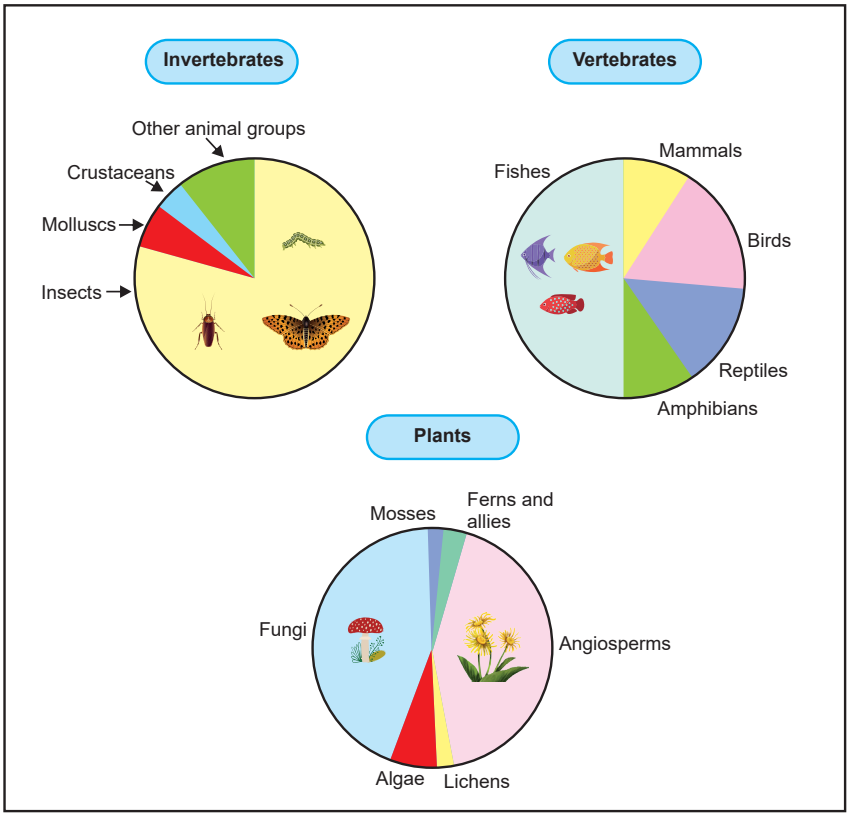


Fig. 15.1 Global biodiversity representation: Proportionate number of species of major taxa of plants, invertebrates and vertebrates.

3. Patterns of Biodiversity

- Biodiversity is not uniform throughout the world because it is affected by two factors— latitudinal gradients and species–area relationship.

(i) Latitudinal gradients

- Biodiversity increases from poles to equators, *i.e.*, from high to low latitude.
- Tropics (23.5°N to 23.5°S) have more species than temperate or polar regions. For example, Columbia located near the ecuator has 1,400 species of birds while New York (41.5°N) has 105 species and Greenland (71°N) has only 56 species. India has more than 1200 species of birds.
- Forest in tropical region like Ecuador has up to 10 times as many species of vascular plants as forest of equal area in temperate region like midwest of USA.

- Tropical rain forests of Amazon in South America possess the greatest biodiversity on earth with more than 40,000 species of plants, 3,000 of fishes, 1,300 of birds, 427 of mammals, 427 of amphibians, 378 of reptiles and more than 1,25,000 of invertebrates.
- Greater biological diversity is observed in tropics because:
  (*a*) Temperate regions have been subjected to frequent glaciations in the past but tropical regions remained undisturbed. Therefore, tropics had a longer evolutionary time for species diversification.
  (*b*) Temperate environment unlike the tropics are more seasonal, less constant and unpredictable, resulting in less niche specialisation and lesser species diversity.
  (*c*) Tropics have greater solar energy exposure which contributes to higher productivity and greater diversity.

(ii) Species–area relationship

- German naturalist and geographer **Alexander von Humboldt** observed that within a region, species richness increased with increasing explored area but up to a limit.
- The relationship between species richness and area for a wide variety of taxa (like vascular plants, birds, bats and freshwater fishes) appears as a rectangular hyperbola.
- On a logarithmic scale, the relationship is a straight line described by the following equation:

$$\log S = \log C + Z \log A$$

where S = Species richness
A = Area
Z = Slope of the line (regression coefficient)
C = Y-intercept.

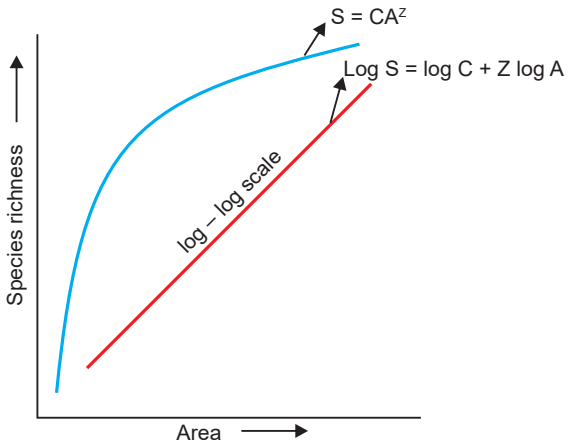


Fig. 15.2 Species–area relationship: On log scale the relationship becomes linear

- The value of Z lies in the range of 0.1–0.2 regardless of taxonomic group or the region. Whether it is plants in Britain, birds in california or malluscs in New York State, slopes of regression are similar.
- However, the analysis in a very large area like the whole continent gives a Z value that ranges from 0.6 to 1.2. For example, for frugivorous (fruit eating) birds and mammals in the tropical forest of different continents, the slope is 1.15.

4. Importance of Species Diversity to the Ecosystem

- Ecologists believe that communities with more species tend to be more stable than those with less species. This was confirmed by **David Tilman**.
- **Characteristics of a stable community:**
  (*i*) Productivity should not vary too much from year to year.
  (*ii*) It should be resistant to occasional natural and man-made disturbances.
  (*iii*) It should be resistant to invasions by alien species.
- Importance of biodiversity for survival of species can be explained by the **'rivet popper hypothesis'** proposed by **Paul Ehrlich**.

- This hypothesis assumes the ecosystem to be an airplane and the species to be the rivets joining all parts together.
- If every passenger pops a rivet to take home (resulting in species extinction), it may not affect the flight safety initially (proper ecosystem functioning) but with time as more rivets are removed the plane becomes dangerously weak and fatal to the life of other species.

5. Loss of Biodiversity

- It is caused by over-population, urbanisation and industrialisation.
- The colonisation of tropical Pacific Islands by humans has led to the extinction of more than 2,000 species of native birds.
- 15,500 species are facing the threat of extinction worldwide.
- IUCN Red list (2004) documents extinction of 784 species including 338 vertebrates, 359 invertebrates and 487 plants in last 500 years.
- At present, 31 per cent of gymnosperms, 32 per cent of amphibians, 12 per cent of bird species and 23 per cent of mammals face the threat of extinction.
- Some recently extinct species are dodo (Mauritius), quagga (Africa), thylacine (Australia), Stellar's sea cow (Russia) and three tiger species (Bali, Java, Caspian).
- In last 20 years, 27 species have disappeared.
- There has been five episodes of mass extinction of species and the sixth extinction is going on, but it is 100–1000 times faster than the earlier ones.
- Loss of biodiversity in a region may lead to
  (*i*) decrease in plant production.
  (*ii*) less resistance to environmental disturbances such as drought.
  (*iii*) increased variability in ecosystem processes like plant productivity, water use, pest and disease cycles.

6. Causes of Biodiversity Losses

- There are four major causes of biodiversity loss. These are also known as **'The Evil Quartet'**.

(i) Habitat loss and fragmentation

- Destruction of habitat is the primary cause of extinction of species.
- The tropical rainforests initially covered 14 per cent of the land surface of earth, but now cover only 6 per cent of land area.
- The Amazon rainforest (called the **"lungs of the planet"**) is being cut and cleared for cultivation of soya beans and for conversion into grasslands for raising beef cattle.
- When large-sized habitats are broken or fragmented due to human settlements, building of roads, digging of canals, etc., the population of animals requiring large territories and some animals with migratory habitats declines.

(ii) Over-exploitation

- When biological system is over-exploited by man for the natural resources, it results in degradation and extinction of the resources.
- For example, Stellar's sea cow, passenger pigeon and many marine fishes have become extinct due to over-exploitation by man.

(iii) Alien (exotic) species invasions

- Some alien (exotic) species when introduced unintentionally or deliberately, become invasive and cause harmful impact, resulting in extinction of the indigenous species.

- **Nile perch,** a large predator fish when introduced in Lake Victoria (East Africa) caused the extinction of an ecologically unique assemblage of more than 200 species of Cichlid fish in the lake.
- Invasive weed species like *Parthenium* (carrot grass), *Lantana* and *Eichhornia* (water hyacinth) caused environmental damage and posed threat to our native species.
- Introduction of African catfish (*Clarias gariepinus*) for aquaculture purposes is posing a threat to the indigenous cat fishes of Indian rivers.

(iv) Co-extinctions

- When a species becomes extinct, the plant and animal species associated with it in an obligatory manner, also become extinct.
- For example, (*a*) if the host fish species becomes extinct, all those parasites exclusively dependent on it, will also become extinct; (*b*) in plant–pollinator mutualism also, extinction of one results in the extinction of the other.

7. Reasons for Biodiversity Conservation

- Biodiversity is important for ecosystem health and for survival of human race on earth. There are three main reasons for conserving the biodiversity which have been classified into the following categories:

(i) Narrowly utilitarian arguments

- Human beings derive direct economic benefits from nature, like food, firewood, fibre, construction material, industrial products (resins, gums, dyes, tannins, etc.) and medicinally important products.
- More than 25 per cent of the drugs are derived from plants and about 25,000 species of plants are used by native people as traditional medicines.

(ii) Broadly utilitarian arguments

- Biodiversity plays a major role in maintaining and sustaining supply of goods and services from various species as well as ecological systems.
- The different ecological services provided are:

(*a*) Amazon forest is estimated to contribute 20 per cent of the total oxygen in the atmosphere on earth by photosynthesis.

(*b*) Ecosystem provides pollinators like bees, bumble bees, birds and bats which pollinate plants to form fruits and seeds.

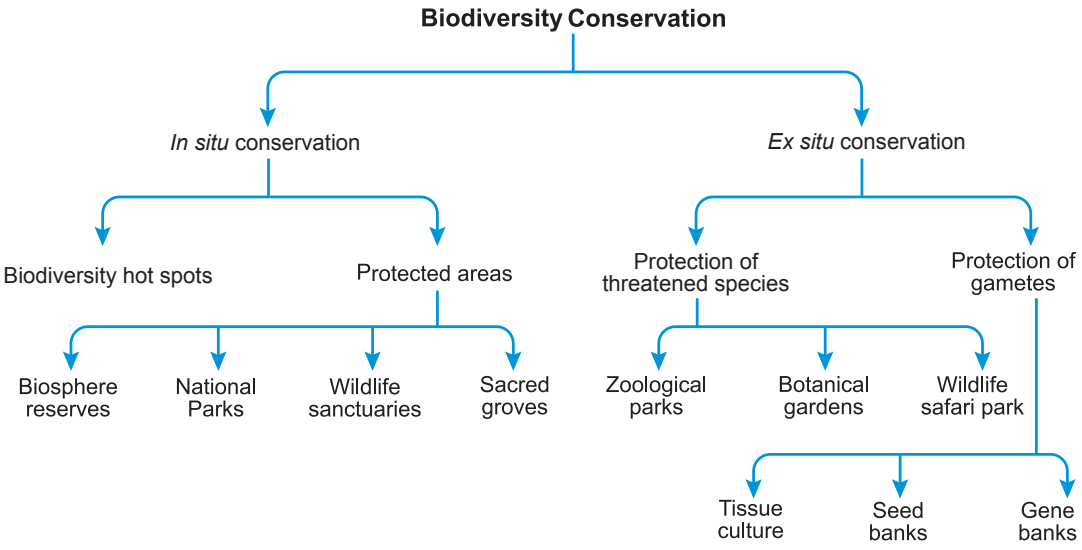
(*c*) Aesthetic pleasures like bird watching, spring flowers in full bloom, walking through the thick forest, waking up to a bulbul's song, etc. are some other benefits of the ecosystem.

(iii) Ethical reasons

- There are thousands of plants, animals and microbes on this earth which are not useless. Every one has some intrinsic value even if it is not of any economic value to us.
- It is, therefore, our moral duty to ensure well-being of all the living creatures for the utilisation of future generations.

8. Conservation of Biodiversity

- Biodiversity can be conserved by protecting its whole ecosystem.
- There are two basic approaches for conservation of biodiversity.



(i) *In situ* conservation (On site conservation)

This approach involves protection of species in their natural habitat.

(a) Biodiversity hotspots

- These are regions of high levels of species richness and high degree of endemism.
- Endemic species are species confined only to a limited region.
- There are 34 hotspots in the world.
- In India, the three hotspots are Western Ghats and Sri Lanka, Indo–Burma and Himalaya.
- Biodiversity hotspots cover less than 2% of earth's land area, but they harbour large number of species. Thus, they could reduce mass extinction by 30%.

(b) Protected areas

- India has 14 biosphere reserves, 90 national parks and 448 wildlife sanctuaries.
- Jim Corbett National Park was the first to be established in India.

(c) Ramsar sites

- **Ramsar sites** are wetlands which are considered to be of international importance.
- **Ramsar Convention (1971)** is an international treaty for the conservation and sustainable utilisation of wetlands.
- Ramsar convention works for (a) conservation and use of wet lands, (b) recognition of fundamental ecological functions of wetlands and their cultural, economic, scientific and recreational value.
- There are 26 Ramsar sites in India. Some of these are Ashtamudi wetland (Kerala), Sambhar lake, Rudrasagar lake, Chilika lake, Bhitakanika wetland (Odisha).
- Wetlands include marshes, lakes, coral reefs, etc.

(d) Sacred groves

- These are forest patches set aside for worship. All the trees and wildlife within are given total protection by tribal people.
- Large number of rare and threatened plants can be found in these regions.
- Some of the sacred groves in India are as follows:
  - — Khasi and Jaintia Hills in Meghalaya
  - — Western Ghat regions of Karnataka and Maharashtra
  - — Aravalli Hills of Rajasthan
  - — Sarguja, Chanda and Bastar areas of Madhya Pradesh.

(ii) *Ex situ* conservation (Off-site conservation)

- This approach involves placing threatened animals and plants in special care units for their protection.
- India has 35 botanical gardens and 275 zoological parks where animals which have become extinct in wild are maintained.
- By using cryopreservation (preservation at –196°C) technique, sperms, eggs, animal cells, tissues and embryos can be stored for long period in genes banks, seed banks, etc.
- Plants are propagated *in vitro* using tissue culture methods (micropropagation).
- It is the desirable approach when urgent measures to save extinction are required.

Table 15.1: Differences between *in situ* conservation and *ex situ* conservation

S. No.	*In situ* conservation	*Ex situ* conservation
(*i*)	It is the conservation and protection of biodiversity in its natural habitat.	It is the conservation of selected threatened plant and animal species in places outside their natural habitat.
(*ii*)	Population is conserved in the surroundings where they have developed their distinctive features.	Population is conserved under simulated conditions that closely resemble their natural habitats.
(*iii*)	*E.g.*, national parks, biosphere reserves, wildlife sanctuaries, etc.	*E.g.*, botanical gardens, zoological parks, wildlife safari, gene banks, etc.

9. Conventions on Biodiversity

- The Earth Summit was held in Rio de Janeiro in 1992, which called upon all nations to take appropriate measures for conservation of biodiversity and sustainable utilisation of its benefits.
- The World Summit on Sustainable Development was held in Johannesburg, South Africa in 2002 in which 190 countries pledged to reduce the current rate of biodiversity loss at global, regional and local levels by 2010.

NCERT Textbook Questions

Q. 1. Name the three important components of biodiversity.

Ans. The three important components of biodiversity are: genetic diversity, species diversity and ecological diversity.

Q. 2. How do ecologists estimate the total number of species present in the world?

Ans. There are two methods to estimate the number of species in the world:

(*i*) By estimating the rate of discovery of new species.

(*ii*) By statistical comparison of the temperate–tropical species richness of an exhaustively studied group of insects and extrapolate this ratio to other groups of animals and plants to come up with a gross estimate of the number of species on earth.

Q. 3. Write any three hypotheses put forth by ecologists explaining the existence of greater biodiversity in tropical regions than in temperate regions.

[CBSE (AI) 2010, 2014; (F) 2010, 2012]

Ans. The three hypotheses to explain species richness in tropics are:

(*i*) The constant environment in tropics promotes niche specialisation and increased species diversity.

(*ii*) There is longer exposure to solar radiation in the tropical regions that contributes directly to higher productivity and indirectly to greater species diversity.

(*iii*) There occurred no glaciation in tropical region and it remained undisturbed. Thus organisms living in tropics continued to flourish and evolved more species diversity.

Q. 4. What is the significance of the slope of regression in a species–area relationship?

Ans. Slope of regression in a species–area relationship indicates that species richness decreases with the decrease in area. Regression coefficient (Z) is 0.1–0.2 regardless of the taxonomic group or the region. However, when very large areas like the entire continent is analysed, it was found that slope of the line is much steeper with Z values in the range of 0.6 – 1.2.

Q. 5. What are the major causes of species losses in a geographical region?

Ans. There are four major causes (The Evil Quartet):

(*i*) Habitat loss and fragmentation (*ii*) Over-exploitation

(*iii*) Alien species invasions (*iv*) Co-extinctions

Q. 6. How is biodiversity important for ecosystem functioning?

Ans. Importance of biodiversity for ecosystem functioning:

(*i*) Stability: Biodiversity is an important aspect for stability of an ecosystem. Ecologists believe that communities with more species tend to be more stable than those with less species.

(*ii*) Productivity: Ecosystem with higher biodiversity show more productivity than ecosystems with lower biodiversity. David Tilman's long-term ecosystem experiments using outdoor plots provide confirmation.

(*iii*) Ecosystem health: Rich biodiversity is not only essential for ecosystem health but imperative for the survival of the human race on earth. Species are interlinked and so, killing or disappearance of one would effect the others also.

(*iv*) Resilience: Increased biodiversity provides resilience of the ecosystem against natural or man-made disturbances.

Q. 7. What are sacred groves? What is their role in conservation?

Ans. Sacred groves are forest patches for worship in several parts of India. All the trees and wildlife in them are venerated and given total protection. They are found in Khasi and Jaintia Hills in Meghalaya, Western Ghat regions of Karnataka and Maharashtra, etc. Tribals do not allow anyone to cut even a single branch of tree in these sacred groves, thus sacred groves have been free from all types of exploitations.

Q. 8. Among the ecosystem services are control of floods and soil erosion. How is this achieved by the biotic components of the ecosystem?

Ans. **Control of soil erosion:** Plant roots hold the soil particles tightly and do not allow the top soil to be drifted away by winds or moving water. Plants increase the porosity and fertility of the soil.

Control of floods: It is carried out by retaining water and preventing run off of rain water. Litter and humus of plants function as sponges thus retaining the water which percolates down and get stored as underground water. Hence, the flood is controlled.

Q. 9. The species diversity of plants (22 per cent) is much less than that of animals (72 per cent). What could be the explanations to how animals achieved greater diversification?

Ans. Animals have achieved greater diversification than plants due to following reasons:

(*i*) They are mobile and thus can move away from their predators or unfavourable environments. On the other hand, plants are fixed and have fewer adaptation to obtain optimum amount of raw materials and sunlight therefore, they show lesser diversity.

(*ii*) Animals have well-developed nervous system to receive stimuli against external factors and thus can respond to them. On the other hand, plants do not exhibit any such mechanism, thus, they show lesser diversity than animals.

Q. 10. Can you think of a situation where we deliberately want to make a species extinct? How would you justify it?

Ans. Species which are harmful to human beings can be made extinct, *e.g.*, HIV, polio virus, etc. Such micro-organisms are not part of any food chain and thus, their extinction would not affect the ecosystem.

Multiple Choice Questions [1mark]

Choose and write the correct option in the following questions.

1. Which one of the following pairs of organisms are exotic species introduced in India?
(*a*) *Lantana camara*, water hyacinth
(*b*) Water hyacinth, *Prosopis cinereria*
(*c*) Nile perch, *Ficus religiosa*
(*d*) *Ficus religiosa, Lantana camara*

2. Which one of the following is not observed in biodiversity hot spots?
(*a*) Lesser inter-specific competition
(*b*) Species richness
(*c*) Endemism
(*d*) Accelerated species loss

3. Which one of the following is an example of *ex situ* conservation?
(*a*) Wildlife sanctuary
(*b*) Seed bank
(*c*) Sacred groves
(*d*) National park

4. Which one of the following is correct expanded form of the following acronyms?
(*a*) IPCC = International Panel for Climate Change
(*b*) UNEP = United Nations Environmental Policy
(*c*) EPA = Environmental Pollution Agency
(*d*) IUCN = International Union for Conservation of Nature and Natural Resources

5. A collection of plants and seed having diverse alleles of all the genes of a crop is called
(*a*) herbarium
(*b*) germplasm
(*c*) gene library
(*d*) genome

6. Biodiversity of a geographical region represents
(*a*) endangered species found in the region
(*b*) the diversity in the organisms living in the region
(*c*) genetic diversity in the dominant species of the region
(*d*) species endemic to the region

7. Which of the following countries has the highest biodiversity? *[NCERT Exemplar]*
(*a*) South America (*b*) South Africa (*c*) Russia (*d*) India

8. Which of the following is not a cause for loss of biodiversity? *[NCERT Exemplar]*
(*a*) Destruction of habitat
(*b*) Invasion by alien species
(*c*) Keeping animals in zoological parks
(*d*) Over-exploitation of natural resources

9. Which of the following is not an invasive alien species in the Indian context? *[NCERT Exemplar]*
(*a*) *Lantana* (*b*) *Cynodon* (*c*) *Parthenium* (*d*) *Eichhornia*

10. Where among the following will you find pitcher plant? *[NCERT Exemplar]*
(*a*) Rain forest of North-East India
(*b*) Sunderbans
(*c*) Thar Desert
(*d*) Western Ghats

11. Which one of the following is not a major characteristic feature of biodiversity hot spots? *[NCERT Exemplar]*
(*a*) Large number of species
(*b*) Abundance of endemic species
(*c*) Mostly located in the tropics
(*d*) Mostly located in the polar regions

12. Match the animals given in column I with their location in column II. *[NCERT Exemplar]*

Column I	Column II
A. Dodo	(*i*) Africa
B. Quagga	(*ii*) Russia
C. Thylacine	(*iii*) Mauritius
D. Stellar's sea cow	(*iv*) Australia

Choose the correct match from the following.

