Order

It is a group of related families that means related families are kept in the same order. For example, the family Felidae of cats and family Canidae of dogs are assigned to the same order **Carnivora**. As they both have canine teeth which is a similar feature found in animals of both the families.

Therefore, order is assemblage of families which exhibit a few similar characters inspite of many differential features. The similar characters are less in number as compared to different genera included in a single family. Different plant families like Convolvulaceae, Solanaceae are included in the order Polymoniales along with three other related families. The common feature of all different families placed in a single order, *i.e.*, Polymoniales is **similar floral characters** found in them.

Example 13 : *In which category organisms of related families are placed?*

Solution : Order

Try Yourself

23. Carnivora includes
    (1) Group of organisms belonging to related genera
    (2) Group of organisms belonging to related species
    (3) Group of organisms belonging to related families
    (4) Group of organisms which are similar in all features
24. The order Polymoniales consists of
    (1) *Canidae* and *Felidae* like families
    (2) *Solanum* and *Petunia* like genera
    (3) *lupus* and *familiaris* like species
    (4) *Convolvulaceae* and *Solanaceae* like families

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Class

A class is a group of one or more related orders. For example, the order Rodentia of rats, Primata of monkey, gorilla and gibbon, and Carnivora of cats and dogs are all placed in the same class **Mammalia**. All these orders are kept under the same class because members of these orders have milk-producing glands and hair on their skin. We can say that class is the assemblage of orders which exhibit a few similar characters.

Example 14 : *Name the class in which organisms like rabbits, cats, dogs are kept.*

Solution : Mammalia

Try Yourself

25. The group of organisms belonging to one or more related orders are assigned to
    (1) Different class but same family
    (2) Same class on basis of a few similar characters
    (3) Any taxa lower to order, in taxonomical hierarchy
    (4) Same family due to similar morphological characters

26. Different organisms belonging to different orders are placed in a single class due to the fact that
(1) They have all similar morphological and reproductive characters
(2) They have similar place of origin
(3) They share a common habitat
(4) They have few similar or common characters

Phylum/Division

It is a category higher than that of class. The term phylum is used for animals, while division is commonly used for plants. Phylum or division is a group of related classes, *i.e.*, it is formed of one or more classes. Different classes, comprising animals like fishes, amphibians, reptiles, birds and mammals, together constitute the next higher category known as **"Phylum"**. All of these different organisms are placed in the phylum **Chordata** as all of the animals in these classes have some common characters like presence of notochord atleast at some stage of their lives, dorsal hollow neural system, etc. In case of plants, classes with a few similar characters are assigned to higher category called division.

Example 15 : *Which is the immediate higher category than class in taxonomical hierarchy?*
Solution : Phylum

Try Yourself

27. Which of the following represents "Phylum"?
(1) Mammalia (2) Chordata
(3) *Solanum* (4) Carnivora
28. Chordata includes
(1) Fishes, birds (2) Mammals, reptiles
(3) Aves, reptilia (4) All of these

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Kingdom

It is the highest category in taxonomic hierarchy. It is a group of phyla (in plural) or divisions, which have certain basic common characteristics. Animals present in all phyla lack cell wall and chlorophyll, are placed in the kingdom **Animalia**. All plants present in different divisions have rigid cell wall around their cells and synthesize their own food by photosynthesis, are included in the kingdom **Plantae**. Hence, we can call these two broad categories of plants and animals as plant and animal kingdoms.

So, now we can recall the basis of arrangement of organisms in taxonomic hierarchy. As we go higher from species to kingdom, the number of common characteristics goes on decreasing. Lower the taxa, more are the characteristics that the members within the taxon share. Higher the category, greater is the difficulty of determining the relationship to the other taxa at the same level. Hence, the problem of classification becomes more complex.