(*a*) A-(*i*), B-(*iii*), C-(*ii*), D-(*iv*) (*b*) A-(*iv*), B-(*iii*), C-(*i*), D-(*ii*)

(*c*) A-(*iii*), B-(*i*), C-(*ii*), D-(*iv*) (*d*) A-(*iii*), B-(*i*), C-(*iv*), D-(*ii*)

13. What is common to the following plants: *Nepenthes*, *Psilotum*, *Rauwolfia* and *Aconitum*? [*NCERT Exemplar*]

(*a*) All are ornamental plants

(*b*) All are phylogenic link species

(*c*) All are prone to over exploitation

(*d*) All are exclusively present in the Eastern Himalayas.

14. The one-horned rhinoceros is specific to which of the following sanctuary? [*NCERT Exemplar*]

(*a*) Bhitar Kanika (*b*) Bandipur

(*c*) Kaziranga (*d*) Corbett park

15. Amongst the animal groups given below, which one appears to be more vulnerable to extinction? [*NCERT Exemplar*]

(*a*) Insects (*b*) Mammals

(*c*) Amphibians (*d*) Reptiles

16. Which one of the following is an endangered plant species of India? [*NCERT Exemplar*]

(*a*) *Rauwolfia serpentina* (*b*) *Santalum album* (Sandal wood)

(*c*) *Cycas beddonei* (*d*) All of the above

17. What is common to *Lantana*, *Eichhornia* and African catfish? [*NCERT Exemplar*]

(*a*) All are endangered species of India.

(*b*) All are keystone species.

(*c*) All are mammals found in India.

(*d*) All the species are neither threatened nor indigenous species of India.

18. Keystone species deserve protection because these

(*a*) are capable of surviving in harsh environmental condition

(*b*) indicate presence of certain mineral in the soil.

(*c*) have become rare due to overexploitation.

(*d*) play an important role in supporting other species.

19. Which of the following statements is correct? [*NCERT Exemplar*]

(*a*) *Parthenium* is an endemic species of our country.

(*b*) African catfish is not a threat to indigenous catfishes.

(*c*) Steller's sea cow is an extinct animal.

(*d*) *Lantana* is popularly known as carrot grass.

20. Among the ecosystem mentioned below, where can one find maximum biodiversity? [*NCERT Exemplar*]

(*a*) Mangroves (*b*) Desert (*c*) Coral reefs (*d*) Alpine meadows

21. Genetic diversity in agricultural crops is threatened by

(*a*) intensive use of pesticides (*b*) extensive intercropping

(*c*) intensive use of fertilisers (*d*) introduction of high yielding varieties.

22. Which of the following forests is known as the 'lungs of the planet Earth'? [*NCERT Exemplar*]

(*a*) Taiga forest (*b*) Tundra forest

(*c*) Amazon rainforest (*d*) Rainforests of North East India

23. The active chemical drug reserpine is obtained from: [*NCERT Exemplar*]

(*a*) *Datura* (*b*) *Rauwolfia* (*c*) *Atropa* (*d*) *Papaver*

24. Which of the following group exhibit more species diversity? [*NCERT Exemplar*]

(*a*) Gymnosperms (*b*) Algae (*c*) Bryophytes (*d*) Fungi

25. The historic convention on Biological Diversity held in Rio de Janeiro in 1992 is known as [*NCERT Exemplar*]

(*a*) CITES Convention (*b*) The Earth Summit
(*c*) G-16 Summit (*d*) MAB Programme

26. What is common to the techniques (*i*) in *vitro* fertilisation, (*ii*) Cryopreservation and (*iii*) tissue culture? [*NCERT Exemplar*]

(*a*) All are *in situ* conservation methods.
(*b*) All are *ex situ* conservation methods.
(*c*) All require ultra modern equipment and large space.
(*d*) All are methods of conservation of extinct organisms.

Answers

1. (*a*)	**2.** (*a*)	**3.** (*b*)	**4.** (*d*)	**5.** (*b*)	**6.** (*b*)	**7.** (*a*)	**8.** (*c*)	**9.** (*b*)	**10.** (*a*)
11. (*c*)	**12.** (*d*)	**13.** (*c*)	**14.** (*c*)	**15.** (*c*)	**16.** (*d*)	**17.** (*d*)	**18.** (*d*)	**19.** (*c*)	**20.** (*c*)
21. (*d*)	**22.** (*c*)	**23.** (*b*)	**24.** (*d*)	**25.** (*b*)	**26.** (*b*)				

Assertion-Reason Questions

In the following questions a statement of assertion followed by a statement of reason is given. Choose the correct answer out of the following choices.

(a) Assertion and reason both are correct statements and reason is correct explanation for assertion.
(b) Assertion and reason both are correct statements but reason is not correct explanation for assertion.
(c) Assertion is correct statement but reason is wrong statement.
(d) Assertion is wrong statement but reason is correct statement.

1. Assertion : Tropical rainforests are disappearing fast from developing countries like India.
Reason : No value is attached to these forests because they are poor in biodiversity.

2. Assertion : Tropical rainforest are rich in flora and founa along with microbes on this biosphere.
Reason : The low latitude humid tropics harbor the rainforest ecosystems.

3. Assertion : Biodiversity is declining at an accelerated rate.
Reason : Exotic species cause extinction of endemic species.

4. Assertion : Tropical rainforest are rich in species diversity than temperate forest.
Reason : Frequent glaciation was quite common in temperate region in the part and absent in tropical rainforest.

5. Assertion : IUCN maintains the red list of threatened species to assess conservation of different species.
Reason : Threatened species are those living species which are on the verge of extinction.

6. Assertion : According to broadly utilitarian arguments, biodiversity needs to be conserved as it plays important role in many ecosystem services.
Reason : Species diversity at molecular and genetic levels are explored to obtain products of economic importance.

7. Assertion : Species with high genetic variability are at greater risk of extinction than species with low genetic variability.
Reason : Species with low genetic variability are more vulnerable to predators and environmental challenges.

8. Assertion : Biodiversity loss of a region is only dependent on the human population around the region.
Reason : Overexploitation of a species reduces the size of its population and can eventually lead to its extinction.

9. **Assertion :** Nile Perch introduced into Lake Victoria in east Africa lead to extinction of many species of Cichlid fish.
Reason : When alien species are introduced in a region, they become invasive and cause extinction of indigenous species.

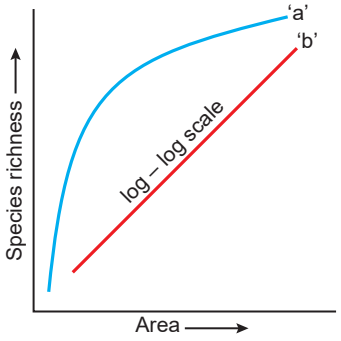
10. **Assertion :** Traditionally, sacred groves acted as repository for various medicines.
Reason : In modern times, sacred groves have become biodiversity rich areas.

Answers

1. (*c*) **2.** (*a*) **3.** (*b*) **4.** (*a*) **5.** (*b*) **6.** (*c*) **7.** (*d*) **8.** (*d*) **9.** (*a*) **10.** (*b*)

Case-based/Source-based Question

1. The following graph shows the species–area relationship. Answer the following questions as directed.



(*i*) Name the naturalist who studied the kind of relationship shown in the graph. Write the observations made by him.

(*ii*) Write the situations as discovered by the ecologists when the value of 'Z' (slope of the line) lies between (*a*) 0.1 and 0.2 (*b*) 0.6 and 1.2.

What does 'Z' stand for?

(*iii*) When would the slope of the line 'b' become steeper?

Ans. (*i*) Alexander von Humboldt.

He observed that within a region, species richness increased with increasing explored area but only up to a limit.

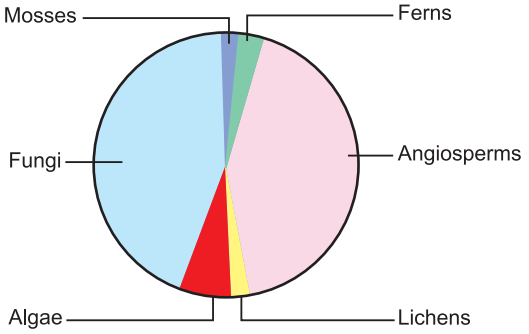
(*ii*) (*a*) The slopes regression lines are similar when unaffected distribution in an area is analysed.

(*b*) The slope of regression is steeper when we analyse the species area relationship among very large areas like entire continent.

Z (slope of the line) is the regression co-efficient.

(*iii*) If species richness is more, *i.e.*, in the range 0.62-1.2.

2. Observe the global biodiversity distribution of major plant taxa in the diagram alongside and answer the questions that follow.



(*i*) Which group of plants are most endangered?

(*ii*) Why are mosses/ferns so few? Give reason.

(*iii*) How do fungi that are heterotrophs sustain themselves as a large population?

(*iv*) Which group of plants is most advanced and which one is most primitive?

Ans. (*i*) Lichens.

(*ii*) Mosses and ferns are few as they need humid conditions in forests that are fast disappearing.

(*iii*) Fungi are able to sustain themselves as a large population because of their wider adaptability to the changing environmental conditions and they grow on dead organic matter.

(*iv*) Most advanced group is of angiosperms and most primitive group is of fungi.

Very Short Answer Questions [1 mark]

Q. 1. Define biodiversity.

Ans. The occurrence of different types of genes, gene pools, species, habitats and ecosystems in a particular place and various parts of earth is called biodiversity.

Q. 2. What is genetic diversity?

Ans. It is the measure of variation in genetic information contained in the organisms.

Q. 3. India has more than 50,000 strains of rice. Mention the level of biodiversity it represents. *[CBSE (AI) 2010]* *[HOTS]*

Ans. 50,000 strains of rice represent genetic biodiversity.

Q. 4. Name the type of biodiversity represented by the following:

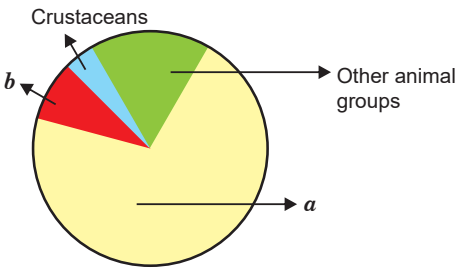
(*i*) 1000 varieties of mangoes in India.

(*ii*) Variations in terms of potency and concentration of reserpine in *Rauwolfia vomitoria* growing in different regions of Himalayas. *[CBSE (AI) 2013]* *[HOTS]*

Ans. (*i*) Genetic diversity

(*ii*) Genetic diversity

Q. 5. Name the unlabelled areas '*a*' and '*b*' of the pie chart (given alongside) representing the global biodiversity of invertebrates showing their proportionate number of species of major taxa. *[HOTS]*



Ans. *a* → Insects;

b → Molluscs

Q. 6. Name the type of biodiversity represented by the following:

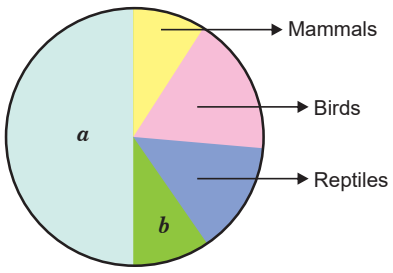
(*i*) 50,000 different strains of rice in India

(*ii*) Estuaries and alpine meadows in India. *[CBSE Delhi 2013]* *[HOTS]*

Ans. (*i*) Genetic diversity

(*ii*) Ecological diversity

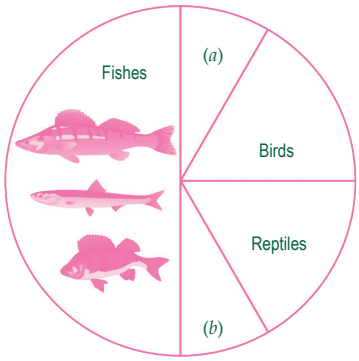
Q. 7. Name the unlabelled areas '*a*' and '*b*' of the pie chart representing biodiversity of vertebrates showing the proportionate number of species of major taxa *[HOTS]*



Ans. *a* → Fishes;

b → Amphibians.

Q. 8. Identify '*a*' and '*b*' in the figure given below representing proportionate number of major vertebrate taxa. [*CBSE Delhi 2014*] [*HOTS*]



Ans. $a \rightarrow$ Mammals
$b \rightarrow$ Amphibians

Q. 9. Name the alien fish species which is posing a threat to the indigenous catfishes in our rivers.

Ans. *Clarias gariepinus* (African catfish)

Q. 10. What is mass extinction?

Ans. Due to natural calamities like volcanic eruptions, prolonged drought, heavy rains, earthquakes, asteroid collision, etc., a large number of species become extinct at the same time which is called mass extinction.

Q. 11. What is meant by alien species?

Ans. Non-native powerful species which invade a new area are known as alien species.

Q. 12. Why is genetic variation important in the plant *Rauwolfia vomitoria*? [*NCERT Exemplar*]

Ans. Genetic variation affects the variation in potency and concentration of the drug reserpine in the medicinal plant *Rauwolfia*.

Q. 13. According to David Tilman, greater the diversity greater is the primary productivity. Can you think of a very low diversity man-made ecosystem that has high productivity. [*NCERT Exemplar*]

Ans. Agricultural fields like wheat field or paddy field which are also examples of monoculture practices.

Q. 14. What is the difference between endemic and exotic species? [*NCERT Exemplar*] [*HOTS*]

Ans. Endemic species are native species restricted to a particular geographical region. Exotic species are species which are introduced from other geographical regions into an area.

Q. 15. Western Ghats have a greater amphibian diversity than the Eastern Ghats. What do you infer from the above two statements? [*HOTS*]

Ans. It can be inferred that Western Ghats have a greater species diversity.

Q. 16. About 200 species of Cichlid fish became extinct when a particular fish was introduced in Lake Victoria of Africa. Name the invasive fish.

Ans. Nile perch.

Q. 17. Name any two sanctuaries in India.

Ans. Keoladeo Ghana bird sanctuary, Bharatpur (Rajasthan) and Periyar sanctuary (Kerala).

Q. 18. What are seed banks?

Ans. The collection of seeds of many different genetic strains of commercially important plants, that are kept viable for longer periods in place are called seed banks.

Q. 19. What is Red Data Book? [*NCERT Exemplar*]

Ans. The Red Data Book is a compilation of data on species threatened with extinction and is maintained by IUCN.

Q. 20. What is the expanded form of IUCN? [*NCERT Exemplar*]

Ans. International Union for Conservation of Nature and Natural Resources.

Q. 21. What are Ramsar sites?

Ans. Ramsar sites are conserved wetlands which are of international importance.

Q. 22. Write the importance of cryopreservation in conservation of biodiversity. [*CBSE Delhi 2011*]

Ans. By cryopreservation, the reproductive parts of rare species can be preserved.

Short Answer Questions [2 marks]

Q. 1. What is the ecological importance of biodiversity?

Ans. The ecological importance of biodiversity:

(*i*) Biodiversity is required for maintaining and sustainable use of goods and services from ecosystem.

(*ii*) Various insects help in pollination.

(*iii*) Various micro-organisms help in the decomposition of organic matter thereby increasing the soil fertility and cleaning the environment.

(*iv*) Various drugs and medicines are extracted from plants.

Q. 2. What does the term genetic diversity refer to? What is the significance of large genetic diversity in a population?

Ans. Genetic diversity is the measure of variety in genetic information contained in the organisms. Significance of large genetic diversity are as follows:

(*i*) Larger genetic diversity provides adaptability at the time of environmental changes and helps the species in surviving.

(*ii*) Larger genetic diversity is also useful in the evolution of species.

Q. 3. State the use of biodiversity in modern agriculture. ***[CBSE (AI) 2011]***

Ans. Biodiversity is a source of hybrids, GM plants, biopesticides, organic farming, biofertiliser, improved varieties of plants, disease resistant plants. (*Any two*)

Q. 4. In the biosphere immense biological diversity exists at all levels of biological organisation. Explain any two levels of biodiversity. ***[CBSE Delhi 2010]***

Ans. Refer to Basic Concepts Point 1.

Q. 5. Mention the kind of biodiversity of more than a thousand varieties of mangoes in India represent. How is it possible? ***[CBSE Delhi 2016]*** ***[HOTS]***

Ans. Thousand varieties of mangoes represent genetic diversity.

This is possible because:

(*i*) Single species show high diversity at genetic level over its distributional range.

(*ii*) Different varieties grow in different geographical areas.

(*iii*) Mutations.

Q. 6. Which region/biome in the world is considered as the 'Lungs of the planet'? Give two reasons for its degradation.

Ans. The Amazon rain forests are considered as the lungs of the planet. They are cut and cleared for cultivation of soya beans. Some part has been converted into grass lands for raising beef cattle.

Q. 7. What is IUCN red list? Give any two uses of this list.

Ans. IUCN red list is a catalogue of species and subspecies that are facing the risk of extinction.

The two uses of this list are:

(*i*) Provides information and develops awareness about the importance of threatened species.

(*ii*) Identification and documentation of endangered species and so measures can be taken for their protection.

Q. 8. Why are conventional methods not suitable for the assessment of biodiversity of bacteria? ***[NCERT Exemplar]***

Ans. Many bacteria are not culturable under normal condition in the laboratory. This becomes a problem in studying their morphological, biochemical and other characterisations which are useful for their assessment. Thus conventional methods are not suitable.

Q. 9. Is it true that there is more solar energy available in the tropics? Explain briefly. ***[NCERT Exemplar]*** ***[HOTS]***

Ans. As one moves from the equator to the polar regions, the length of the day decreases and the length of the night increases. The length of day and night are same at the equator.

Therefore, it is true that there is more solar energy available in the tropics.

Q. 10. List the features that make a stable biological community. **[*CBSE (AI) 2010*]**

Ans. Features of a stable biological community are as follows:

(*i*) Communities should have greater biodiversity for greater stability.

(*ii*) It should be able to prevent invasion by alien species.

(*iii*) It should be able to restore itself in a short period of time.

(*iv*) Variations should be minimal in the community.

Q. 11. Where would you expect more species biodiversity— in tropics or in polar regions? Give reasons in support of your answer. **[*CBSE (AI) 2013*]**

Ans. More biodiversity is found in the tropics. This is because tropical regions remain undisturbed from frequent glaciations as in polar regions. Also, the tropics are less seasonal/more constant.

Q. 12. "Stability of a community depends on its species richness." Write how did David Tilman show this experimentally. **[*CBSE (AI) 2013; 2019 (57/5/1)*]**

Ans. David Tilman found that plots with more species showed less year-to-year variation in total biomass. He also showed that in his experiments, increased diversity contributed to higher productivity.

Q. 13. Why are certain regions on the Earth called hot-spots? Name any two hot-spots in India. **[*CBSE Delhi 2010; (AI) 2013*]**

Ans. Certain regions have been declared as "hot spots" for maximum protection of these regions which have high levels of species richness and high degree of endemism.

Western Ghats and Sri Lanka and Himalayas are two example of hot-spots.

Q. 14. Justify with the help of an example where a deliberate attempt by humans has led to the extinction of a particular species. **[*CBSE Delhi 2011*]**

Ans. When Nile perch, a large predator fish, was introduced in Lake Victoria, it started feeding on the native fish, Cichlid fish. As a result, Cichlid fish became extinct and Nile perch, not finding any food for itself, died too.

Q. 15. Biodiversity must be conserved as it plays an important role in many ecosystem services that nature provides. Explain any two services of the ecosystem. **[*CBSE Delhi 2010*]**

Ans. The two ecosystem services are:

(*i*) Forest ecosystem purify air, mitigate droughts and floods.

(*ii*) The cycling nutrients generate fertile soil and maintains biodiversity.

Q. 16. How is the presently occurring species extinction different from the earlier mass extinctions? **[*NCERT Exemplar*] [*HOTS*]**

Ans. Species extinction occurring at present is due to anthropogenic or man-made causes whereas the earlier extinction was due to natural causes. Present extinction is occurring at 100 – 1000 times fast rate.

Q. 17. In an experiment, the slope of regression (Z) is 0.2 and in another experiment the value obtained is 1.2. Explain the two situations in respect of species area relationships. **[*HOTS*]**

Ans. 0.2 is obtained in studies regardless of the taxonomic group and the region 1.2 is obtained if species area relationship is analysed among very large areas like the entire continents.

Q. 18. Discuss one example, based on your day-to-day observations, showing how loss of one species may lead to extinction of another. **[*NCERT Exemplar*] [*HOTS*]**

Ans. In case a species becomes extinct, the plant and animal species associated within an obligatory way also become extinct. For example,

(*i*) When a fish species which is a host for a number of parasites becomes extinct, the parasite species which are uniquely dependent on the host fish will also become extinct.

(*ii*) The insects may be polyphagous (feed on more than one plant species) or monophagous (feed on only one particular plant species) in nature. The monophagous insect species are valuable and may become extinct if the plant species upon which it feeds becomes extinct.

Q. 19. Would the extinction of one insect pollinator affect the ecosystem? Explain. ***[HOTS]***

Ans. It would affect the ecosystem because insect pollinators form a part of food web. It may lead to co-extinction of species in the case of a co-evolved plant. It is a case of mutualism where extinction of one invariably leads to the extinction of the other.

Q. 20. *Lantana* and *Eichhornia* are examples of two weeds. How do they affect the ecosystem? ***[HOTS]***

Ans. These are examples of Alien species invasions. They threaten the indigenous species and lead to their extinction.

Q. 21. Assess the effects of loss of biodiversity in a region. Mention any four such effects. ***[CBSE Sample Paper 2014, 2015, 2017, 2018]***

Ans. (*i*) Decline in plant production and animal species.

(*ii*) Lowered resistance to environmental perturbations such as drought.

(*iii*) Increased variability in certain ecosystem processes such as plant productivity/water use/ pest and disease cycles.

(*iv*) Increased rate of species extinction.

Q. 22. Explain, giving one example, how co-extinction is one of the causes of loss of biodiversity. List the three other causes also (without description). ***[CBSE (F) 2011]***

Ans. When a species becomes extinct, the plant and animal species associated with it in an obligatory may also become extinct. This is called co-extinction. For example, when a host fish species becomes extinct, its unique assemblage of parasites also becomes extinct.

The three other causes are:

(*i*) Habitat loss and fragmentation, (*ii*) Over-exploitation, (*iii*) Alien species invasion.

Q. 23. Narrowly utilitarian arguments are put forth in support of biodiversity conservation. Explain the other two arguments that are put forth in support of the same cause. ***[CBSE (F) 2016]***

Ans. Refer to Basic Concepts Points 7(*ii*) and (*iii*).

Q. 24. State how does *ex-situ* conservation help in protecting biodiversity. ***[CBSE (F) 2017]***

Ans. Refer to Basic Concepts Point 8 (*ii*)

Q. 25. Differentiate between *in situ* and *ex situ* approaches of conservation of biodiversity. ***[CBSE (AI) 2011]***

Ans. Refer to Table 15.1.

Q. 26. Why are sacred groves highly protected? ***[CBSE (AI) 2016]***

Ans. Sacred groves are highly protected because of religious and cultural traditions. These are refuges for large number of rare and threatened plants. They are ecologically unique and biodiversity rich regions.

Q. 27. List any four techniques where the principle of *ex situ* conservation of biodiversity has been employed. ***[CBSE (AI) 2015]***

Ans. Cryopreservation, *in vitro* fertilisation, micropropagation/tissue culture, sperm bank/seed bank/gene bank.

Q. 28. A particular species of wild cat is endangered. In order to save them from extinction, which is a desirable approach *in situ* or *ex situ*? Justify your answer and explain the difference between the two approaches. ***[HOTS]***

Ans. *Ex situ* is a desirable approach to protect the wild cat. The organism is protected outside their natural habitat where special care is taken to protect them. By using cryopreservation techniques, gametes of threatened species can also be preserved under very low temperature.

For difference, refer to Basic Concepts Point 8.

Q. 29. Seeds of different genetic strains are kept for long periods in seed banks. Explain the conservative strategy involved in this process. ***[HOTS]***

Ans. The strategy is called *Ex-situ* conservation. In this technique, seeds are preserved in viable and fertile condition for long periods using cryopresrvation techniques.

Q. 30. What is cryopreservation? Give its one use. **[*CBSE 2018, 2019 (57/5/1)*]**

Ans. Cryopreservation is a preservation technique in which sperms, eggs, cells, tissues, etc., are stored at ultra-low temperature of −196°C under nitrogen. Cells and gametes of threatened species can also be preserved by this method.

Long Answer Questions–I [3 marks]

Q. 1. Why should biodiversity be conserved? List any two ethical arguments in its support. **[*CBSE (F) 2013*]**

Ans. The biodiversity should be conserved because of the following reasons: (*Any two*)

(*i*) Narrowly utilitarian arguments for deriving direct economic benefit from nature.

(*ii*) Broadly utilitarian arguments as biodiversity plays a major role in many ecosystem services.

(*iii*) Ethical reasons: There is a need to realise that every species has an intrinsic value and we need to pass on our biological legacy to future generations.

Q. 2. Alien species are highly invasive and are a threat to indigenous species. Substantiate this statement with any three examples. **[*CBSE (AI) 2012*]**

Ans. Exotic species are defined as species that have been introduced from another geographic region to an area outside its natural range. For example,

(*i*) *Parthenium*, *Lantana* and *Eichhornia* are the exotic species of plants that have invaded the native species of India and caused environmental damage.

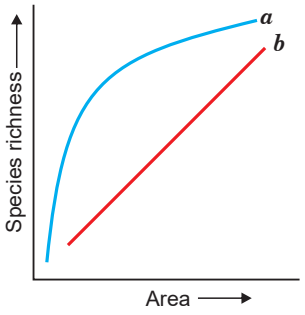
(*ii*) Introduction of African catfish *Clarias gariepinus* for aquaculture purpose is posing threat to many indigenous catfish.

(*iii*) Nile perch introduced into lake Victoria in East Africa led to the extinction of cichlid fish.

Q. 3. Explain 'rivet popper' hypothesis. Name the ecologist who proposed it. **[*CBSE (F) 2011*]**

Ans. Paul Ehrlich proposed the rivet popper hypothesis. This hypothesis states that in an airplane (ecosystem) all parts are joined together using thousands of rivet (species). If every passenger travelling in it starts popping a rivet to take home (causing a species to become extinct), it may not affect flight safety (proper functioning of the ecosystem) initially but as more and more rivets are removed, the plane becomes dangerously weak over a period of time. Also, which rivet is removed may also be critical like loss of rivets on the wings (key species) is more serious threat to flight safety than loss of few rivets on the seats or windows inside the plane.

Q. 4. The given graph alongside shows species–area relationship. Write the equation of the curve '*a*' and explain. **[*CBSE (AI) 2011*]**



Ans. The equation of the curve '*a*' is $S = CA^Z$.

(*i*) Within a region, species richness increases with increasing explored area but only up to a limit.

(*ii*) Relationship between species richness and area for a wide variety of taxa turns out to be rectangular hyperbola.

Q. 5. Compare narrowly utilitarian and broadly utilitarian approaches to conserve biodiversity, with the help of suitable examples. **[*CBSE (F) 2015*]**

Ans. Refer to Basic Concepts Point 7(*i*) & (*ii*).

Q. 6. Many plant and animal species are on the verge of their extinction because of loss of forest land by indiscriminate use by the humans. As a biology student what method would you suggest along with its advantages that can protect such threatened species from getting extinct? **[*CBSE Delhi 2015*] [*HOTS*]**

Ans. *Ex situ* conservation method can be used.
Refer to Basic Concepts Point 8 (*ii*).

Q. 7. There are many animals that have become extinct in the wild but continue to be maintained in Zoological parks.

(*i*) What type of biodiversity conservation is observed in this case?

(*ii*) Explain any two other ways which help in this type of conservation. **[*CBSE Delhi 2014*]**

Ans. (*i*) *Ex-situ* conservation

(*ii*) (*a*) In-vitro fertilisation: Gametes of threatened species can be fertilised for their propagation.

(*b*) Cryopreservation techniques: Gametes of threatened species can be preserved in viable and fertile condition for long periods.

Q. 8. Name and describe any three causes of biodiversity losses. **[*CBSE Delhi 2017*]**

Ans. Refer to Basic Concepts Point 6.

Q. 9. Co-extinction and introduction of alien species too are responsible for the loss of biodiversity. Explain how. **[*CBSE (F) 2017*]**

Ans. Refer to Basic Concepts Points 6 (*iii*) & (*iv*).

Q. 10. '*In situ*' conservation can help endangered/threatened species. Justify the statement.

Ans. In '*in situ*' conservation threatened organisms are conserved in their natural habitat or eco-system, and such regions are legally protected. This has been carried out by identifying certain regions as hotspots, biosphere reserves, national parks, sanctuaries, sacred groves and Ramsar sites. For details, Refer to Basic Concepts Point 8(*i*).

Q. 11. (*a*) "India has greater ecosystem diversity than Norway." Do you agree with the statement? Give reasons in support of your answer.

(*b*) Write the difference between genetic biodiversity and species biodiversity that exists at all the levels of biological organisation. **[*CBSE Delhi 2018*]**

Ans. (*a*) Yes, India has greater ecosystem diversity than Norway because of following reasons.

	India (Tropical Region)	Norway (Temperate Region)
1.	This region is less seasonal and the seasons are more constant.	This region is more seasonal and the seasons and less constant.
2.	Species diversity increases as we move towards equator.	Species diversity decreases as we move away from equator.
3.	The climate in this region promotes niche specialisation resulting in greater biodiversity.	The climate in this region do not promote niche specialistion resulting in lower biodiversity.

(*b*) Genetic diversity refers to the variation within a species over its distributional range.

Species diversity refers to the variation at a species level.

Q. 12. Explain the effect on the characteristics of a river when urban sewage is discharged into it.

Ans. —Rise in organic matter, leads to increased microbial activity/growth of microbes.

—It results in decrease in dissolved oxygen/rise in Biochemical Oxygen Demand.

—Leads to fish mortality/algal bloom/colour change/foul odour/increase in toxicity. (*Any two*)

Long Answer Questions–II [5 marks]

Q. 1. Explain, giving three reasons, why tropics show greatest levels of species diversity. **[*CBSE (AI) 2014*]**

Ans. (*i*) Tropical latitude have remained relatively undisturbed and had a long evolutionary time for species diversification.

(*ii*) Tropical environments have less seasonal variations, more constant and predictable environmental conditions. This promotes niche specialisation for greater species diversity.

(*iii*) There is more availability of solar energy which contributes to higher productivity.

Q. 2. (*a*) Why is there a need to conserve biodiversity?

(*b*) Name and explain any two ways that are responsible for the loss of biodiversity.

[*CBSE (F) 2014*]

Ans. (*a*) Refer to Basic Concepts Point 7.

(*b*) Refer to Basic Concepts Point 6.

Q. 3. (*a*) Why should we conserve biodiversity? How can we do it?

(*b*) Explain the importance of biodiversity hotspots and sacred groves. **[*CBSE Delhi 2016*]**

Ans. (*a*) Refer to Basic Concepts Point 7.

(*b*) Refer to Basic Concepts Point 8.

Q. 4. (*a*) What are the two types of desirable approaches to conserve biodiversity? Explain with examples bringing out the difference between the two types.

(*b*) What is the association between the bumble bee and its favourite orchid *Ophrys*? How would extinction or change of one would affect the other? **[*CBSE Delhi 2012*]**

Ans. (*a*) Refer to Basic Concepts Point 8(*i*) and (*ii*).

(*b*) Commensalism because *Ophrys* employs sexual deceit to get pollination by species of bee as petal of its flower bears resemblance to female of the bee in size, colour and markings and so male bee is attracted to what it perceives as female; *pseudo* copulates with the flower and thus pollinates it. If the female bee's colour patterns change even slightly due to any reason during evolution, pollination success will be reduced unless the orchid flower co-evolves to maintain the resemblance of its petal to the female bee.

Q. 5. (*a*) Taking one example each of habitat loss and fragmentation, explain how are the two responsible for biodiversity loss.

(*b*) Explain two different ways of biodiversity conservation. **[*CBSE (AI) 2012*]**

Ans. (*a*) Refer to Basic Concepts Point 6(*i*).

(*b*) Refer to Basic Concepts Point 8(*i*) and (*ii*).

Q. 6. The graph shows species-area relationship:

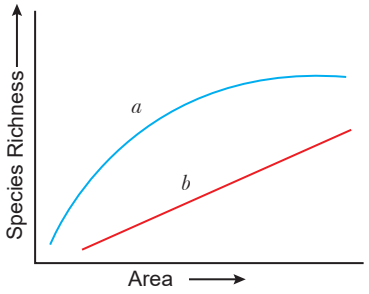
(*a*) If *b* denotes the relationship on log scale-

(*i*) Describe *a* and *b*.

(*ii*) How is slope represented? Give the normal range of slope.

(*iii*) What kind of slope will be observed for frugivorous birds and mammals in a tropical forest?

(*b*) Species diversity of plants (22%) is much less than that of animals (72%). Analyze the reasons for greater diversity of animals as compared to plants.



[*CBSE Sample Paper 2016*]

Ans. (*a*) (*i*) *a* is $S = CA^2$

b is $\log S = \log C + Z \log A$

(*ii*) Slope is Z (regression coefficient). Its normal value ranges from 0.6 to 1.2.

(*iii*) In frugivorous birds and mammals, value of Z=1.15

(*b*) Reasons for greater diversity of animals are:

(*i*) Animals are mobile and can avoid predator or unfavourable event.

(*ii*) Well developed nervous system to receive stimuli against external factors and respond to them.

Self-Assessment Test

Time allowed: 1 Hour **Max. marks: 30**

1. Choose and write the correct option in the following questions. **(3×1 = 3)**

(i) The extinction of passenger pigeon was due to

(a) increased number of predatory birds. (b) over exploitation by humans.

(c) non-availability of the food. (d) bird flu virus infection.

(ii) Which of the below mentioned regions exhibit less seasonal variations?

(a) Tropics (b) Temperates

(c) Alpines (d) Both (a) and (b)

(iii) Biosphere reserves differ from National Parks and Wildlife Sanctuaries because in the former

(a) human beings are not allowed to enter.

(b) people are an integral part of the system.

(c) plants are paid greater attention than animals

(d) living organisms are brought from all over the world and preserved for prosperity.

2. In the following questions a statement of assertion followed by a statement of reason is given. Choose the correct answer out of the following choices. **(3×1 = 3)**

(a) Assertion and reason both are correct statements and reason is correct explanation for assertion.

(b) Assertion and reason both are correct statements but reason is not correct explanation for assertion.

(c) Assertion is correct statement but reason is wrong statement.

(d) Assertion is wrong statement but reason is correct statement.

(i) Assertion : Simplest measure of species diversity is species richness.
Reason : Species diversity refers to variety of species within a region.

(ii) Assertion : Extinction is an unnatural process.
Reason : Extinction has increased due to human activity.

(iii) Assertion : National parks are a method of *in situ* conservation.
Reason : Genetic resources are maintained within natural ecosystems in national parks.

3. Define endemism. **(1)**

4. What are biodiversity hot spots? **(1)**

5. Describe what are sacred groves. **(2)**

6. Explain the 'rivet popper hypothesis'. **(2)**

7. Alien species are a threat to native species. Justify taking examples of an animal and a plant alien species. **(2)**

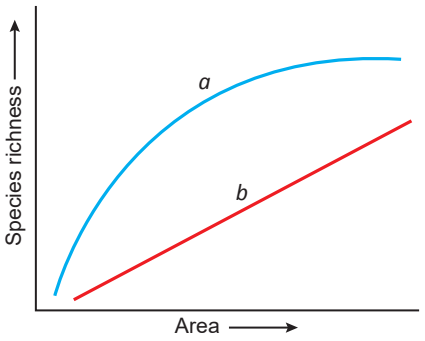
8. Name the type of biodiversity represented by the following:

(i) 1000 varieties of mangoes in India.

(ii) Variations in terms of potency and concentration of reserpine in *Rauwolfia vomitoria* growing in different regions of Himalayas. **(2)**

9. Differentiate between *in-situ* and *ex-situ* approaches of conserving biodiversity. **(3)**

10. The graph shows species-area relationship: **(3 × 1 = 3)**



If b denotes the relationship on log scale-

(i) Describe a and b.

(ii) How is slope represented? Give the normal range of slope.

(iii) What kind of slope will be observed for frugivorous birds and mammals in a tropical forest?

11. Why certain regions have been declared as biodiversity "hotspots" by environmentalists of the world? Name any two "hotspot" regions of India. **(3)**

12. Write a note on the efforts for the conservation of biodiversity in India. **(5)**

Answers

1. (*i*)—(*b*), (*ii*)—(*a*), (*iii*)—(*b*) **2.** (*i*)—(*a*), (*ii*)—(*d*), (*iii*)—(*a*)

Chapter–16

Environmental Issues

basic concepts

1. Pollution

- **Pollution** is defined as an undesirable change in physical, chemical or biological characteristics of air, land, water or soil.
- **Pollutants** are the agents which bring about an undesirable change in the properties of air, water and soil.
- The Government of India has passed the **Environment (Protection) Act, 1986** to protect and improve the quality of environment. (air, water and soil)

2. Air Pollution

- Any undesirable change in the physical, chemical and biological characteristics of air that exert adverse effects on living beings is defined as **air pollution**.

(i) Causes

(*a*) Smoke from forest fires, volcanic eruptions, etc.

(*b*) Decomposition of garbage resulting in release of unwanted gases into the atmosphere.

(*c*) Burning of fossil fuels in automobiles and industries release particulate and air pollutants.

(*d*) Use of leaded petrol.

(*e*) Gaseous wastes or particulate matter as by-products of various industries.

(*f*) Smoke stacks of thermal power plants, smelters and other industrial release, particulate and gaseous air pollutants with harmless gases like N_2, O_2, etc.

(ii) Air pollutants

- Air pollutants can be classified into two groups:

(*a*) Particulate pollutants, *e.g.*, metallic particles, dust particles, soot, aerosol and smoke.

(*b*) Gaseous pollutants, *e.g.*, carbon monoxide (CO), nitrogen dioxide (NO_2), hydrogen sulphide (H_2S), sulphur dioxide (SO_2), etc.

(iii) Harmful effects

- The harmful effects of air pollutants depend on (*i*) concentration of pollutants, (*ii*) duration of exposure, and (*iii*) the organism being exposed.

(*a*) Carbon monoxide causes giddiness, headache, decreased vision, cardiovascular malfunction and asphyxia.

(*b*) Hydrogen sulphide causes nausea, eye and throat irritation.

(*c*) **Sulphur dioxide** causes respiratory tract diseases like asthma, bronchitis, cancer, emphysema, etc.

(*d*) In plants, air pollution reduces growth and yield and leads to premature death.

(*e*) **Fine particulates** cause breathing and respiratory problems, irritation, inflammation and damage to the lungs.

(iv) Control methods of air pollution

(a) Electrostatic precipitator (ESP)

- It is an electrical device used to remove particulate matter present in the exhaust of thermal power plant.
- More than 99% particulate matter can be removed by this method.
- ESP has electrode wires and a stage of collecting plates.
- Electrode wires are provided with an electric current of several thousand volts, which produces a corona that releases electrons.
- These electrons attach to dust particles and give them a negative charge within a very small fraction of a second.
- Collecting plates are earthed so that they attract charged dust particles.
- The velocity of air passing through plates is slow enough to allow the dust particles to fall.

■ **Limitations/Disadvantages:** Very small particulate matters are not removed by these precipitators.

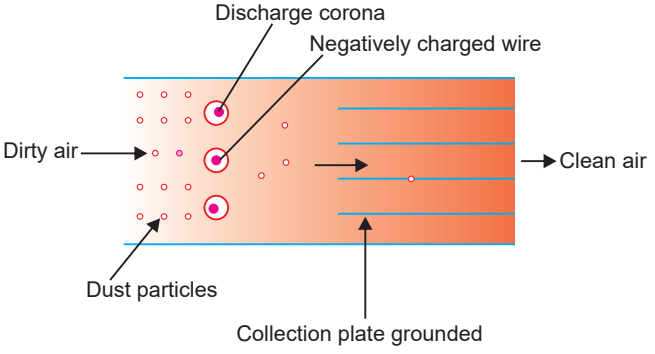


Fig. 16.1 Electrostatic precipitator

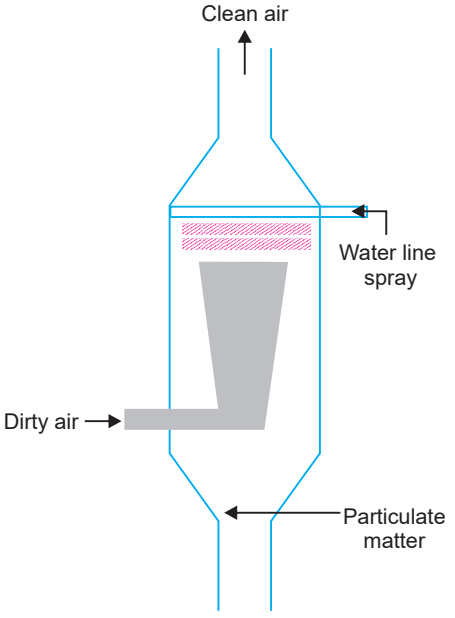


Fig. 16.2 Scrubber

(b) Scrubber

- It is used to remove gases like sulphur dioxide from industrial exhaust.
- The exhaust is passed through a spray of water or lime.
- Water dissolves gases and lime reacts with sulphur dioxide to form a precipitate of calcium sulphate and sulphide.

(c) Catalytic converters

- These are fitted into automobiles for reducing emission of poisonous gases like NO_2 and CO.
- They have expensive metals like platinum–palladium and rhodium as catalysts.

- As the exhaust emission passes through catalytic converter, nitric oxide splits into nitrogen and oxygen; carbon monoxide is oxidised to carbon dioxide and unburnt hydrocarbons get burnt completely into CO_2 and H_2O.
- Motor vehicles fitted with catalytic converter should use unleaded petrol as lead in petrol inactivates the catalyst.

(v) Control of air pollution in Delhi

- In 1990's Delhi ranked 4th among 41 most polluted cities of the world. A Public Interest Litigation (PIL) was filed in the Supreme Court.
  - All buses of Delhi were converted to run on CNG by the end of 2002 as per the directives of the Supreme Court.
  - Advantages of CNG over diesel/petrol:
    (*a*) CNG burns most efficiently without leaving any unburnt remnant behind.
    (*b*) CNG is cheaper than petrol or diesel.
    (*c*) CNG cannot be siphoned off by thieves and adulterated like petrol or diesel.
  - Some other steps to reduce vehicular pollution:
    (*a*) Phasing out of old vehicles.
    (*b*) Use of unleaded petrol.
    (*c*) Use of low-sulphur petrol and diesel.
    (*d*) Use of catalytic converters in vehicles.
    (*e*) Applying stringent pollution level norms for vehicles.
    (*f*) Opting for car pooling whenever possible.
    (*g*) Promoting public transport by Government of India to cut down vehicular pollution.