Table : Organisms with their taxonomic categories

Common names	Biological name	Genus	Family	Order	Class	Phylum OR Division	Kingdom
Man	*Homo sapiens*	*Homo*	Hominidae	Primata	Mammalia	Chordata	Animalia
Housefly	*Musca domestica*	*Musca*	Muscidae	Diptera	Insecta	Arthropoda	Animalia
Mango	*Mangifera indica*	*Mangifera*	Anacardiaceae	Sapindales	Dicotyledonae	Angiospermae	Plantae
Wheat	*Triticum aestivum*	*Triticum*	Poaceae	Poales	Monocotyledonae	Angiospermae	Plantae
Brinjal	*Solanum melongena*	*Solanum*	Solanaceae	Polymoniales	Dicotyledonae	Angiospermae	Plantae

Example 16 : *Name the highest category in taxonomic hierarchy.*
Solution : Kingdom

Try Yourself

29. From species to kingdom, the number of common characteristics among organisms goes on___
    (1) Increasing
    (2) Increasing upto taxon family then further decreases
    (3) Decreasing
    (4) Decreasing upto class then increases afterwards
30. All plants are included in
    (1) Division – Angiospermae (2) Class – Dicotyledonae
    (3) Kingdom – Animalia (4) Kingdom – Plantae

Knowledge Cloud

1. In accordance with International Code of Botanical Nomenclature (ICBN), the names of different categories must end in the standard endings **(suffixes)** given below :

Term given by:	Category:	Suffix
J. Eichler	**Division**	**-phyta**
C. Linnaeus	**Class**	**-phyceae** or **-opsida** or **-ae**
C. Linnaeus	**Order**	**-ales**
John Ray	**Family**	**-aceae**
	Tribe	**-eae**
Suffixes used in the animal kingdom are :		
	Family	**-idae**
	Tribe	**-ini**

2. **Tribe** is an intermediate category between sub-family and genus.

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TAXONOMICAL AIDS

The systematic study of diverse organisms is beneficial for human kind. As human can exploit this knowledge of various species of plants, animals and other organisms in agriculture, forestry, fishery, industries, etc. and can also exactly understand different bio-resources existing on earth. Therefore, accurate classification and identification of organisms is required which needs field studies and intensive laboratory work. This is done after collection of actual specimens of plants and animal species which is the primary source of all taxonomic studies. This helps in not only studying diverse organisms morphology etc. but also various relationships present amongst them. It also plays an essential role in systematics training. Hence, these taxonomical studies help in :

1. Fundamental study of different living organisms.
2. Also aid in their systematic study.
3. Information gathered is stored with specimens for future studies.

Therefore, biologists have established certain procedures and techniques to store and preserve the information as well as the specimens. Some of the locations where one can find information with specimen of various plants, animals and other organisms are Herbarium, Botanical Gardens, Museums and Zoological Parks.

Example 17 : *What is the prime source of taxonomic studies?*

Solution : The collection and preservation of actual specimens of plants and animals, is the prime source of taxonomic studies.

Try Yourself

31. Taxonomic study of various species of plants, animals and other organisms is useful for human beings because it helps in field of
    (1) Agriculture (2) Industry
    (3) Forestry (4) All of these
32. Taxonomic study of a newly discovered organism is done by
    (1) Identifying it, only
    (2) Gathering information about its habitat and habit only
    (3) Collecting its actual specimen and then identifying and classifying it
    (4) Studying previously recorded information about various other organisms

Herbarium

It is defined as "store house of collected plant specimens that are dried, pressed and preserved on sheets". Further, these sheets are arranged in the sequence of a universally accepted system of classification.

Fig.: Herbarium showing stored specimens

The sheets having different specimens along with their accurate information form a herbarium. These herbarium sheets are carefully preserved for future use. These sheets carry a label on the right-hand side at lower corner which provides information about :

1. Date on which the specimen was collected.
2. Place from where the specimen was collected
3. English name of the specimen.
4. Vernacular or local name of the specimen.
5. Botanical name of the specimen.
6. Family of the specimen.
7. Name of the collector of that specific specimen.

Such herbaria serve as **quick source of reference** in taxonomical studies. It also provides information about the local flora as well as flora of distant areas. This information is also useful in locating wild varieties and relatives of economically important plants.

List of some Herbaria of the world :

1. Royal Botanical Gardens, Kew (England)
2. Central National Herbarium, Calcutta

Content Builder

Herbarium Technique : The herbarium technique involves the following steps:

(a) Collection (b) Drying (c) Poisoning (d) Mounting (e) Stitching (f) Labelling (g) Deposition

(a) **Collection :** Collection of plant material is done with an aesthetic sense and scientific mind.

The material should be perfect and complete for determination, *i.e.*, must have fully grown leaves, complete inflorescence etc.