Auto Fuel Policy

(*a*) Euro II norms were stipulated to control sulphur content at 350 ppm in diesel and 150 ppm in petrol and aromatic hydrocarbons are to be contained at 42%.
(*b*) Goal being to reduce sulphur to 50 ppm in petrol and diesel and bring down to 35%.
(*c*) According to it, all automobiles were to meet the Euro III emission specifications in eleven Indian cities by April 1, 2005 (Delhi, Mumbai, Kolkata, Chennai, Bangalore, Hyderabad, Ahmedabad, Puna, Surat, Kanpur, Agra).
(*d*) These eleven new cities have maintained the Euro IV norms since April 1, 2010.
(*e*) Rest of the country have met Euro III norm complaint vehicles by 2010.

- **Air (Prevention and Control of Pollution)** Act, came into force in India in 1981, but was amended in 1987 to include noise as an air pollutant.

3. Noise Pollution

- Noise is defined as undesired high level of sound.

(i) Causes

(*a*) Loudspeakers, music systems and TV, used for entertainment.
(*b*) Jet planes and rockets (release 150 dB or more sound)
(*c*) Industrial noises
(*d*) Social functions
(*e*) Crackers, detonations

(ii) Harmful effects (Psychological and Physiological disorders)

(*a*) Sleeplessness (*b*) Stress

(*c*) Increased rate of heartbeat and hypertension
(*d*) Breathing problems
(*e*) Damage of ear drums impairing hearing ability permanently (by the sound of jet plane/rocket or chronic exposure to sound).
(*f*) Gastric problems—nausea
(*g*) Emotional disturbance

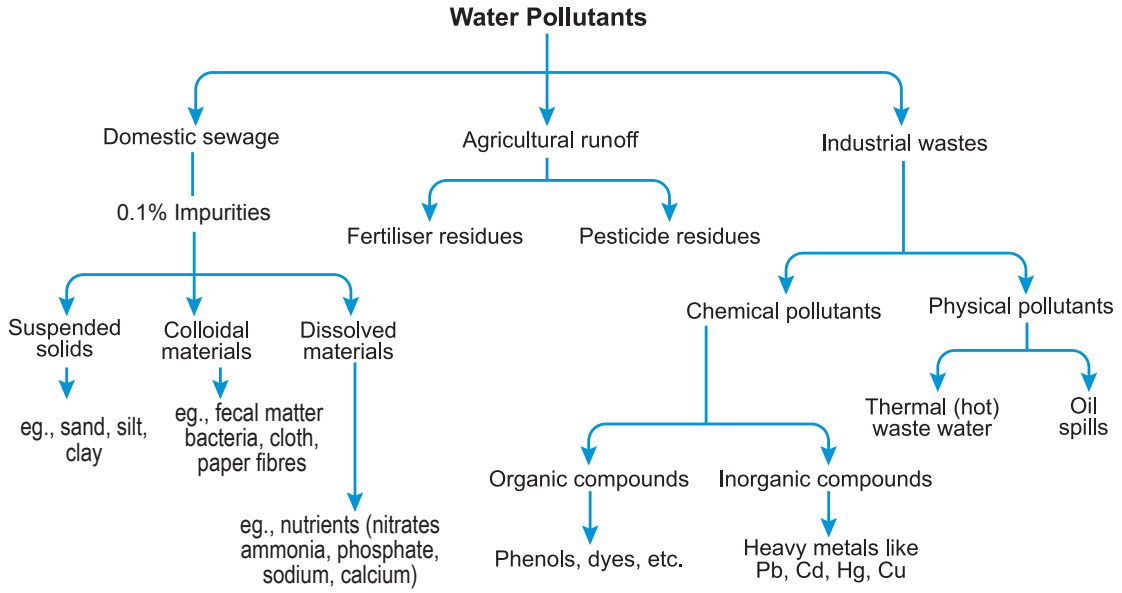
(iii) Control methods

(*a*) Industrial noise can be reduced by using sound-absorbent materials or by muffling noise.
(*b*) Delimitation of horn-free zones around hospitals and schools.
(*c*) Stringent laws should be laid for permissible sound levels of crackers and loudspeakers.
(*d*) Setting timing after which loudspeakers cannot be played.

4. Water Pollution

- **Water pollution** is defined as any undesirable change in the physical, chemical and biological properties of water that may affect the human beings and domestic species.
- The Government of India has passed the **Water (Prevention and Control of Pollution) Act, 1974,** to safeguard our water resources.

Table 16.1: Sources of Water Pollution and its Effects on Living Organisms



(i) Domestic sewage

- It includes everything that comes from residential area to common public sewage system.
- Domestic sewage contains
  —Suspended solids, *e.g.*, sand, silt and clay.
  —Colloidal materials, *e.g.*, faecal matter, bacteria, paper and cloth fibres.
  —Dissolved materials, *e.g.*, nitrates, ammonia phosphate, sodium, calcium salt.
- Domestic sewage mainly contains biodegradable organic wastes which are readily decomposed with the help of decomposers.
- It is possible to estimate the amount of organic matter in sewage water by measuring Biological Oxygen Demand.

(ii) Industrial wastes

- Industries like petroleum, paper manufacturing, metal extraction, processing, etc., release waste water containing heavy metals like mercury and many organic compounds.
- Mercury and DDT are well known for biological magnification.
- **Biological magnification** or **biomagnification** is defined as increase in concentration of toxicants at successive trophic levels of a food chain.
- Toxic substances cannot be metabolised or excreted, therefore they get accumulated in an organism and passed on to higher trophic levels.
- **Effects of DDT accumulation in birds:** Calcium metabolism in birds is disturbed, which results in thinning of eggshell their, premature breaking and this leads to decline in bird population.

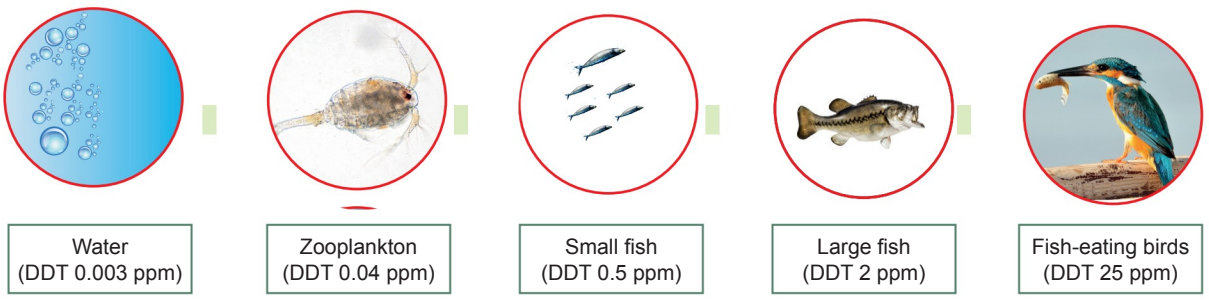


Fig. 16.3 Biomagnification of DDT in an aquatic food chain

5. Some Important Terms

(i) Eutrophication

- It is defined as the natural aging of a lake by biological enrichment of its water.
- Water in a young lake is cold and clear to support life.
- With time, it is enriched with nutrients like nitrogen and phosphorus by streams draining into it.
- This encourages growth of aquatic life—plant and animal life.
- Organic remains deposit at the bottom of the lake and with time makes the water warmer and shallower.
- Marsh plants take root in the shallows and begin to fill in original lake basin.
- Eventually, floating plants develop in the lake, finally converting it into land.
- According to climate, size of the lake and other factors, natural ageing of lake may span up to thousands of years.
- The accelerated aging of lakes due to sewage, agricultural and industrial wastes is called **cultural** or **accelerated eutrophication**.
- **Prime contaminants are** nitrates and phosphates (plant nutrients) that overstimulate algal growth. This causes unsightly scum, unpleasant odour, etc. Which depletes the amount of dissolved oxygen. Other pollutant may also poison fish, whose decomposing remains further depletes the dissolved O_2 and thus choke a lake to death.

  Heated (thermal) waste waters flowing out of electricity generating units like thermal power plants also act as pollutants.
- **Effect:** (*i*) Eliminate or reduce number of organisms sensitive to high temperature.
  (*ii*) Enhance growth of plant and fish in extremely cold areas.
  (*iii*) Cause damage to indigenous flora and fauna.

(ii) BOD (Biochemical Oxygen Demand)

- The amount of oxygen required for microbial breakdown of biodegradable organic matter is called **BOD**.
- It is higher in polluted water and lesser in drinking water.
- Microorganisms use lot of oxygen for degradation of organic matter and thus there is sharp decline in dissolved oxygen downstream from point of sewage discharge. This causes mortality of fish and other aquatic life.

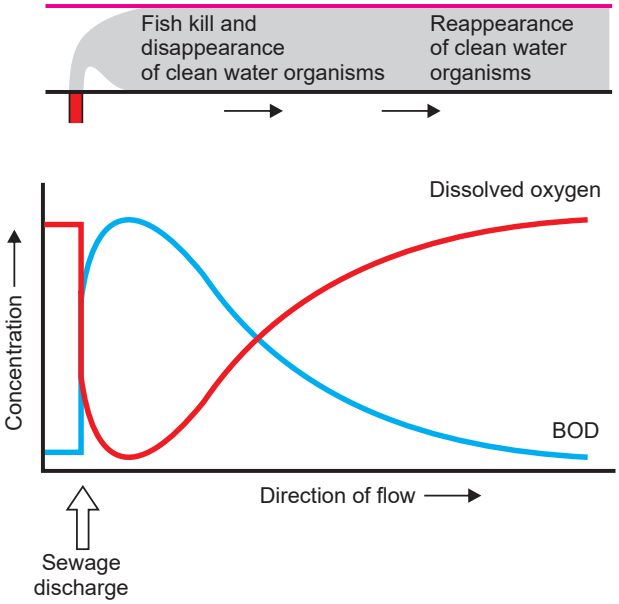


Fig. 16.4 Effect of sewage discharge on some important characteristics of a river

(iii) Algal bloom

- Domestic sewage contains nutrients like nitrogen and phosphorus which favour the excessive growth of planktonic (free-floating) algae called as **algal bloom**.
- Algal bloom causes fish mortality and deterioration of water quality.
- Some algae are toxic to humans and animals as well.
- **Water hyacinth** (*Eichhornia crassipes*), the world's most problematic aquatic weed, also called **"Terror of Bengal"**, grows abundantly in **eutrophic** water bodies and imbalances water ecosystem.
- ***Eichhornia*** was introduced into India for its lovely mauve coloured flowers but caused havoc due to excessive growth that caused blockage in waterways as well.

6. Integrated Waste Water Treatment

- In the town of Arcata, situated on northern coast of California, an integrated waste water treatment process was developed with the help of biologists from Humboldt State University.
- The cleaning occurs in two stages:
  - (*i*) The conventional sedimentation, filtration and chlorine treatments are given. The treated water still contains lots of heavy metals and other dangerous pollutants.
  - (*ii*) Biologists developed series of six connected marshes over 60 hectares of marshland. Appropriate plants, algae, fungi and bacteria were grown in this marshland and these life forms neutralise, absorb and assimilate the pollutants and purify the water naturally.

(*iii*) Marshes also constitute a sanctuary, with high level of biodiversity in the form of fish, animals and birds that now reside there.

- Citizens group called **Friends of the Arcata Marsh** (FOAM) are responsible for the upkeep and safeguarding of this project.
- **'Ecosan'** toilets have been developed in areas of Kerala and Sri Lanka for **ecological sanitation**.
- **Advantages of ecological sanitation:**
  (*i*) It is a practical, hygienic and efficient method of human waste disposal.
  (*ii*) It is cost effective.
  (*iii*) Human excreta can be recycled into natural fertiliser to replace chemical fertiliser.

7. Solid Wastes

- These are discarded solid materials which are produced due to various human activities.
- Solid wastes can be biodegradable, recyclable or non-biodegradable.
- Solid wastes can be of the following types:
  (*i*) Municipal solid wastes: Wastes from homes, offices, schools, hospitals, etc., that are collected and disposed by the municipality which generally consists of paper, leather, textile, rubber, glass, etc.
  (*ii*) Industrial wastes: The wastes like scraps, fly ash, etc., generated by industries.
  (*iii*) Hospital wastes: Hazardous wastes containing disinfectants and other harmful chemicals, pathogenic microbes, generated by hospitals.
  (*iv*) Electronic wastes (e-wastes): These are the damaged electronic goods and irreparable computers.
  (*v*) Polystyrene and plastic packaging, used for fruits, vegetables, biscuits, milk, etc.

8. Methods of Solid Waste Disposal

(*i*) Open burning: Municipal waste is reduced by burning in open dumps but the unburnt waste serve as the breeding ground for rats and flies.

(*ii*) Sanitary landfills: Wastes are dumped in a depression or trench after compaction and covered with dirt. But seepage of chemicals from these landfills can pollute underground water resources. Landfills are also getting filled.

(*iii*) Rag-pickers and *kabadiwallahs*: Wastes are collected and separated out into reusable or recyclable categories.

(*iv*) Natural breakdown: The biodegradable materials are kept into deep pits in the ground for natural breakdown.

(*v*) Recycling: E-wastes can be recycled in specifically built factories or manually to recover important metals like copper, iron, silicon, nickel and gold but in eco-friendly manner. Recycling in developing countries involve manual participation, exposing workers to toxic substances present in e-waste.

(*vi*) Incineration: Majority of e-wastes generated in developed world is exported to developing world (mainly China, India, Pakistan) where they are incinerated. Incinerators are crucial for disposal of hospital wastes.

Remedy for Plastic Waste

- A fine powder of recycle modified plastic is called **polyblend**. Polyblend has been mixed with bitumen to lay roads in Bangalore. Polyblend was made by company of Ahmed Khan who had been producing plastic sacks for 20 years.
- Polyblend enhanced bitumen's water repellent properties and helped increase the life of road.
- Against the cost of ₹ 0.40/kg for plastic waste, Ahmed Khan now offers ₹ 6/kg.

9. Soil Pollution

- Undesirable changes in soil profile affecting its productivity is called **soil pollution**.

(i) Causes

- Chemical seepage from industries.
- Inorganic fertilisers and pesticides, herbicides, etc.

(ii) Harmful effects

- Non-target organisms in the soil are killed.
- Soil becomes infertile.
- Pesticides can result in biomagnification.
- Eutrophication.

(iii) Control methods

(*a*) **Safe disposal of industrial wastes.**

(*b*) **Organic farming:** It is a cyclical, zero-waste procedure where waste products from one process are cycled in as nutrients for other processes, allowing maximum utilisation of resource and increasing the efficiency of production.

Case Study of Integrated Organic Farming

- Integrated organic farming is a cyclical, zero-waste procedure, where waste products from one process are cycled in as nutrients for other processes.
- **Ramesh Chandra Dagar** from Sonipat is making maxmium use of resources and his work includes bee-keeping, dairy management, water harvesting, composting and agriculture in a chain of processes that support each other and allows economical and sustainable venture.

Advantages of Organic Farming

- Chemical fertilisers are not required because cattle excreta is used as manure.
- Crop waste is used for making compost which is used as natural fertiliser.
- Compost generates natural gas which is used for energy needs on farm.
- Dagar has created 'Haryana Kisan Welfare Club' with membership of 5000 farmers.

10. Radioactive Pollution

- Nuclear energy was assumed to be a natural, non-polluting way of electricity generation till the incidents at Three Mile Island and Chernobyl. It is now considered as the most potent pollutant.

(i) Causes

- Leakage of radioactive materials from power plants.
- Unsafe disposal of radioactive wastes.

(ii) Harmful effects

- Radiations from nuclear wastes cause mutations at a very high rate.
- In high doses, nuclear radiations are lethal.
- In low doses, radiations cause disorders and cancer and hence is a potent pollutant.

(iii) Disposal of radioactive waste

- Nuclear waste should be pre-treated and stored in shielded containers and then buried about 500 m deep below earth's surface. This method is meeting stiff opposition.

11. Greenhouse Effect

- The phenomenon of keeping the earth warm due to presence of certain gases (CO_2, NO_2, CH_4, CFC's) in the atmosphere is called **greenhouse effect**.
- One-fourth of the incoming solar radiation is reflected by the atmospheric gases and clouds and only half of the incoming solar radiation falls on the earth's surface, heating it. Of this, only a small portion is reflected back.
- **Greenhouse gases** (CO_2, CH_4, N_2O, chlorofluorocarbons or CFCs) allow the solar radiations to enter but prevent the escape of heat radiations of longer wavelength.
- The absorbed radiations again come to earth's surface and heat it up. This cycle is repeated many times, considerably heating the Earth.
- Greenhouse gases absorb long wave (infrared) radiation from earth and emit it again towards the earth. Cycle continues till the earth's surface has no long wave radiation to emit.
- CO_2 and methane are called as Greenhouse gases because they are responsible for the greenhouse effect.

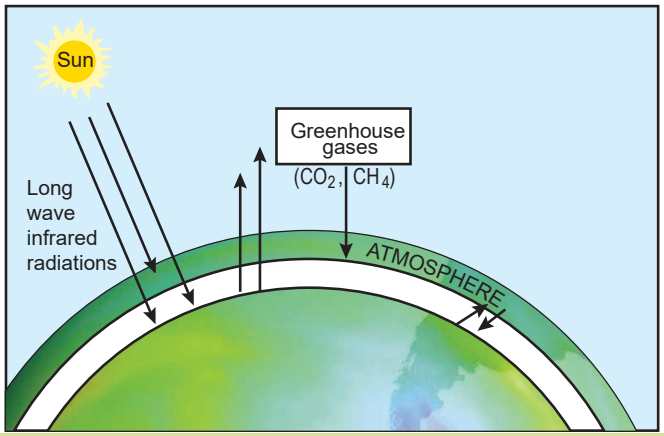


Fig. 16.5 Sunlight energy at the outermost atmosphere

12. Global Warming

- The gradual continuous increase in average temperature of surface of the Earth as a result of increase in concentration of greenhouse gases is termed as **global warming**.

(i) Cause

- Increase in the level of greenhouse gases (CO_2, methane, etc.) in the atmosphere. These gases allow the heat waves to reach earth but prevent their escape and thus the earth becomes warm.

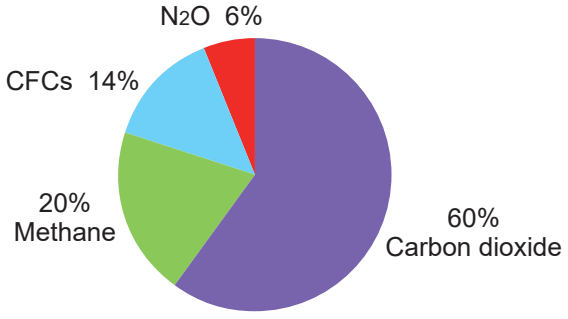


Fig. 16.6 Relative contribution of various greenhouse gases to global warming

(ii) Effects

- The temperature of the earth has increased by 0.6°C in the last three decades, which will lead to changes in precipitation patterns.
- Rise in temperature leads to deleterious changes in environment resulting in odd climatic changes called **El Nino effect**.
- The rise in temperature will lead to the increased melting of polar ice caps which will cause the rise in sea level and many coastal areas will be submerged.
- Increased temperature will lead to increased weed growth, eruption of diseases and pests. Thus, crop productivity will decrease.

(iii) Control of global warming

- Global warming can be controlled by:
  (*a*) Reducing deforestation
  (*b*) Planting trees (afforestation)

(*c*) Slowing down the growth of human population
(*d*) Reduction of emission of greenhouse gases into the atmosphere
(*e*) Cutting down use of fossil fuels
(*f*) Improving efficiency of energy usage.
(*g*) International initiatives requited to reduce emission of greenhouse gases into atmosphere.

13. Ozone Depletion in the Stratosphere

- Ozone is of two types:
  - **(*i*) 'Bad' ozone:** formed in troposphere and is harmful to plants and animals.
  - **(*ii*) 'Good' ozone:** formed in stratosphere and absorbs harmful UV radiations from the Sun.
- The thickness of ozone is measured in **Dobson units (DU)**.

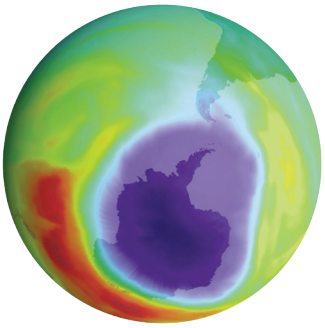


Fig. 16.7 Ozone hole is the area above Antarctica, shown in purple colour, where the ozone layer is the thinnest. Ozone thickness is given in Dobson unit (see carefully the scale shown in colour violet to red). The ozone hole over Antarctica develops each year between late August and early October.

(i) Formation of ozone

- Nascent oxygen combines with molecular oxygen (O_2) to form ozone by the action of UV rays.

$$\underset{\text{Molecular oxygen}}{O_2} \xrightarrow{UV} [O] + \underset{\text{Nascent oxygen}}{[O]}$$

$$O_2 + [O] \xrightarrow{UV} \underset{\text{Ozone}}{O_3}$$

- Ozone is degraded into molecular oxygen in the stratosphere by UV action to maintain a balance between production and degradation.

$$O_3 \xrightarrow{UV} O_2 + [O]$$

$$O_2 + [O] \xrightarrow{UV} O_3$$

(ii) Cause of ozone depletion

(*a*) Ozone degradation has increased due to chlorofluorocarbons (CFCs).
(*b*) CFCs are used as refrigerants, react with UV rays in stratosphere to release chlorine atoms.
(*c*) Chlorine atoms act as catalyst to degrade ozone and release molecular oxygen,

(*i*) $CFCl_3 \xrightarrow{UV-C} CFCl_2 + Cl$ (*ii*) $CFCl_2 \xrightarrow{UV-C} CFCl + Cl$

(*iii*) $Cl + O_3 \longrightarrow ClO + O_2$ (*iv*) $ClO + \underset{\text{(Ozone depletion)}}{O_3} \longrightarrow Cl + 2O_2$

(*d*) CFCs have permanent and continued effect as chlorine atoms are not consumed.
(*e*) Over the Antarctic region, there has been thinning of large area of ozone layer that has resulted in formation of **ozone hole**.