Woody elements are well represented by flowering twigs with 30-40 cm in lengths, while herbaceous plants are collected alongwith underground parts.

Diseased plants, infected twigs should be avoided.

The collections are kept inside **metallic vasculum** or polythene bags, to preserve moisture.

(b) **Drying :** The plant collections are pressed in ordinary newspaper folders, avoiding overlapping. The folders, in turn, are pressed in a field press. The moistened folders are changed frequently to avoid blackening and decay of plant material.

(c) **Poisoning :** The specimens are poisoned to keep away the microbes. When the specimens are partially dehydrated, they are poisoned by using chemicals like **0.1% of corrosive sublimate ($HgCl_2$).** Following the chemical treatment, the specimens are again dried.

(d-f) **Mounting, Stitching and Labelling :** Dried specimens are glued and stitched on herbarium sheets made up of thick card sheets cut to the required size. **The international size of the herbarium sheet is 41 × 29 cm²** $\left(16\frac{1}{2}\times 11\frac{1}{2}\text{ inches}^2\right)$**.** The field data is entered on **label** on the right hand side lower corner of the herbarium sheet. Size of label is commonly 7 × 12cm. The small paper envelopes called **fragment packets** are often attached to the herbarium sheet to hold seeds, extra flowers or loose plant parts.

(g) **Deposition :** Arrangement of genus folders, according to accepted classification, is called deposition. In India, herbaria are arranged according to **Bentham and Hooker** system of classification.

The specimens so preserved are sprayed with repellents or disinfectants such as DDT powder, copper sulphate solution at intervals of 4 to 6 months to keep off small insect pests such as silver fish.

Functions of a Herbarium: The two **primary** functions of herbarium are **accurate identification** and **alpha taxonomic research** (based on gross morphology).

The **secondary** functions include closer interaction between the student of general systematics and the herbarium.

Other important functions of a herbarium are

(i). To preserve plant wealth including type material and palaeobotanical collections.

(ii) To carry out exchange and loan of preserved plant material for research, exhibitions etc.

The herbaria are classified as :

(a) **Major or National Herbaria** which cover the flora of the world and serve the purpose of research as well as identification.

(b) **Minor Herbaria** which include smaller herbaria such as **Regional herbaria** (set up by government), **Local herbaria** (serve the purpose of a small area like a district) and **College / University herbaria** (primarily for teaching and post graduate research).

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A list of important herbaria of the world is given below along with their standard abbreviations and the approximate number of specimens they hold :

1.	**Royal Botanical Gardens, Kew (K)**	**Over 6,000,000**
2.	British Museum of Natural History (BM)	6,000,000
3.	Royal Botanical Garden, Edinburgh (E)	1,500,000
4.	**Central National Herbarium, Calcutta (CAL)**	**2,000,000**
5.	Herbarium of the Forest Research Institute, Dehradun (DD)	300,000
6.	Herbarium of the National Botanical Research Institute, Lucknow	80,000

Example 18 : *Name the place where one can find various plant specimens with relevant information and mounted on sheets.*

Solution : Herbarium

Try Yourself

33. In Herbarium, actual finely preserved specimens of _____ are systematically arranged.
    (1) Animals
    (2) Plants
    (3) Bacteria
    (4) Fungi
34. Herbarium sheets provide information about
    (1) Place from where animal specimen is collected
    (2) Place and date on which plant specimen was collected
    (3) Only botanical name of the plant specimen mounted on it
    (4) Date, place and local name of acellular organism mounted on such sheets

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Botanical Gardens

Botanical garden is an institution located in an enclosed piece of land which grows numerous kinds of plants obtained from different places for botanical studies. It is *ex-situ* conservation strategies of plants. Each plant is first identified and then labelled indicating its botanical/scientific name and its family.

List of some Botanical Gardens :

1. Royal Botanical Garden, Kew (England)
2. National Botanical Garden, Lucknow
3. Indian Botanical Garden, Howrah
4. Lloyd Botanical Garden, Darjeeling

Example 19 : *What are botanical gardens?*

Solution : Botanical gardens are sufficiently large-sized tracts where plants of different types and areas are grown for scientific and educational purposes.