(iii) Harmful effects

(*a*) UV radiations of wavelength shorter than UV-B are almost completely absorbed by Earth's atmosphere.
(*b*) UV-B rays damage DNA and proteins of living organisms causing mutation.
(*c*) It causes skin aging, skin cell damage and skin cancers.
(*d*) UV-B rays are absorbed by human eye and in high dose, they cause inflammation of cornea. This is called **snow-blindness** cataract and it may damage cornea permanently.

(iv) Control of ozone depletion

(*a*) An international treaty, **Montreal Protocol**, was signed at Montreal, Canada, in 1987 to curb the emission of ozone depleting substances.

(*b*) More protocols have been laid down in controlling emission of CFCs and other ozone depleting chemicals.

14. Degradation by Improper Resource Utilisation and Maintenance

(i) Soil erosion and desertification

- Development of fertile top soil takes centuries.
- The fertile top-soil is removed by human activities like over-cultivation, unrestricted grazing, deforestation and poor irrigation practices.
- This leads to formation of arid patches of land.
- These large barren patches when left for a long time, form deserts.
- Desertification has become a major problem due to increased urbanisation.

(ii) Water logging and soil salinity

- Water logging in soil results from irrigation without proper drainage of water.
- This affects the plants and draws salts to the soil surface.
- The salt is either deposited as a layer on land surface or collects at roots of plants.
- Increased salt concentration damages agriculture.
- This is one of the problems arising due to Green Revolution.

15. Deforestation

- **Deforestation** is defined as the conversion of forested areas to non-forested area.
- Removal of forest areas to fulfil the need of growing human population is called deforestation.
- Almost 40 per cent forests have been lost in the tropics and 1 per cent forests in the temperate region.
- In India, at the beginning of the twentieth century, forests covered about 30 per cent of land whereas by the end of the century, it shrunk to 19.4 per cent.
- **The National Forest Policy** (1988) of India has recommended 33 per cent forest cover for the plains and 67 per cent for the hills.

(i) Causes for deforestation

(*a*) Human settlements

(*b*) Forest fires

(*c*) Hydroelectric projects

(*d*) Over-grazing by livestock

(*e*) Demand for wood, timber

(*f*) **Jhum cultivation or slash and burn agriculture:** The farmers cut the forest trees and burn the plant remains. The land is then used for farming or cattle grazing. After cultivation, the land is left barren for years to allow its recovery. The farmer then moves to other areas and repeat the process with increasing population and repeated cultivation, recovery phase is not being provided, causing deforestation.

(ii) Effects of deforestation

(*a*) Increase in carbon dioxide concentration in atmosphere.

(*b*) Loss of biodiversity due to habitat destruction.

(*c*) Disturbance in hydrologic cycle.

(*d*) Soil erosion that may lead to desertification.

Reforestation

- It is the process of restoring a forest that once existed but was removed at some point of time in the past. It may occur naturally in a deforested area.
  - We can plant trees; considering biodiversity that earlier existed in that area.

People's Participation in Conservation of Forests

- In 1731, a Bishnoi woman **Amrita Devi,** showed exemplary courage by hugging a tree in order to prevent its cutting. Her three daughters and hundreds of other Bishnois followed her and were killed by soldiers of king of Jodhpur. But the King's men cut down the Tree along with Amrita Devi and others.
- The Government of India has instituted **Amrita Devi Bishnoi Wildlife Protection Award** for individuals or communities from rural areas that shows extraordinary courage and dedication in protecting wildlife.
- ***Chipko* Movement** was started in Garhwal, Himalayas in 1974 by Shri Sundar Lal Bahuguna to prevent cutting down of trees. Local women hugged trees to prevent their cutting by the contractors.
- In 1980, the Government of India has introduced the concept of **'Joint Forest Management'** (JFM) to work closely with the local communities for protecting and managing forests. In return for their services to the forest the communities get benefit of various forest products like fruits, gum, rubber, medicines etc.

NCERT Textbook Questions

Q. 1. What are the various constituents of domestic sewage? Discuss the effects of sewage discharge on a river.

Ans. The various constituents of domestic sewage are:

(*i*) Suspended solids: Grit made up of sand, silt and clay.

(*ii*) Colloidal materials: Including faecal matter, bacteria, paper fibres, cloth fibres, etc.

(*iii*) Dissolved solids: They are inorganic nutrients (*e.g.*, nitrates, ammonium salts, calcium salts), toxic metal ions and organic compounds.

(*iv*) Pathogens: A number of pathogens cause various diseases like typhoid, cholera, dysentery, etc.

Effect of sewage discharge on a river:

Domestic sewage mainly contains biodegradable organic wastes which are decomposed by decomposers like bacteria and other micro-organisms. Decomposers require oxygen for their activity and hence BOD (Biochemical Oxygen Demand) increases. Many aquatic organisms die due to lack of dissolved oxygen. Domestic sewage contains nitrogen and phosphorus which favour the excess growth of algae called algal bloom. Excessive growth of water hyacinth causes imbalance in water ecosystem and thus aquatic animals die.

Q. 2. List all the wastes that you generate, at home, school or during your trips to other places, could you very easily reduce? Which would be difficult or rather impossible to reduce?

Ans. Wastes are used up, unwanted and discarded materials which have to be disposed off.

(*i*) Wastes generated at home include kitchen waste, food left-overs, old and torn clothes, paper, polythene bags, plastic bags, carry bags, broken glass, carton boxes, tissue papers, etc.

(*ii*) Wastes generated at school include pens, papers, chalk, plastic envelopes, polythene, food wrappers, waste food, etc.

(*iii*) Wastes generated during trips include food wrappers, waste papers, polythene, disposable plates, spoons, cups, discarded food, etc.

Yes, we can reduce most of the wastes by its judicious use. Biodegradable wastes include all articles of organic origin, *i.e.*, food wastes, waste paper, wood, leather articles and disposable articles which will be broken down by micro-organisms. Non-biodegradable wastes can be recycled and often taken away by rag-pickers. It is difficult to reduce non-biodegradable wastes.

Q. 3. Discuss the causes and effects of global warming. What measures need to be taken to control global warming?

Ans. Refer to Basic Concepts Point 12.

Q. 4. Match the items given in column A and B.

Column A	Column B
(*a*) Catalytic converter	**(*i*) Particulate matter**
(*b*) Electrostatic precipitator	**(*ii*) Carbon monoxide and nitrogen oxides**
(*c*) Earmuffs	**(*iii*) High noise level**
(*d*) Landfills	**(*iv*) Solid wastes**

Ans. (*a*)–(*ii*), (*b*)–(*i*), (*c*)–(*iii*), (*d*)–(*iv*).

Q. 5. Write critical notes on the following:

(*a*) Eutrophication **(*b*) Biological magnification**

(*c*) Groundwater depletion and ways for its replenishment.

Ans. **(*a*) Eutrophication:** Refer to Basic Concepts Point 5(*i*).

(*b*) Biological magnification: Unknowingly some harmful chemicals enter our bodies through the food chain. We use several pesticides and other chemicals to protect our crops from diseases and pests. These chemicals are either washed down into the soil or into the water bodies. From the soil, these are absorbed by the plants along with water and minerals, and from the water bodies these are taken up by aquatic plants and animals. This is one of the ways in which they enter the food chain. As these chemicals are not degradable, these get accumulated progressively at each trophic level. As human beings occupy the topmost level in any food chain, the maximum concentration of these chemicals get accumulated in our bodies. This phenomenon is known as biological magnification.

(*c*) Groundwater depletion and ways for its replenishment: Groundwater is depleting due to various reasons like deforestation, agricultural use, daily use at home, etc. Groundwater level is going down in several states due to its unjudicious use. Replenishment of groundwater can be done by rainwater harvesting and reforestation. Rainwater can be collected on the roof top of the buildings and can be stored underground for later use.

Q. 6. Why ozone hole forms over Antarctica? How will enhanced ultraviolet radiation affect us?

Ans. In Antarctica, winter months receive no sunlight and thus the temperature is extremely low (–85°C). It facilitates the formation of ice clouds which provide the catalytic surface on which the chlorine atoms react with ozone and degrade it. This happens with the return of sun to Antarctica in spring (September and October). Therefore, an ozone hole appears in Antarctica in spring.

Enhanced ultraviolet radiation will cause the following effects:

(*i*) Damage skin cells, ultimately leading to skin cancer.

(*ii*) Mutation will result due to damage of DNA.

(*iii*) Malfunctioning of immune system.

Q. 7. Discuss the role of women and communities in protection and conservation of forests.

Ans. Women and communities played an important role in protection and conservation of forests. In 1731, a Bishnoi woman, Amrita Devi showed exemplary courage by hugging a tree to prevent its cutting. Amrita Devi Bishnoi Wildlife protection Award is being awarded by the Government of India to individuals or communities from rural areas that show extraordinary courage and dedication in protecting wildlife. In Garhwal, local women hugged trees to prevent the contractor from cutting down trees.

Q. 8. What measures, as an individual, you would take to reduce environmental pollution?

Ans. I will take following measures to reduce environmental pollution:

(*i*) Use of renewable energy resources.

(*ii*) Use of television and other instruments, at low pitch.

(*iii*) Minimum use of fossil fuel.

(*iv*) No tobacco smoking.

(*v*) Planting more trees.

Q. 9. Discuss briefly the following:

(*a*) Radioactive wastes

(*b*) Defunct ships and e-wastes

(*c*) Municipal solid wastes

Ans. **(*a*) Radioactive wastes:** These are nuclear wastes which are most potent pollutants as they cause mutations. These cannot be reused or recycled and are disposed off carefully to prevent leakage.

(*i*) Accidents: There are accidental leakage as in Three Mile Island and Chernobyl incidents.

(*ii*) Radioactive waste disposal: Radiation given off by nuclear waste is extremely damaging to living organisms as it causes mutation at an extremely high rate, causing cancer. Therefore, nuclear waste is an extremely potent pollutant.

(*b*) Defunct ships: Old defunct ships are dismantled to obtain scrap metals. Defunct ships contains toxicants like asbestos, mercury, lead, tributylin, etc. The workers engaged in ship are exposed to toxic chemicals. The coastal areas connected with ship breaking yard also become polluted.

e-wastes: These are the wastes (like irreparable computers and other electronic goods) generated in the developed countries and exported to developing countries including India, China and Pakistan where metals like gold, nickel, silicon, copper, iron, etc., are recovered during recycling process. Recycling is done manually by workers and hence they are exposed to some toxic substances.

(*c*) Municipal solid wastes: Wastes produced from homes, offices, schools, hospitals, etc., are collected and disposed off by the municipality. These generally consists of paper, leather, textile, rubber, glass, etc. Sanitary landfills are used to dump these wastes.

Q. 10. What initiatives were taken for reducing vehicular air pollution in Delhi? Has air quality improved in Delhi?

Ans. Delhi Government took following initiatives to reduce vehicular air pollution:

(*i*) Switching over to CNG for public transport vehicle.

(*ii*) Application of Euro II norms for vehicles.

(*iii*) Use of unleaded petrol.

(*iv*) Use of low-sulphur petrol and diesel.

(*v*) Use of catalytic converter in vehicles.

(*vi*) Phasing out of old vehicles.

In recent years, air quality of Delhi has improved with a substantial fall in pollutant gases like level between 1997 and 2005.

Q. 11. Discuss briefly the following:

(*a*) Greenhouse gases (*b*) Catalytic converter (*c*) Ultraviolet B

Ans. **(*a*) Greenhouse gases:** The gases which allow solar radiations to pass through them but retain and partially reflect back radiation of longer wavelength are called greenhouse gases, *e.g.*, CO_2, NO_2, CH_4, etc. These gases are required to keep earth warm and hospitable. They prevent a substantial part of long wave radiations emitted by earth to escape into space. Rather greenhouse gases radiate a part of this energy back to the earth.

(*b*) Catalytic converter: Refer to Basic Concepts Point 2 (*iv*)(*c*).

(*c*) Ultraviolet B: These are UV radiations with wavelength ranging between 280–320 nm. They are harmful radiations that penetrate through the ozone hole to reach the earth. Ozone shield is thinning over the equator. UV-B radiation causes cataract and skin cancer in human beings. High levels of UV-B radiation damages DNA of an individual.

Multiple Choice Questions [1mark]

Choose and write the correct option in the following questions.

1. Biochemical oxygen demand (BOD) in a river water

(*a*) has no relationship with concentration of oxygen in the water

(*b*) gives a measure of *Salmonella* in the water

(*c*) increases when sewage gets mixed with river water

(*d*) remains unchanged when algal bloom occurs.

2. Montreal Protocol aims at

(*a*) biodiversity conservation (*b*) control of water pollution

(*c*) control of CO_2 emission (*d*) reduction of ozone depleting substances

3. The two gases making highest relative contribution to greenhouse gases are

(*a*) CO_2 and CH_4 (*b*) CH_4 and N_2O

(*c*) CFCs and N_2O (*d*) CO_2 and N_2O

4. Eutrophication is often seen in

(*a*) deserts (*b*) fresh water lakes (*c*) ocean (*d*) mountains

5. "Good ozone" is found in the

(*a*) mesosphere (*b*) troposphere (*c*) stratosphere (*d*) ionosphere

6. In an area where DDT had been used extensively population of birds declined significantly because

(*a*) birds stopped laying eggs (*b*) earthworms in the area got eradicated

(*c*) cobras were feeding exclusively on birds (*d*) many of the birds laid eggs, did not hatch

7. Non-biodegradable pollutants are created by [*NCERT Exemplar*]

(*a*) nature (*b*) excessive use of resources

(*c*) humans (*d*) natural disasters

8. Compressed Natural Gas (CNG) is [*NCERT Exemplar*]

(*a*) propane (*b*) methane (*c*) ethane (*d*) butane

9. World's most problematic aquatic weed is [*NCERT Exemplar*]

(*a*) *Azolla* (*b*) *Wolffia* (*c*) *Eichhornia* (*d*) *Trapa*

10. Which of the following exhibits biomagnification? [*NCERT Exemplar*]

(*a*) SO_2 (*b*) Mercury (*c*) DDT (*d*) Both (*b*) and (*c*)

11. Match the items given in Column I with those in Column II and select the correct option given below:

Column I	Column II
A. Eutrophication	(*i*) UV-B radiation
B. Sanitary landfills	(*ii*) Deforestation
C. Snow blindness	(*iii*) Nutrient enrichment
D. Jhum cultivation	(*iv*) Waste diposal

(*a*) A-(*iii*), B-(*iv*), C-(*i*), D-(*ii*) (*b*) A-(*i*), B-(*iii*), C-(*iv*), D-(*ii*)

(*c*) A-(*ii*), B-(*i*), C-(*iii*), D-(*iv*) (*d*) A-(*i*), B-(*ii*), C-(*iv*), D-(*iii*)

12. The expanded form of DDT is [*NCERT Exemplar*]

(*a*) dichloro diphenyl trichloroethane (*b*) dichloro diethyl trichloroethane

(*c*) dichloro dipyrydyl trichloroethane (*d*) dichloro diphenyl tetrachloroacetate

13. Which of the following material takes the longest time for biodegradation? [*NCERT Exemplar*]

(*a*) Cotton (*b*) Paper

(*c*) Bone (*d*) Jute

14. Choose the incorrect statement. [*NCERT Exemplar*]

(*a*) The Montreal protocol is associated with the control of emission of ozone depleting substances

(*b*) Methane and carbon dioxide are green house gases

(*c*) Dobson units are used to measure oxygen content of air

(*d*) Use of incinerators is crucial to disposal of hospital wastes

15. Among the following which one causes maximum indoor chemical pollution? [*NCERT Exemplar*]

(*a*) Burning coal (*b*) Burning cooking gas

(*c*) Burning mosquito coil (*d*) Room spray

16. The green scum seen in the fresh water bodies is: [*NCERT Exemplar*]

(*a*) blue green algae (*b*) red algae

(*c*) green algae (*d*) both (*a*) and (*c*)

17. The major source of noise pollution world wide is due to [*NCERT Exemplar*]

(*a*) office equipment (*b*) transport system

(*c*) sugar, textile and paper industries (*d*) oil refineries and thermal power plants.

18. Match the following and choose the correct option. [*NCERT Exemplar*]

Column I	Column II
A. Environment Protection Act	(*i*) 1974
B. Air Prevention & Control of Pollution Act	(*ii*) 1987
C. Water Act	(*iii*) 1986
D. Amendment of Air Act to include noise as an air pollutant	(*iv*) 1981

The correct matches is

(*a*) A-(*iii*), B-(*iv*), C-(*i*), D-(*ii*) (*b*) A-(*i*), B-(*iii*), C-(*ii*), D-(*iv*)

(*c*) A-(*iv*), B-(*i*), C-(*ii*), D-(*iii*) (*d*) A-(*iii*), B-(*iv*), C-(*ii*), D-(*i*)

19. Increased rate of skin cancer and mutation might be because of

(*a*) increase in CO_2 concentration (*b*) increase in CO concentration

(*c*) ozone layer depletion (*d*) acid rain

20. Catalytic converters are fitted into automobiles to reduce emission of harmful gases. Catalytic converters change unburnt hydrocarbons into [*NCERT Exemplar*]

(*a*) carbon dioxide and water (*b*) carbon monoxide

(*c*) methane (*d*) carbon dioxide and methane

21. Why is it necessary to remove sulphur from petroleum products? [*NCERT Exemplar*]

(*a*) To reduce the emission of sulphur dioxide in exhaust fumes

(*b*) To increase efficiency of automobiles engines

(*c*) To use sulphur removed from petroleum for commercial purposes

(*d*) To increase the life span of engine silencers

22. Which one of the following impurities is easiest to remove from wastewater? [*NCERT Exemplar*]

(*a*) Bacteria (*b*) Colloids (*c*) Dissolved solids (*d*) Suspended solids

23. Nuisance growth of aquatic plants and bloom-forming algae in natural waters is generally due to high concentrations of [*NCERT Exemplar*]

(*a*) carbon (*b*) sulphur (*c*) calcium (*d*) phosphorus

24. Algal blooms impart a distinct colour to water due to [*NCERT Exemplar*]

(*a*) their pigments

(*b*) excretion of coloured substances

(*c*) formation of coloured chemicals in water facilitated by physiological degradation of algae.

(*d*) absorption of light by algal cell wall.

25. Match the items in column I and column II and choose the correct option. [*NCERT Exemplar*]

Column I	Column II
A. UV	(*i*) Biomagnification
B. Biodegradable Organic matter	(*ii*) Eutrophication
C. DDT	(*iii*) Snow blindness
D. Phosphates	(*iv*) BOD

The correct match is:

(*a*) A-(*ii*), B-(*i*), C-(*iv*), D-(*iii*)
(*b*) A-(*iii*), B-(*ii*), C-(*iv*), D-(*i*)
(*c*) A-(*iii*), B-(*iv*), C-(*i*), D-(*ii*)
(*d*) A-(*iii*), B-(*i*), C-(*iv*), D-(*ii*)

26. In the textbook you came across "Three Mile Island and Chernobyl disasters associated with accidental leakage of radioactive wastes." In India we had Bhopal gas tragedy. It is associated with which of the following? [*NCERT Exemplar*]

(*a*) CO_2
(*b*) Methyl Isocyanate
(*c*) CFC
(*d*) Methyl Cyanate

Answers

1. (*c*)	**2.** (*d*)	**3.** (*a*)	**4.** (*b*)	**5.** (*c*)	**6.** (*d*)	**7.** (*c*)	**8.** (*b*)	**9.** (*c*)	**10.** (*d*)
11. (*a*)	**12.** (*a*)	**13.** (*c*)	**14.** (*c*)	**15.** (*a*)	**16.** (*d*)	**17.** (*b*)	**18.** (*a*)	**19.** (*c*)	**20.** (*a*)
21. (*a*)	**22.** (*d*)	**23.** (*d*)	**24.** (*a*)	**25.** (*c*)	**26.** (*b*)				

Assertion-Reason Questions

In the following questions a statement of assertion followed by a statement of reason is given. Choose the correct answer out of the following choices.

(a) Assertion and reason both are correct statements and reason is correct explanation for assertion.
(b) Assertion and reason both are correct statements but reason is not correct explanation for assertion.
(c) Assertion is correct statement but reason is wrong statement.
(d) Assertion is wrong statement but reason is correct statement.

1. Assertion : Eutrophication shows increase in productivity in water.
Reason : With increasing eutrophication, the diversity of phytoplankton increases.

2. Assertion : Inhabitants close to very busy airports are likely to experience health hazards.
Reason : Sound level of jet aeroplanes usually exceeds 160 dB.

3. Assertion : Suspended particulate matter (SPM) is an important pollutant released by diesel vehicles.
Reason : Catalytic convertors greatly reduce pollution caused by automobiles.

4. Assertion : Presently the global atmosphere is warming up.
Reason : The depletion of stratospheric ozone layer has resulted in increase in UV radiations reaching the earth.

5. Assertion : Deforestation is one main factor contributing to global warming.
Reason : Increased greenhouse gases capture the infra red rays from the sun.

6. Assertion : UV radiation causes photodissociation of ozone into O_2 and O_3, thus causing damage to the stratospheric ozone layer.
Reason : Ozone hole is not resulting in global warming and climate change.

7. Assertion : The sharp decline in dissolved oxygen in the water body causes mortality of aquatic creatures.
Reason : Micro-organisms involved in bio-degradation of organic matter in the water body consume a lot of oxygen.

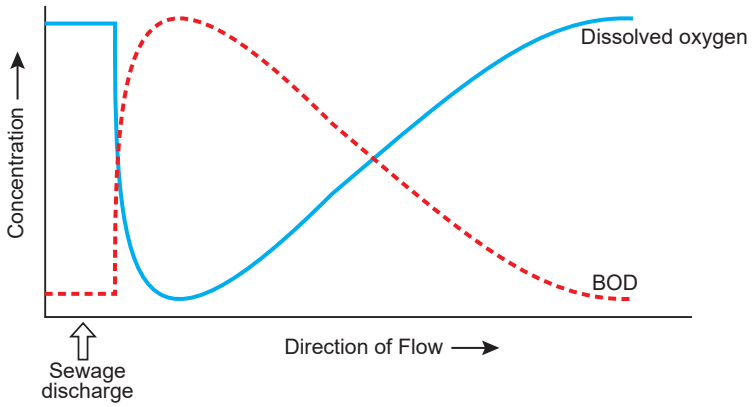
8. **Assertion :** The concentration of ozone over Africa is decreasing leading to thinning of ozone layer.
   Reason : Ozone depleting substances react with ozone present in stratosphere and destroy the same.
9. **Assertion :** Presence of large amounts of nutrients in water causes algal bloom.
   Reason : Algal bloom causes deterioration of the water quality and may lead to fish mortality.
10. **Assertion :** Motor vehicles equipped with catalytic convertors should use unleaded petrol.
    Reason : Lead in petrol leads to blockage of catalytic convertors.

Answers

1. (*b*) **2.** (*b*) **3.** (*b*) **4.** (*b*) **5.** (*a*) **6.** (*c*) **7.** (*c*) **8.** (*d*) **9.** (*b*) **10.** (*c*)

Case-based/Source-based Question

1. Study the graph given below and answer the questions that follow:



(*i*) What is the relationship between dissolved oxygen and biochemical oxygen demand (BOD)?
(*ii*) Mention their effect on aquatic life in the river.

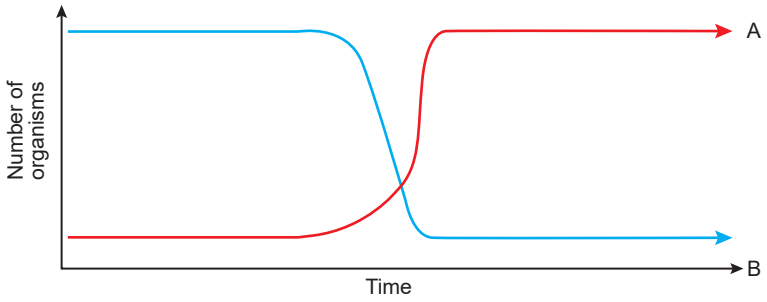
Ans. (*i*) BOD refers to the amount of oxygen consumed if all the organic matter in one litre of water were oxidised by bacteria. Thus, greater the BOD, lesser will be the dissolved oxygen in sewage discharge.

(*ii*) Effects on aquatic life:

(*a*) It causes high mortality rate of aquatic animals.

(*b*) The excessive nutrients facilitate algal growth causing algal bloom.

2. Two types of aquatic organisms in a lake show specific growth patterns as shown below, in a brief period of time. The lake is adjacent to an agricultural land extensively supplied with fertilisers.



Answer the questions based on the facts given above:

(*i*) Name the organisms depicting the patterns A and B.

(*ii*) State the reason for the growth pattern seen in A.

(*iii*) Write the effects of the growth patterns seen above.

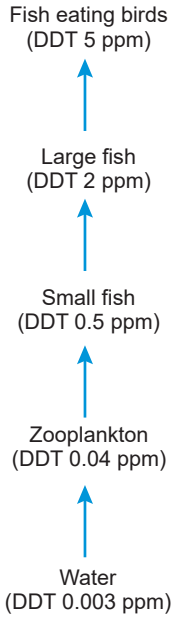
Ans. (*i*) A-algae/planktonic (free floating) algae

B-fish/aquatic animals

(*ii*) Due to excessive loading of nutrients or fertilisers from adjacent agricultural land, results in increase in nutrients.

(*iii*) Effects: decrease in dissolved oxygen (DO), increase in BOD, fish mortality, unpleasant odour/eutrophication.

3. Study the given aquatic food chain and answer the questions that follow:



(*i*) Name the phenomenon responsible for the increase in DDT content.

(*ii*) Lower BOD of a water body helps reappearance of clean-water organisms. Explain.

(*iii*) A crane had DDT level at 5 ppm in its body. What would happen to the population of such birds? Explain giving reasons.

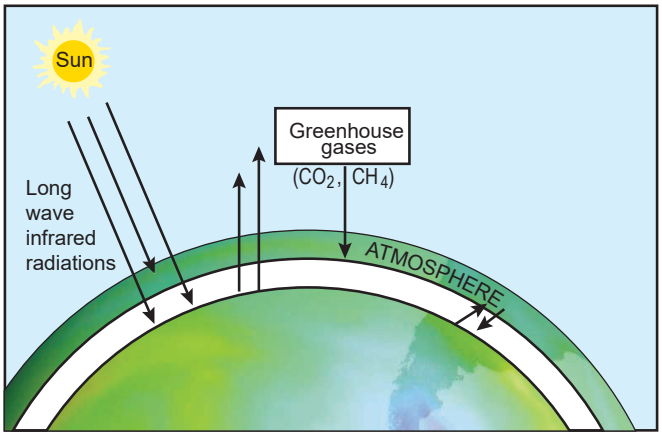
Ans. (*i*) Biological magnification

(*ii*) Lowering of Biological Oxygen Demand (BOD) results in decreased biodegradable material in the water body. This results in reduced microbial decomposition. When there is no decomposition, oxygen utilisation is reduced and there is more Dissolved Oxygen (DO) available. Thus, clean water-organisms reappear.

(*iii*) DDT being a toxic substance gets accumulated in the organism and passes on to the next higher trophic level because it cannot be metabolised or excreted. Thus, concentration of DDT has increased in the birds in the given case. The high concentration of DDT disturbs the calcium metabolism in birds, causes thinning of eggshells, their premature breaking and eventually causes a decline in the bird population.

The phenomenon is called biomagnification.

4. Sunlight energy at outermost atmosphere is reflected by the atmospheric gases and clouds. Answer the questions given below based on the information given.



(*i*) Mention the effect of global warming on the geographical distribution of stenothermals like amphibians.

(*ii*) Mention the effect of UV rays on DNA and proteins in living organisms.

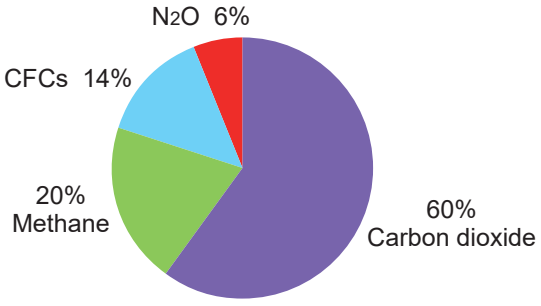
(*iii*) How is snow-blindness caused in humans?

Ans. (*i*) Due to global warming, stenothermals would either migrate or die due to change in the temperature.

(*ii*) The high energy of UV rays breaks the chemical bonds within DNA and protein molecules.

(*iii*) In human eye, cornea absorbs UV-B radiation, and a high dose of UV–B causes inflammation of cornea leading to snow-blindness.

5. The figure given below shows the relative contribution of various greenhouse gases to global warming. Answer the questions based on the figure.



(*i*) Name two greenhouse gases produced by anaerobic microbes.

(*ii*) It is a common practice to plant tree and shrubs near the boundary walls of building. What purpose do they serve?

(*iii*) Why is global warming a warning to mankind?

Ans. (*i*) Carbon dioxide and methane

(*ii*) The plant growing near the boundary wall act as barrier for sound pollution and act as dust catchers.

(*iii*) Global warming has resulted in climatic changes. This has disrupted the lifecycles of many organisms and has caused melting of ice caps.

Very Short Answer Questions [1 mark]

Q. 1. Mention two advantages for preferring CNG over diesel as an automobile fuel. *[CBSE (AI) 2016]*

Ans. Advantages of CNG are:
(*i*) burns efficiently and leaves behind less unburnt residues
(*ii*) cheaper than petrol or diesel
(*iii*) causes less pollution
(*iv*) cannot be adulterated
(*v*) cannot be siphoned by thieves. (*any two*)

Q. 2. In which year was the Air Prevention and control of pollution Act amended to include noise as air pollution. *[NCERT Exemplar]*

Ans. 1987.

Q. 3. Name the city in which the entire public road transport runs on CNG. *[NCERT Exemplar]*

Ans. Delhi.

Q. 4. How do plants control pollution?

Ans. Plants absorb and assimilate the pollutants like CO_2 and provide oxygen by the process of photosynthesis. This reduces the pollution.

Q. 5. Name an industry which can cause air pollution, thermal pollution and eutrophication. *[NCERT Exemplar]*

Ans. Fertiliser factory.

Q. 6. List two advantages of the use of unleaded petrol in automobiles as fuel. *[CBSE (AI) 2015]* *[HOTS]*

Ans. (*i*) Allows the catalytic convertor to remain active.
(*ii*) Reduces air pollution.

Q. 7. Why is the use of unleaded petrol recommended for motor vehicles equipped with catalytic converters? *[CBSE (AI) 2013; (F) 2010]* *[HOTS]*

OR

Why is it desirable to use unleaded petrol in vehicles fitted with catalytic converters? *[CBSE (AI) 2012]* *[HOTS]*

Ans. Lead in petrol inactivates the catalysts (platinum, palladium and rhodium) which convert harmful pollutants (CO, unburnt hydrocarbons, nitric oxide) to lesser harmful pollutants (CO_2, H_2O, N_2).

Q. 8. An electrostatic precipitator in a thermal power plant is not able to generate high voltage of several thousands. Write the ecological implication because of it. *[CBSE (AI) 2017]*

Ans. As a result of this particulate matter or dust particles will be released in the air causing air pollution.

Q. 9. In spite of being non-polluting, why are there great apprehensions in using nuclear energy for generating electricity? *[CBSE (F) 2014]* *[HOTS]*

Ans. There are great apprehensions in using nuclear energy because of accidental leakages and finding ways for safe disposal of radioactive waste.

Q. 10. What is an algal bloom? *[NCERT Exemplar]*

Ans. The excessive growth of algae (free-floating) that causes colouration of water bodies is called algal bloom.

Q. 11. It is a common practice to undertake desilting of the overhead water tanks. What is the possible source of silt that gets deposited in the water tanks. *[NCERT Exemplar]* *[HOTS]*

Ans. The soil particles carried by water from the source of supply.

Q. 12. Domestic sewage contains certain substances or salts which are difficult to remove. Name any four of them. *[HOTS]*

Ans. Nitrate, phosphate, metal ions and organic compound.

Q. 13. Eutrophication is the natural aging of a lake; mention any other feature which defines this term. ***[CBSE Sample Paper 2014]***

Ans. —Depletion of dissolved oxygen in water

—Nutrient enrichment (*Any one*)

Q. 14. Mention the information that the health workers derive by measuring BOD of a water body. ***[CBSE (AI) 2010]***

Ans. By measuring BOD of a water body, health workers find the amount of dissolved oxygen in water. The lesser the amount of dissolved oxygen, the more polluted the water body will be.

Q. 15. BOD of two samples of water A and B were 120 mg/L and 400 mg/L, respectively. Which sample is more polluted? ***[HOTS]***

Ans. Sample B is more polluted than Sample A.

Q. 16. Write the name of the organism that is referred to as the 'Terror of Bengal'. ***[CBSE Delhi 2014]***

Ans. Water hyacinth (*Eichhornia crassipes*).

Q. 17. Excessive nutrients in a fresh water body cause fish mortality. Give two reasons. ***[CBSE Delhi 2016]*** ***[HOTS]***

Ans. Excessive nutrients result in excessive algal growth or eutrophication in the water body. Thus, the water quality becomes poor as the oxygen level decreases.

Q. 18. Why is *Eichhornia crassipes* nicknamed as "Terror of Bengal"? ***[CBSE Delhi 2012]*** ***[HOTS]***

Ans. *Eichhornia crassipes* is an aquatic weed that grows abundantly and very fast in eutrophic water bodies and causes imbalances in water ecosystem. It causes oxygen depletion leading to death of aquatic life (eutrophication).

Q. 19. State the cause of accelerated eutrophication. ***[CBSE Delhi 2014]***

Ans. Pollutants from human activities, effluents from industries, effluents from home, sewage and agricultural wastes (chemical wastes) radically accelerate the aging process.

Q. 20. How do algal blooms affect the life in water bodies? ***[CBSE (AI) 2011]***

Ans. (*i*) Algal bloom pollutes water and deteriorates the water quality by depleting the oxygen content. This turns the water toxic and increases its BOD.

(*ii*) Algal blooms lead to death of aquatic organisms due to oxygen depletion.

Q. 21. Name two greenhouse gases produced by anaerobic microbes. ***[CBSE (F) 2010]***

Ans. Carbon dioxide and methane.

Q. 22. State the effect of UV-B on human eye. ***[CBSE (F) 2013]***

Ans. UV-B is absorbed by human eye and at high dose, it causes inflammation of cornea. This is called snow-blindness cataract.

Q. 23. Write the unit used for measuring ozone thickness. ***[CBSE Delhi 2011]***

Ans. Dobson unit.

Q. 24. Mention the effect of global warming on the geographical distribution of stenothermals like amphibians. ***[CBSE (F) 2012]***

Ans. Due to global warming, stenothermals would either migrate or die due to change in the temperature.

Q. 25. Mention the effect of UV rays on DNA and proteins in living organisms. ***[CBSE (F) 2013]***

Ans. The high energy of UV rays breaks the chemical bonds within DNA and protein molecules.

Q. 26. How is snow-blindness caused in humans? ***[CBSE (AI) 2010]***

Ans. In human eye, cornea absorbs UV-B radiation, and a high dose of UV–B causes inflammation of cornea leading to snow-blindness.

Q. 27. Name the greenhouse gases that contribute to total global warming. ***[CBSE Delhi 2014]***

Ans. N_2O, CFC, CH_4, CO_2.

Q. 28. State the purpose of signing the Montreal Protocol. ***[CBSE (F) 2014]***

Ans. **Montreal Protocol,** was signed at Montreal, in 1987 to curb the emission of ozone depleting substances.

Q. 29. Why are lichens regarded as pollution indicators? *[CBSE (AI) 2013]* *[HOTS]*

Ans. Lichens are regarded as pollution indicators because they do not grow in areas that are polluted. So their presence indicates no pollution in that area and their absence indicates that the area is polluted.

Q. 30. Which of the following is not a greenhouse gas?

CO_2, CH_4, O_2, CFCs.

Ans. O_2.

Q. 31. Why does ozone hole form in spring and not in winter? *[HOTS]*

Ans. Sunlight is necessary for ozone degradation and it is available only during spring.

Q. 32. What is meant by ozone hole?

Ans. Depletion of ozone widely in the stratosphere, particularly over the Antarctic region result in formation of thinned ozone layer called ozone hole.

Q. 33. Name the gas which holds up ultraviolet rays.

Ans. Ozone

Q. 34. What is reforestation? *[NCERT Exemplar]*

Ans. Reforestation is the process of restoring a forest that once existed but was removed at some point of time in the past.

Short Answer Questions [2 marks]

Q. 1. Thermal power plants are inevitable in an industrial and densely populated country like ours. What harm do they do to the environment? Also mention any precaution that could be taken to save our environment.

Ans. The particulate and gaseous pollutants are released from thermal power plants which lead to harmful effects. These pollutants can cause:

(*i*) breathing or respiratory symptoms when inhaled.

(*ii*) irritation, inflammations and damage to lungs and premature death.

Precautionary measures include use of electrostatic precipitators by which 99% of the particulate matters can be removed from the exhaust.

Q. 2. How do automobiles fitted with catalytic converters reduce air pollution? Suggest the best fuel for such vehicles.

Ans. Catalytic converters have expensive metals like platinum-palladium and rhodium as catalysts. As exhaust emission passes through catalytic converter, unburnt hydrocarbons are converted into carbon dioxide and water, and carbon monoxide and nitric oxide are changed to carbon dioxide and nitrogen gas.

Unleaded petrol is the best fuel for such vehicles.

Q. 3. What is hybrid vehicle technology? Explain the advantages with a suitable example. *[NCERT Exemplar]*

Ans. Vehicle running on dual mode like petrol and CNG are hybrid vehicle. As CNG is a green fuel there is conservation of fossil fuel and reduction in the environmental pollution.

Q. 4. A person has inhaled air having particulate pollutants of size less than 2.5 micrometers in diameter. What could be the impact of their pollutants on his respiratory system? *[HOTS]*

Ans. Particulate pollutants inhaled deep into the lungs cause irritation, inflammation, damage to the lungs, and premature death.

Q. 5. (*a*) Name any two places where it is essential to install electrostatic precipitators. Why it is required to do so?

(*b*) Mention one limitation of the electrostatic precipitator. *[CBSE Delhi 2016]* *[HOTS]*

Ans. (*a*) It is essential to install electrostatic precipitators in thermal power plants and smelters to remove particulate matter.

(*b*) Limitation of the electrostatic precipitator:
(*i*) particulate matter less than 2.5 micrometres are not removed.
(*ii*) velocity of air between plates must be low enough to allow the dust to fall.
(*iii*) it cannot work without electricity. (*Any one*)

Q. 6. What is polyblend? Why did the plastic manufacturers think of producing it? Write its usefulness. [*CBSE (AI) 2011*]

Ans. Polyblend is a fine powder of recycled modified plastic. Polyblend was produced to recycle plastic waste. When blended with bitumen, polyblend can be used to lay roads that have increased road life.

Q. 7. Mention how e-waste is produced and disposed off. Write the solution for its treatment.

OR [*CBSE (AI) 2010*]

Name any two sources of e-wastes and write two different ways for their disposal.

OR [*CBSE Delhi 2013*]

How e-wastes are being handled in our country? Write the correct solution for treating this waste. [*CBSE (F) 2016*]

Ans. Irreparable computers and other electronic goods are the known sources of electronic wastes (e-wastes). E-wastes are buried in landfills or incinerated. Recycling is the only solution for the treatment of e-wastes.

Q. 8. (*a*) Why are the colourful polystyrene and plastic packaging used for protecting the food, considered an environmental menace?

(*b*) Write about the remedy found for the efficient use of plastic waste by Ahmed Khan of Bangalore. [*CBSE Delhi 2012*]

Ans. (*a*) The colourful polystyrene and plastic packaging are non-biodegradable and non-ecofriendly.

(*b*) The remedy was found by developing polyblend, which is a fine powder of recycled modified plastic. Polyblend is mixed with bitumen to lay roads. This enhanced the water repellent property of bitumen and enhanced the life of roads.

Q. 9. How does an algal bloom cause eutrophication of a water body? Name the weed that can grow in such a eutrophic lake. [*CBSE Delhi 2012*]

Ans. Algal bloom in the lake or any other water body forms a scum. The scum depletes the oxygen in the water leading to foul smelling of the water body. The oxygen depletion affects the aquatic life adversely resulting in the death of fish and ultimately the eutrophic lake itself dies. Water hyacinth grows in such a eutrophic lake.

Q. 10. Is it true that if the dissolved oxygen level drops to zero the water will become septic? Given example which could lower the dissolved oxygen content of an aquatic body. [*NCERT Exemplar*] [*HOTS*]

Ans. Yes, the water will become septic if the dissolved oxygen drops to zero. Organic pollution (biodegradable) is an example.

Q. 11. Plenty of algal bloom is observed in a pond in your locality.

(*a*) Write what has caused this bloom and how does it affect the quality of water.

(*b*) Suggest a preventive measure. [*CBSE Delhi 2017*]

Ans. (*a*) Presence of large amounts of nutrients (Nitrogen and Phosphorus) in water causes excessive growth of algae. This growth depletes dissolved oxygen in water and imparts distinct colour to the water bodies. The bloom forming algae are extremely toxic and deteriorates water quality resulting in fish mortality.

(*b*) Following preventive measures can be carried out:
(*i*) Treatment of waste water before it reaches the pond.
(*ii*) Integrated waste water treatment.
(*iii*) Avoid using NPK fertilisers.
(*iv*) Use of organic or biodegradable manure or resort to organic farming.

Q. 12. A crane had DDT level at 5 ppm in its body. What would happen to the population of such birds? Explain giving reasons.

OR

DDT content in the water of a lake that supplies drinking water to the nearby villages, is found to be 0.003 ppm. The kingfishers of that area were reported to have 2 ppm of DDT. Why has the concentration increased in these birds? What harm will this cause to the bird population? Name the phenomenon.

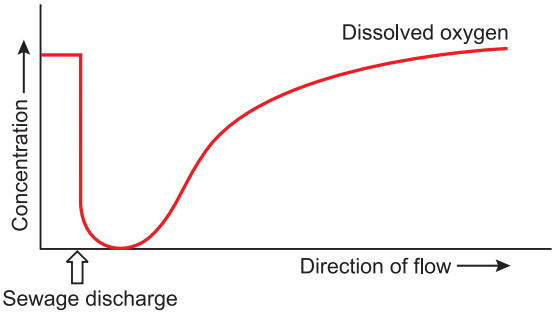
Ans. DDT being a toxic substance gets accumulated in the organism and passes on to the next higher trophic level because it cannot be metabolised or excreted. Thus, concentration of DDT has increased in the birds in the given case. The high concentration of DDT disturbs the calcium metabolism in birds, causes thinning of eggshells, their premature breaking and eventually causes a decline in the bird population.

The phenomenon is called biomagnification.

Q. 13. Ornithologists observed decline in the bird population in an area near a lake after the setting of an industrial unit in the same area. Explain the cause responsible for the decline observed.

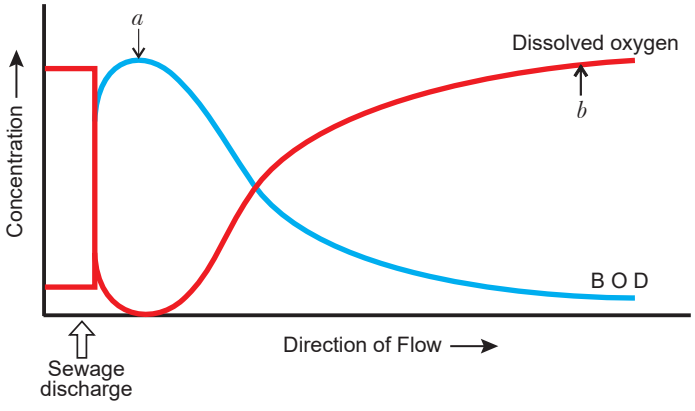
Ans. Harmful wastes from the industrial unit must have entered the trophic levels of food chain causing biomagnification. It must have accumulated in the birds as it can neither be metabolised nor be excreted. High concentration of harmful chemical may disturb calcium metabolism in birds causing thinning of the egg shells and their premature breaking, ultimately causing decline in bird populations.

Q. 14. Study the graph given below. Explain how is oxygen concentration affected in the river when sewage is discharged into it. ***[CBSE Delhi 2011]***



Ans. When sewage is discharged into the river, the oxygen concentration declines sharply because a large amount of oxygen is consumed by aerobic microorganisms in river to decompose the organic matter in river. When the amount of organic matter reduces, the amount of dissolved oxygen again increases.

Q. 15. Explain giving reasons the cause of appearance of peaks *'a'* and *'b'* in the graph shown below. ***[CBSE (AI) 2010]*** ***[HOTS]***



Ans. '*a*'–High BOD due to sewage discharge.
'*b*'–Increase in dissolved oxygen due to sewage decomposition.

Micro-organisms involved in biodegradation of organic matter consume a lot of oxygen, therefore, there is a sharp decline in dissolved oxygen. When the sewage is completely degraded, oxygen concentration again increases.

Q. 16. "Determination of Biological Oxygen Demand (BOD) can help in suggesting the quality of a water body." Explain. ***[CBSE Delhi 2015]***

Ans. High BOD of a water body indicates growth of more number of micro-organisms in water. This results in bad quality of water. Bad water quality will lead to death of aquatic creatures and hence more polluting potential. Whereas lower BOD of water body indicates less number of micro-organisms in water. There is good quality of water in which aquatic life flourishes and there is less polluting potential.

The amount of oxygen required for microbial breakdown of biodegradable organic matter is called BOD.

Q. 17. Lower BOD of a water body helps reappearance of clean-water organisms. Explain. ***[CBSE (F) 2016]*** ***[HOTS]***

Ans. Lowering of Biological Oxygen Demand (BOD) results in decreased biodegradable material in the water body. This results in reduced microbial decomposition. When there is no decomposition, oxygen utilisation is reduced and there is more Dissolved Oxygen (DO) available. Thus, clean water-organisms reappear.

Q. 18. Suppose sewage water is disposed off in the river. What will be its effect on BOD and dissolved oxygen?

OR

Sewage discharge into clean water body leads to increased fish mortality. Explain. ***[CBSE (F) 2016]*** ***[HOTS]***

Ans. Discharge of sewage water into a river will increase nutrients and thereby promotes algal growth. This will result in rise of BOD (Biochemical Oxygen Demand) as decomposers will consume more dissolved oxygen in river. If sewage quantity is large, the whole of the dissolved oxygen will be consumed leaving nothing for respiration of fishes and other aquatic organisms. This increases the mortality rate of aquatic creatures.

Q. 19. Explain the causes of global warming. Why is it a warning to mankind?

Ans. Refer to Basic Concepts Point 12.

Q. 20. (*a*) Name the green house gases that cause global warming.

(*b*) Which of them has caused ozone hole and how?

Ans. (*a*) CO_2, CH_4, N_2O, chlorofluorocarbons or CFCs

(*b*) Ozone degradation has increased due to chlorofluorocarbons (CFCs). CFCs are refrigerants which react with UV in stratosphere to release chloride atoms. Chloride atoms act as catalyst to degrade ozone and release molecular oxygen. CFCs have permanent and continued effect as chloride atoms are not consumed.

Q. 21. Explain the relationship between green house gases and global warming. ***[CBSE (F) 2017]***

Ans. Greenhouse gases (CO_2, CH_4, N_2O, CFCs) allow the solar radiations to enter but prevent the escape of heat radiations of longer wavelength. The absorbed radiations again come to earth's surface and heat it up. Increase in the level of these greenhouse gases allow the heat waves to reach earth but prevent their escape and thus the earth becomes warm. There is gradual continuous increase in average temperature of earths' surface leading to global warming.

Q. 22. Explain the relationship between CFCs and ozone in the stratosphere. ***[CBSE (AI) 2016]***

Ans. UV rays act on CFCs and release chlorine. These chlorine atoms act on ozone to release O_2, resulting in ozone layer depletion.

Q. 23. List four benefits to human life by eliminating the use of CFCs. ***[CBSE (AI) 2017]***

Ans. (*i*) Delay in aging of skin (*ii*) Prevent damage to skin cells
(*iii*) Prevent skin cancer (*iv*) Prevent snow blindness or inflammation of cornea
(*v*) Prevent cataract (*vi*) Prevents ozone depletion
(*vii*) Prevents global warming (*viii*) Reduces greenhouse effect
(*ix*) Reduces odd climatic changes or El Nino effect. (*Any four*)

Q. 24. Chlorofluorocarbons (CFCs) are widely used as refrigerants. Then why is it suggested to reduce its emission as far as possible? Explain. ***[CBSE Delhi 2010]*** ***[HOTS]***

OR

Refrigerants are considered to be a necessity in modern living, but are said to be responsible for ozone holes detected in Antarctica. Justify. ***[CBSE (F) 2012]*** ***[HOTS]***

Ans. CFCs find wide use as refrigerants. CFCs discharged in the lower part of atmosphere move upward and reach stratosphere. In stratosphere, UV rays act on them releasing chloride atoms. Chloride atoms degrade ozone, releasing molecular oxygen. Whatever CFCs are added to the stratosphere have permanent and continuing effects on ozone. These have resulted in ozone hole.

Q. 25. Why are there regular reminders to reduce the use of CFCs in the production of industrial and household appliances? Explain. ***[CBSE (F) 2017]***

Ans. CFCs discharged in the lower part of atmosphere move upward and reach stratosphere. In stratosphere, UV rays act on them releasing Cl atoms, which in turn degrade ozone. Ozone depletion will result in entry of harmful UV-B radiations into the earth's atmosphere resulting in deleterious effects on all living organisms.

Q. 26. (*a*) State the cause of depletion of ozone layer.

(*b*) Specify any two ill-effects that it can cause in the human body. ***[CBSE (F) 2014]***

Ans. (*a*) UV radiations act upon CFCs (chlorofluorocarbons) releasing Cl atoms in the stratosphere. These Cl atoms combine with O_3 and degrade it.

(*b*) Ill-effects of ozone depletion:

(*i*) UV-B damages DNA and proteins of living organisms causing mutation.

(*ii*) It causes skin aging, skin cell damage and skin cancers.

(*iii*) UV-B is absorbed by human eye and at high dose it causes inflammation of cornea. This is called **snow-blindness** cataract.

Q. 27. (*a*) Rearrange the following greenhouse gases in increasing order of their relative contribution to the total global warming:

N_2O; CFC; CO_2; C_2H_4

(*b*) What is the effect of global warming on polar ice-caps? Comment on its possible ecological impact. ***[CBSE (F) 2016]*** ***[HOTS]***

Ans. (*a*) $C_2H_4 < N_2O <$ CFC $< CO_2$

(*b*) Global warming results in rise of atmospheric temperature. This leads to the increased melting of polar ice caps which will cause the rise in sea level and many coastal areas will be submerged.

Q. 28. Justify the need for signing of Montreal Protocol by the participating nations. ***[CBSE (F) 2017]***

Ans. The Montreal Protocol was signed to control the emission of ozone depleting substances. Excessive use of CFCs and other ozone depleting chemicals has resulted in thinning of ozone layer. Further thinning would allow harmful UV-B radiations to enter Earth's atmosphere and have deleterious effects on living organisms.

Q. 29. It is a common practice to plant tree and shrubs near the boundary walls of building. What purpose do they serve? ***[NCERT Exemplar]*** ***[HOTS]***

Ans. The plant growing near the boundary wall act as barrier for sound pollution and act as dust catchers.

Q. 30. What is ozone shield and why is it important? Name the gases that cause stratospheric ozone depletion.

Ans. The thin layer of ozone around the atmosphere that prevents entry of harmful UV rays is called ozone shield. Ozone shield functions as a shield against strong UV radiations. The gases that cause ozone depletion are methane, nitrous oxide and chlorofluorocarbons.

Q. 31. Name any one of the green house gases and its possible source of production on a large scale. What are the harmful effects of it? ***[NCERT Exemplar]***

Ans. CO_2 and Methane. CO_2 levels are increasing due to burning of fossil fuel leading to global warming.

Q. 32. How do chlorofluorocarbons destroy ozone layer?

Ans. Chlorofluorocarbons (CFCs) break down in the presence of UV rays and produce active chlorine. The chlorine atoms break down ozone into molecular O_2, thereby depleting ozone layer.

Q. 33. What is joint forest management? How can it help in conservation of forests? ***[CBSE (F) 2015]***

Ans. Joint Forest Management (JFM) is a programme initiated by the Government of India in 1980 where government works closely with the local communities for protecting and managing forests.

By this programme forests are conserved by locals in a sustainable manner as locals are also benefited with forest products like fruits, gum, rubber, medicines, etc.

Q. 34. How have human activities caused desertification? Explain. ***[CBSE Delhi 2013]***

Ans. Human activities like over-cultivation, unrestricted grazing, deforestation and poor irrigation practices result in arid patches of land. The fertile top soil that may take centuries to develop is eroded due to these activities. When large barren patches extend and meet over time, a desert is created. Increased urbanisation is also one of the causes of desertification.

Q. 35. Write what was the percentage of forest cover of India at the beginning and at the end of the twentieth century. How different is it from the one recommended by the National Forest Policy of our country? ***[CBSE (F) 2014] [HOTS]***

Ans. At the beginning of the twentieth century, forests covered about 30 % of the land of India. By the end of the century, it shrunk to 19.4 %, whereas the National Forest Policy (1988) of India has recommended 33 % forest cover for the plains and 67 % for the hills.

Q. 36. Justify the need for signing of 'Montreal Protocol' by the participating nations in 1987. ***[CBSE 2019 (57/4/1)]***

Ans. Montreal Protocol has been signed to control the emission of ozone depleting substances which results in thinning of ozone layer and allows the UV rays to penetrate the earths surface. These harmful UV rays cause deleterious effects (cataract/skin cancer/ageing of skin.)

Long Answer Questions–I [3 marks]

Q. 1. Explain any three remedial measures to overcome the acute air pollution in our cities. ***[CBSE 2019 (57/3/1)]***

Ans. (*i*) Electrostatic precipitators to remove paritculate matter present in the exhaust from thermal power plant.

(*ii*) Scrubber to remove SO_2 from the exhaust of thermal power plant.

(*iii*) Alternative sources of energy in place of petrol.

(*iv*) Lead-free petrol or diesel.

(*v*) Catalytic convertors - to reduce lead pollution.

(*vi*) Use of CNG.

(*vii*) Use of low sulphur petrol and diesel.

(*viii*) Phasing out of old vehicles and stringent enforcement of pollution level norms.

Q. 2. (*i*) State the consequence if the electrostatic precipitator of a thermal plant fails to function.
(*ii*) Mention any four methods by which the vehicular air pollution can be controlled.
[*CBSE (AI) 2011; CBSE Sample Paper 2014*]

Ans. (*i*) Particulate matter will pollute the air.
(*ii*) Vehicular pollution can be controlled by:
Refer to Basic concepts Point 2 (*v*).

Q. 3. How does an electrostatic precipitator work to remove particulate pollutants released from the thermal power plants? **[*CBSE Delhi 2010*]**

Ans. Refer to Basic Concepts Point 2(*iv*)(*a*).
For diagram, refer to Fig. 16.1.

Q. 4. Mention the major cause of air pollution in metro cities. Write any three ways by which it can be reduced. **[*CBSE (AI) 2010*]**

Ans. **Major causes of air pollution are:** Refer to Basic Concepts Point 2(*i*).

Control methods:
(*i*) Using electrostatic precipitators to remove particulate matter from exhaust of industries and thermal power plant.
(*ii*) Using scrubber to remove gases like SO_2.
(*iii*) Use of catalytic converters in automobiles for reducing emission of poisonous gases.

Q. 5. By the end of 2002 the public transport of Delhi switched over to a new fuel. Name the fuel. Why is this fuel considered better? Explain. **[*CBSE Delhi 2012*]**

Ans. The fuel was CNG or compressed natural gas. CNG is considered better because of the following reasons:
(*i*) CNG burns more efficiently unlike diesel or petrol.
(*ii*) Very little of it is left unburnt.
(*iii*) It cannot be adulterated.
(*iv*) It is cheaper than petrol or diesel.

Q. 6. Write any three ways by which noise pollution affects the human body adversely. List any three steps that should be followed in order to reduce noise pollution. **[*CBSE 2019 (57/3/1)*]**

Ans. **Effects of noise pollution are:** sleeplessness, increased heart beat, altered breathing pattern, damaged hearing ability and damaged ear drum (*Any three*)

Steps to be followed to reduce noise pollution:
(*i*) Following of stringent laws laid down in relation to noise level.
(*ii*) Delimitation of horn free zones around hospitals and schools.
(*iii*) To adopt permissible sound level of crackers and loudspeakers.
(*iv*) Adhereing to time limit for loudspeakers beyond which it cannot be played.
(*v*) Use of sound absorbent material in industries.
(*vi*) Muffling of noise. (*Any three*)

Q. 7. With the help of a flow chart, show the phenomenon of biomagnification of DDT in an aquatic food chain. **[*CBSE (AI) 2015*]**

Ans. Refer to Fig. 16.3.

Q. 8. Explain accelerated eutrophication. Mention any two consequences of this phenomenon.

Ans. Accelerated eutrophication is nutrient enrichment of water bodies due to human activities like passage of sewage.
Consequences are:
(*i*) Large amount of nutrients in water causes excessive growth of planktonic algae (called algal bloom) which impart characteristic colour to water bodies.
(*ii*) Depletion of oxygen content of water leading to the death of the aquatic organisms.

Q. 9. With the help of a flow-chart exhibit the events of eutrophication. ***[CBSE (AI) 2015]***

Ans.

Water in young lake is cold and clear to support life.

↓

With time, water is enriched with nutrients such as nitrogen and phosphorus by streams draining into it.

↓

As lake's fertility increases, plant and animal life increase/proliferates.

↓

Organic matter begins to deposit at the bottom of the lake. Silt and organic debris pile up and makes the lake shallower and warmer.

↓

Marsh plants develop roots and begin to fill the original lake basin

↓

Eventually the lake gives way to large masses of floating plants finally converting it into land. (Natural aging)

Q. 10. Eutrophication is the natural aging of a lake. Explain. ***[CBSE (F) 2011]***

Ans. Eutrophication is the natural aging of a lake by biological enrichment of its water. In a young lake, the water being cold and clear, does not support much life. But with time, streams draining into the lake introduce nutrients such as nitrogen and phosphorus, which encourage the growth of aquatic organisms. As the lake's fertility increases, plant and animal life begins to develop and organic remains begin to be deposited on the lake's bottom. Over the centuries, as silt and organic debris pile up, the lake grows shallower and warmer. Now, the warm water organisms replace those that live in a cold environment. Marsh plants take root in the shallows and begin to fill in the original lake basin. Eventually, the lake develops large masses of floating plants (bog), finally converting into land.

Q. 11. What is eutrophication? How does a lake undergo accelerated eutrophication? ***[CBSE (F) 2013]***

Ans. Refer to Basic Concepts Point 5(*i*).

Q. 12. Explain the cause of algal bloom in a water body. How does it affect an ecosystem?

OR

How does algal bloom destroy the quality of a fresh water body? Explain. ***[CBSE Delhi 2013]***

Ans. Domestic sewage and industrial effluents contains nutrients like nitrogen and phosphorus which favour the excessive growth of planktonic (free-floating) algae.

Its harmful effects cause:

(*i*) sharp decline in dissolved oxygen content in the water.

(*ii*) deterioration of water quality and causes mortality of aquatic life forms.

(*iii*) distinct odour from the water bodies.

Q. 13. Why is the concentration of toxins found to be more in the organisms occupying the highest trophic level in the food chain in a polluted water body? Explain with the help of a suitable example. ***[CBSE (F) 2013]*** ***[HOTS]***

Ans. The concentration of toxic materials like heavy metals and pesticides increase at each trophic level of a food chain and is more in organisms of highest trophic level due to their accumulation at each trophic level. For example, when DDT was used to control mosquitoes in a lake of USA, 800 times more DDT was found in the phytoplanktons than in the water of the lake. Zooplanktons had about 13 times more DDT than phytoplanktons. It was also observed that the fishes population had 9–40 times more DDT than zooplanktons and fish eating birds had 25 times more DDT than fish.

Q. 14. Mention the six harmful effects of noise on human health.

Ans. Six harmful effects of noise on human population are:

Refer to Basic concepts Point 3 (*ii*).

Q. 15. (*a*) Expand BOD.

(*b*) At a particular segment of a river near a sugar factory, the BOD is much higher than the normal level. What is it indicative of? What will happen to the living organisms in this part of the river?

(*c*) Under what conditions will the BOD be lowered in the river? How will it affect the aquatic life?

Ans. (*a*) BOD—Biochemical Oxygen Demand

(*b*) It indicates the addition of lot of organic matter; microorganisms involved in the biodegradation of organic matter in the water body consume a lot of oxygen and as a result, there is a sharp decline in the dissolved oxygen content, downstream from the point of addition of effluent from the factory. This causes mortality of fish and other aquatic organisms.

(*c*) When the amount of organic matter decreases and the microbes do not need oxygen for decomposition, the BOD decreases. Thus, aquatic organisms will start flourishing.

Q. 16. What is global warming? List four strategies for reducing global warming.

Ans. Increase in the level of greenhouse gases in the atmosphere causes rise in global mean temperature called global warming.

Four strategies for reducing global warming are:

Refer to Basic concepts Point 12 (*iii*).

Q. 17. Explain the causes of global warming. Why is it a warning to mankind?

Ans. **Causes of global warming:**

(*i*) Deforestation

(*ii*) Rise in the concentration of greenhouse gases (CO_2, CH_4, CFCs, N_2O).

(*iii*) Burning of fossil fuels

(*iv*) Rise in industrial wastes and pollutants.

Global warming is a warning to mankind because:

(*i*) Rise in temperature is leading to increased melting of polar ice-caps as well as of other places like the Himalayan snow caps. This will result in a rise in sea level that can submerge many coastal areas.

(*ii*) Deleterious changes in the environment results in odd weather and climate changes, e.g., El Nino effect.

Long Answer Questions–II [5 marks]

Q. 1. A plastic sack manufacturer in Bengaluru, Ahmed Khan has managed to find an ideal solution to the problem of plastic waste. Explain in five steps the efforts of Ahmed Khan to meet the challenges of solid waste management. ***[CBSE 2019 (57/2/1)]***

Ans. (*i*) Ahmed Khan developed polyblend, which is a fine powder of recycled modified plastic.

(*ii*) Polyblend is mixed with bitumen and used to lay roads. This work is done in collaboration with R V engineering college and Bangalore city corporation.

(*iii*) Polyblend enhanced water-repellant property of bitumen and increase the road life.

(*iv*) Khan offered a price to rag pickers which enhanced their income and improved their livelihood.

(*v*) Thus solid waste management was achieved by removal and proper disposal of plastic waste from the city.

Q. 2. Discuss the following:

(*i*) *Chipko* Movement

(*ii*) Scrubber

(*iii*) Radioactive wastes.

Ans. **(*i*) *Chipko* Movement:** *Chipko* movement (Hug the Trees Movement) was an organised resistance to the destruction of forests. It started in 1974 in Reni village of Garhwal. A contractor was allowed to cut trees in a forest near the village. When the contractor's workers appeared, the women of the village reached the forest quickly and clasped the tree trunks with their arms, preventing the workers from cutting down the trees. Mr. Sunder Lal Bahuguna, a Gandhian activist and philosopher was the leader of *Chipko* Movement.

(*ii*) Scrubber: Refer to Basic Concepts Point 2(*iv*)(*b*).

For diagram refer to Fig. 16.2.

(*iii*) Radioactive wastes: Radioactive wastes such as uranium, are used as fuel in the atomic power plant. The accidental leakage and disposal of radioactive wastes are the most serious problems. All safety measures for this purpose should be strictly enforced. High-level radioactive wastes generate a lot of heat and thus require cooling, as well as special protective shield during handling and transport. Radiation, that is given off by nuclear wastes is extremely harmful to the organisms, because it causes mutation at a very high rate. At high doses, nuclear radiation is lethal but at lower doses, it creates various disorders, the most frequent of all being cancer. Therefore, nuclear waste is an extremely potent pollutant and has to be dealt with utmost caution.

Q. 3. Explain the ways by which solid waste can be disposed.

Ans. Refer to Basic Concepts Point 8.

Q. 4. Explain biomagnification. How does biomagnification of DDT affect the population of fish-eating birds? ***[CBSE (F) 2010; 2019 (57/4/2)]***

Ans. Unknowingly some harmful chemicals enter our bodies through the food chain. We use several pesticides and other chemicals to protect our crops from diseases and pests. These chemicals are either washed down into the soil or into the water bodies. From the soil, these are absorbed by the plants along with water and minerals, and from the water bodies these are taken up by aquatic plants and animals. This is one of the ways in which they enter the food chain. As these chemicals are not degradable, these get accumulated progressively at each trophic level. As human beings occupy the topmost level in any food chain, the maximum concentration of these chemicals get accumulated in our bodies. This phenomenon is known as biological magnification.

The population of fish-eating birds living on the bank of a contaminated lake differs from those living on the bank of another lake free from such insecticides (DDT). DDT being highly poisonous caused the thinning of their egg-shells and population of birds declined. The phenomenon is known as biological magnification.

Q. 5. (*a*) What depletes ozone in the stratosphere? How does this affect human life?

(*b*) Explain biomagnification of DDT in an aquatic food chain. How does it affect the bird population? ***[CBSE (AI) 2012]***

Ans. (*a*) Chlorofluorocarbons (CFCs) deplete ozone in the stratosphere.

UV(B) damages DNA causing mutation, skin cancer, inflammation of cornea, cataract, aging of skin, snow blindness.

(*b*) If DDT reaches from the agricultural field, it gets into the water body (the concentration is 0.0003 ppm) and enters the food chain: zooplanktons (0.04 ppm) → small fish (0.05 ppm) → large fish (2 ppm) → any fish eating bird (5 ppm). Concentration of DDT increases along the food chain, reaching a high level in the top carnivore bird.

DDT concentration disturbs Ca^{++} metabolism, egg shells become thin, premature breaking resulting in decline in bird population.

Q. 6. (*a*) What is El Nino effect? Explain how it accounts for biodiversity loss.

(*b*) Explain any three measures that you as an individual would take, to reduce environmental pollution. ***[CBSE Delhi 2011]***

Ans. (*a*) El Nino effect refers to the odd climatic changes in pacific ocean due to rise in temperature. It leads to increased melting of polar ice caps as well as other places like the Himalayan snow caps. This will result in a rise in sea level that can submerge many coastal areas. Thus, resulting in biodiversity loss, it can also result in intense storms in some places and droughts or more rains in others.

(*b*) Measures to reduce environmental pollution

(*i*) Use of renewable energy resources.

(*ii*) Use of television and other gadgets at low pitch.

(*iii*) Minimum use of fossil fuel.

(*iv*) No tobacco smoking.

(*v*) Planting more trees.

Self-Assessment Test

Time allowed: 1 Hour **Max. marks: 30**

1. Choose and write the correct option in the following questions. **(3×1 = 3)**

(i) Which one of the following diseases is not caused due to contamination of water?

(a) Hepatitis-B (b) Jaundice

(c) Cholera (d) Typhoid

(ii) The loudness of a sound that a person can withstand without discomfort is about

(a) 150 dB (b) 215 dB

(c) 30 dB (d) 80 dB

(iii) The material generally used for sound proofing of rooms like a recording studio and auditorium is

(a) cotton (b) coir

(c) wood (d) styrofoam

2. In the following questions a statement of assertion followed by a statement of reason is given. Choose the correct answer out of the following choices. **(3×1 = 3)**

(a) Assertion and reason both are correct statements and reason is correct explanation for assertion.

(b) Assertion and reason both are correct statements but reason is not correct explanation for assertion.

(c) Assertion is correct statement but reason is wrong statement.

(d) Assertion is wrong statement but reason is correct statement.

(i) Assertion : Greenhouse gases are envelope of gases around the earth.

Reason : Concentration of greenhouse gases in atmosphere can vary.

(ii) Assertion : Nitrogen when mixed with water becomes harmful.

Reason : Air pollution cause serious consequences like global warming.

(iii) Assertion : Dumping of waste in the soil pollutes it.

Reason : Non-biodegradable wastes do not get decomposed one time.

3. How is snow-blindness caused in humans? **(1)**

4. Why are owners of motor vehicles equipped with catalytic convertors advised to use unleaded petrol? **(1)**

5. Why are CO_2 and CH_4 known as greenhouse gases? **(2)**

6. What is an algal bloom? **(2)**

7. DDT content in the water of a lake that supplies drinking water to the nearby villages is found to be 0.004 ppm. The pelicans of that area are reported to have 2.6 ppm of DDT. Why has the concentration increased in these birds? What possible harm can this cause to the bird population? Also give the name of the phenomenon. **(2)**

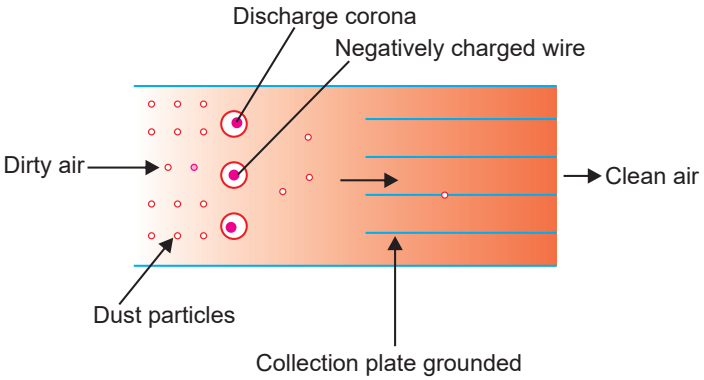
8. What are the major consequences of deforestation? **(2)**

9. (i) Explain biomagnification.

   (ii) How does the biomagnification of DDT affect the population of fish eating birds? **(3)**

10. How can pollution by auto exhaust be minimised? **(3)**

11. Observe the diagram of electrostatic precipitator given below. **(3 × 1 = 3)**



Answer the questions that follow:

(i) An electrostatic precipitator in a thermal power plant is not able to generate high voltage of several thousands. Write the ecological implication because of it.

(ii) Name any two places where it is essential to install electrostatic precipitators. Why it is required to do so?

(iii) Mention one limitation of the electrostatic precipitator.

12. (i) Why is the ozone layer required in the stratosphere? How does it get degraded? Explain.

    (ii) Why is the ozone depletion a threat to mankind? **(5)**

Answers

1. (*i*)—(*a*), (*ii*)—(*d*), (*iii*)—(*d*) **2.** (*i*)—(*b*), (*ii*)—(*d*), (*iii*)—(*a*)

PART–B

CASE-BASED QUESTIONS

Competency Based Questions

Case-based Questions

1. Read the following and answer the questions given below:

Turner's Syndrome

Turner's syndrome is an example of monosomy. It is formed by the union of an allosome free egg and a normal 'X' containing sperm or a normal egg and an allosome free sperm. The individual has 2n = 45 chromosomes (44 + XO) instead of 46. Such individuals are sterile females who have rudimentary ovaries, under-devloped breasts, small uterus, short stature, webbed neck and abnormal intelligence. They may not menstruate or ovulate. Individuals with Turner's syndrome have deficiency of FSH and oestrogen secretion. This disorder can be treated by giving female sex hormone to the women from the age of puberty to make them develop breasts and have menstruation. This makes them feel more normal.

(i) How do humans with 'XO' abnormality suffer? Explain. 1

(ii) Turner's syndrome is an example of 1

(a) aneuploidy (b) euploidy

(c) polyploidy (d) autosomal abnormality

(iii) Name a disorder, give the karyotype and write the symptoms where a human male suffers as a result of an additional X-chromosome. 2

(iv) Which of the following statement regarding Turner's syndrome is not correct? 1

(a) It is a case of monosomy of sex chromosomes.

(b) The suffering individual is sterile female will one 'X' chromosome missing in the cells.

(c) The problem can be cured by taking regular injection of female sex hormone after puberty.

(d) The individuals are of short stature.

2. Read the following and answer the questions given below:

Placenta: A vital connecting tissue

After implantation the foetus develops a connection with uterine wall known as placenta. It facilitates the supply of oxygen and nutrient to the foetus and removal of carbon-dioxide and excretory wastes produced by the foetus. Placenta is connected to the embryo through an umbilical cord which helps in the transport of substances to and from the embryo. Placenta also acts as an endocrine tissue and produces several hormones like human chorionic gondotropin (hCG), human placental lactogen (hPL), estrogens, progesterones etc. In the later phase of pregnancy, a hormone called relaxin is also secreted by the ovary. In addition, during pregnancy, levels of other hormones like estrogens, progesterones, cortisol, prolactin, thyroxine, etc. are increased several folds in the maternal blood. Increased production of these hormones is essential for supporting the foetal growth, metabolic changes in the mother and maintenance of pregnancy.

(i) Name the hormones produced by placenta. 2

(ii) What stimulates pituitary to release the hormone responsible for parturition? Name the hormone. 2

(iii) Which of the following is not a function of placenta? 1

(a) Production of hCG and hPL.

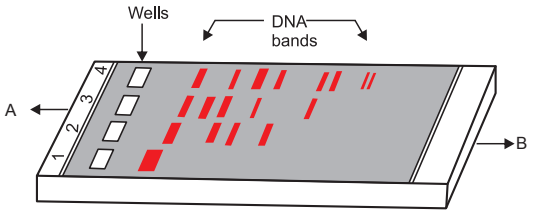
(b) Removal of excretory wastes of foetus.

(c) Facilitates supply of oxygen and nutrient.

(d) Production of prolactin.

3. Read the following and answer the questions given below:

Rajesh was doing gel electrophoresis to purify DNA fragments. Given below is the sketch of the observations of the experiment performed by him.



(i) At which end he would have loaded the samples and where? 1

(ii) Analyse the reason for different positions taken up by the DNA bands. 1

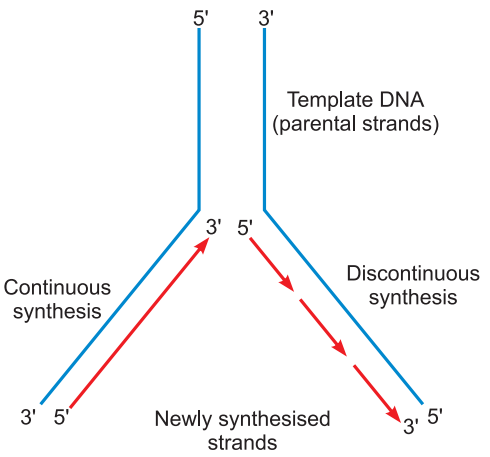
(iii) Elaborate the step he would have followed to visualise DNA bands. 1

(iv) What is the need of purifying DNA sample? 1

4. Read the following and answer the questions given below:

DNA Replication

The process of DNA replication takes place in direction 3′ → 5′ of the template. The enzyme DNA polymerase performs polymerization in 5′ → 3′ direction. The enzyme helicase opens up the DNA helix to develop a replication fork. In prokaryotes, the replication fork runs in both directions from the point of 'origin' to complete DNA replication.



(i) How many origins are present in prokaryotic DNA? 1

(ii) Why do you see two different types of replicating strands in the given DNA replication fork? Explain. Name these strands. 2

(iii) State the dual role of deoxyribonucleoside triphosphates during DNA replication. 2

5. Read the following and answer the questions given below:

Double fertilisation

Following compatible pollination, the pollen grain germinates on the stigma to produce a pollen tube which grows through the tissues of stigma and style and reaches to ovary. If the pollen grain was shed at 2-celled stage, the generative cell divides and forms the two male gametes during the growth of pollen tube. In plants which shed pollen grains in 3-celled condition, pollen tube carries the two male gametes from the beginning. The pollen tube enters into ovule and peneterates into

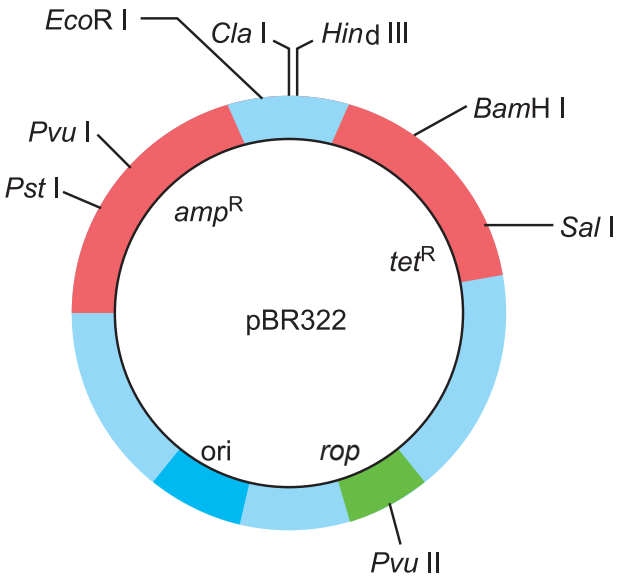
the embryo sac. Within embryo sac, the pollen tube enters into one of the synergids through the filiform apparatus. Now the pollen tube releases two male gametes into the space developed by degeneration of peneterated synergid. One of the male gamete moves towards the egg cell and fuses with its nucleus thus completing syngamy resulting into the formation of diploid zygote. The other male gamete moves towards the two polar nuclei located in the central cell and fuses with them to produce a triploid primary endosperm nucleus (PEN). As this involves the fusion of three haploid nuclei, it is termed as triple fusion. Since two types of fusion – syngamy and triple fusion, takes place in an embryo sac, this phenomenon is termed as double fertilisation, an event unique to flowering plants. After fusion, the central cell become primary endosperm cell (PEC) and develops into endosperm while the zygote develops into an embryo.

(i) Why angiospermic plants produce endosperm while the other plants do not? 2

(ii) What is the entry point of pollen tube into embryo sac? 1

(iii) What does double fertilisation refer to? 2

6. Study the following diagram and answer the questions given below:



(a) Name the organism in which the vector shown is inserted to get the copies of the desired gene. 1

(b) Mention the area labelled in the vector responsible for controlling the copy number of the inserted gene. 1

(c) Name and explain the role of a selectable marker in the vector shown. 2

7. Read the following and answer the questions given below:

Kangaroo rat seldom drinks water. It has thick coat to minimise evaporative desiccation. The animal seldom comes out of its comparatively humid and cool burrow during the day time. 90% of its water requirement is met from metabolic water (water produced by respiratory breakdown of fats) while 10% is obtained from its food. Loss of water is minimised by producing nearly solid urine and faeces. As the animal faces acute water scarcity, it develops two types of adaptations: reducing water loss and ability to tolerate desert conditions.

(i) In what habitats do kangaroo rats dwell? 1

(ii) How do desert animals minimise water loss? 2

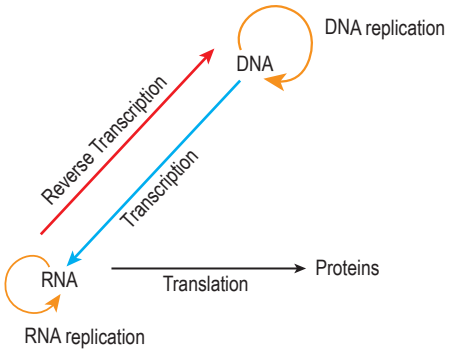
(iii) What do you understand by metabolic water? 1

(iv) Kangaroo rat is a **1**

(a) partial regulator (b) partial conformer

(c) regulator (d) conformer

8. Read the following and answer the questions given below:



The diagram represents flow of genetic information in the living world (including viruses). It is termed as "Central Dogma of molecular Biology". The concept of central Dogma got modified after the discovery of viral genetics.

(i) Who proposed the Central Dogma? **1**

(ii) Name the stage in the cell cycle where DNA replication occurs. **1**

(iii) Discuss the role of enzyme DNA ligase plays during DNA replication. **2**

9. Read the following and answer the questions given below:

Health, for a long time was considered as a state of body and mind where there was balance of certain humors. It was the concept that early Greeks like Hippocrates as well as Indian Ayurveda system of medicine asserted. It was believed that persons with blackbile belonged to hot personality and would have fevers. This idea was arrived at pure reflective thought. The discovery of blood circulation by William Harvey using experimental method and the demonstration of normal body temperature using thermometer in persons with blackbile disproved that good humor hypothesis of health. Later on, it was found that our mind influences our immune system, through neural system and endocrine system, to maintain our health. Hence mind and mental state can affect our health. Human health can get affected by mainly three different ways:

(a) Due to genetic disorders

(b) Due to infections by pathogens

(c) Due to life style including food and water taken, rest and exercise we give to our bodies.

(i) How does colostrum provide initial protection against diseases to new born infants? Give one reason. **1**

(ii) Write the events that take place when a vaccine for any disease is introduced into the human body. **3**

(iii) Our immune system is functional with the help of **1**

(a) Neural system (b) Endocrine system

(c) Mascular system (d) Neural and Endocrine system

10. Read the following and answer the questions given below:

Regular change in temperature that occurs at specific intervals of time is called thermoperiodicity. It is of two types—Diurnal and Seasonal thermoperiodicity. It is a very common phenomenon that different temperature prevails in different seasons of the year. They favour different aspects

of plant and animal life termed as phenology. For example in wheat, leaf growth requires a temperature of 10°–25° C while stem growth is favoured by a temperature of 30°C found in early spring of wheat growing areas. Apple requires a temperature below 7°C for a period of 800 hrs before flowering and fruiting can occur. Low temperature is required for germination of some seeds as well as flowering in some plants. It also determines growth, reproduction, colour and morphology of animals. Both low and high temperature causes stress in organisms which is overcome by particular adaptations.

(i) How do organisms like fungi, zooplanktons and bears overcome the temporary short-lived climatic stressful conditions? Explain. 3

(ii) Which of the followings represents an adaptation in polar bear to cope up with low temperature? 1

(iii) How do cold blooded animals maintain their body temperature? 1

(a) Larger body size

(b) Shorter limbs

(c) Presence of blubber (a thick layer of fat below skin)

(d) Presence of snow-white fur

11. Read the following and answer the questions given below:

Sex-Determination in Honey Bees

In case of honey bee, the male is haploid while the female is diploid. Similar conditions are found in some other insects like ants and wasps. Male insects are haploid because they develop parthenogenetically from unfertilised eggs. The phenomenon is called arrhenotoky. Meiosis does not occur in the formation of sperms. Females grow from fertilized egg and are hence diploid.

Queen bee picks up all the sperms from drone during nuptial flight and stores them in seminal receptacle. When the queen visits drone cells it lays eggs but seminal receptacles fails to emit the sperms. The male honey bee develops parthenogenetically from these unfertilised eggs. However in all other cells, i.e., cells of workers, the female lays eggs and sperms are emitted properly from its seminal receptacle, upon these eggs leading to their fertilization. Hence except drones other honey bees (worker and queen) are diploid.

(i) The diploid number of chromosomes for honey bee is 32. How many chromosomes will be present in the cells of drone? 1

(ii) What type of cell division is involved in spermatogenesis in honey bee? 1

(iii) What factors are responsible for the fertilised eggs to develop into queen or workers? 2

12. Read the following and answer the questions given below:

Maintenance of personal and public hygiene is very important for prevention and control of many infectious diseases. Measures of personal hygiene include keeping the body clean, consumption of clean drinking water, food, vegetables, fruits, etc. Public hygiene includes proper disposal of waste and excreta, periodic cleaning and disinfection of water reservoirs, pools, cesspools and tanks and observing standard practices of hygiene in public catering. These measures are particularly essential where the infectious agents are transmitted through contaminated food and water such as in case of disease typhoid and amoebiasis.

In case of air-borne diseases such as pneumonia and common cold, close contact with infected persons or their belongings should be avoided. For the vector transmitted disease the most important measure is to control or eliminate the vectors and their breeding places. The advancement made in biological science have armed us to effectively deal with many infectious diseases. The use of vaccines and immunization programmes have enabled us to completely eradicate a deadly disease like small pox.

(i) Name two diseases transmitted through contaminated food and water. 1

(ii) Define the term 'health'. Mention any two ways of maintaining it. 2

(iii) Explain the relationship between B-lymphocytes and T-lymphocytes in developing an immune response. 2

13. Read the following and answer the questions given below:

Herbivores are the predators for plants. Nearly 25% of insects are phytophagus (feeding on the plant sap and other parts of the plants). The problem of predation is particularly severe for plants because unlike animals, they can not run away from their predators. Plants therefore have evolved variety of chemical and morphological defences against herbivores. Thorns are the most common morphological means of defence (as in Acacia and various Cacti). Many plants produce and store chemicals that make the herbivore sick when they are eaten, inhibit feeding or digestion, disrupt its reproduction or even causes death. The plant Calotropis provides an example, it produces a highly poisonous cardiac glycosides and that is why you never see any cattle and goats browsing on this plant. A wide variety of chemicals that we extract from plants on a commercial scale (e.g., alkaloids like nicotine, caffeine, quinine, opium, strychnine, etc.) are produced by them actually acts as a defence against grazers and browsers.

(i) For plants, herbivores are predators and for herbivores plants are 1

(a) host (b) prey

(c) fodder (d) all of these

(ii) What defence mechanism is shown by *Acacia* and cactus? 2

(iii) Egrets are often seen along with grazing cattle. How do you refer to this interaction? Give a reason for this association. 2

14. Read the following and answer the questions given below:

Microbes: Friend or Foe

Microbes are a very important component of life on earth. Not all microbes are pathogenic. Many microbes are very useful to human beings. We use microbes and microbially derived products almost everyday. Bacteria called lactic acid bacteria (LAB) grow in milk to convert it into curd. The dough which is used to make bread is fermented by yeast called Saccharomyces cerevisiae. Certain dishes such as idli and dosa are made from dough fermented by microbe.

Bacteria and fungi are used to impart particular texture, taste and flavour to cheese. Several microbes are used to produce industrial products like lactic acid, acetic acid and alcohol, which are used in a variety of processes in the industry. Antibiotic like penicillin produced by useful microbes are used to kill disease-causing harmful microbes. Antibiotics have played major role in controlling infectious diseases like diphtheria, whooping cough and pneumonia. Microbes can also be used to kill harmful pests, a process called biocontrol. The biocontrol measures helps us to avoid heavy use of toxic pesticides.

(i) Which microbes is used for bread making? 1

(ii) How was penicillin discovered and by whom? 2

(iii) Why is curd more nutritious than milk? 1

(iv) Why does a dough appear puffed up? 1

15. Read the following and answer the questions given below:

In prokaryotes, control of the rate of transcriptional initiation is the predominant site for the control of gene expression. In a transcription unit, the activity of RNA polymerase with accessory proteins, which affects its ability to recognise start sites. These regulatory proteins can act both positively (activators) and negatively (repressors). The accessibility of promoter regions of prokaryotic DNA is in many cases regulated by the interaction of proteins with sequences termed

operators. The operator region is adjacent to the promoter region in most operons and in most cases the sequence of operator binds a repressor proteins. Each operon has its specific operator and specific repressor, as in case of '*lac* Operon' there is presence of Lac operator which interacts specifically with lac repressor only.

(i) What does the presence of a functional repressor in any operon mean? 1

(ii) Which of the following statement is correct? 1

(a) operator-repressor means functional repressor.

(b) repressor binds to promoter.

(c) regulatory proteins are only repressors.

(d) repressor bound to operator means non-functional operon.

(iii) How is *lac* operon regulated? 2