Try Yourself

35. Botanical gardens consist of
    (1) Dried and preserved plant specimens
    (2) Living plants and animals specimens
    (3) Living plants specimens
    (4) Dead specimens of plants are preserved in jars
36. A famous botanical garden known as Royal Botanical Garden is located in
    (1) Lucknow, India
    (2) Kew, England
    (3) Howrah, India
    (4) Darjeeling, India

Museum

Museum is a place used for storing, preservation and exhibition of both plants and animals. All educational institutes and universities maintain museums in their Botany and Zoology departments.

These museums have collection of preserved plants and animals which are used for study and reference. These specimens are kept in the containers or jars in preservative solution. A commonly used preservative solutions is "Formalin". Plants and animals specimen may also be preserved as dry specimens. For instances, insects are collected, killed and pinned before preserving them in special insect boxes while larger animals like reptiles, birds and mammals are usually stuffed and then preserved. Skeleton of some larger animals are also preserved in various museums. Thus, preservation of specimens collected and stored in museum is done by either putting specimens into a condition that checks deterioration or it is protected by other means as no specimens will last forever. National Museum of Natural History (NMNH) in Delhi is important from natural science point of view.

Example 20 : *How are plants, animals and other organisms kept in museum?*

Solution : Museum displays animals, plants and other organisms after preserving them in either preservative solution or stuffing them.

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Try Yourself

37. In museum, specimens are preserved carefully so that they can be used for
    (1) Research purposes
    (2) Study of breeding among plants and animals
    (3) Exhibition
    (4) More than one option is correct
38. In museums, insects are preserved by
    (1) Pinning without killing them and then preserving in containers
    (2) Killing, pinning and then mounting in special boxes
    (3) Mounting them alive in jars with various preservative solutions
    (4) Killing, pinning and then stuffing them

Zoological Parks

Zoological parks commonly known as zoos are the places where live wild animals are kept in protected environment which is made similar to their natural habitats as much as possible. Thus, these are *ex-situ* conservation of animals. Here, they are provided with protection and care by human beings. These parks serve as ideal means to study and learn different food habits and behaviour of variety of animals. So, students should visit nearby zoos for knowledge and entertainment both. National Zoological Park (Delhi) is one of the finest zoos of Asia.

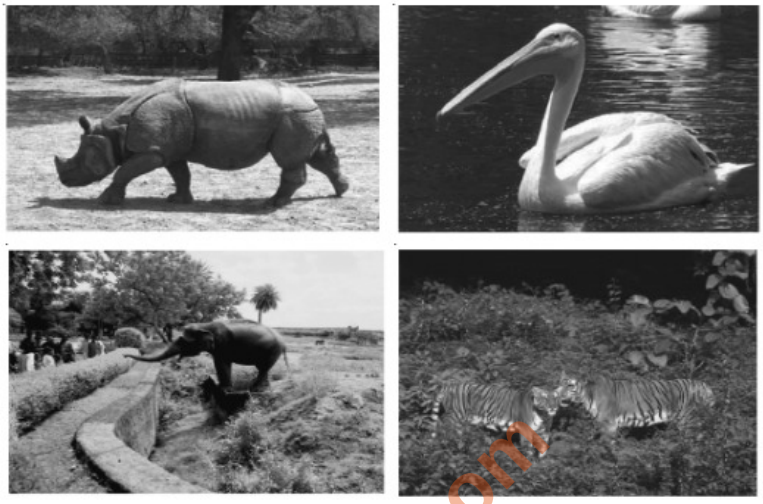

Fig. : Pictures showing animals in different zoological parks of India

Example 21 : *Name one zoological park of Asia.*

Solution : National Zoological Park (Delhi).

Try Yourself

39. The place where wild animals are kept in captivity, under human care is known as
    (1) Herbarium (2) Museum
    (3) Botanical gardens (4) Zoological parks
40. Animals in zoological parks are kept in
    (1) Fully man-made environment
    (2) Containers with preservative solutions
    (3) Conditions similar to natural habitats
    (4) Herbarium sheets

Key

Key is an important taxonomic aid used for identification of plants and animals based on the **similarities** and **dissimilarities**. Actually, it is a set of alternate characters of different types arranged sequence wise in such a fashion that by selection and elimination one can quickly find out the name of the organism. The keys are based on the set of contrasting characters generally in a pair known as **"couplet"**. Each character of the couplet or statement in the key is called as **"lead"**. One has to choose correct option between two statements of characters of definite species so that the animal or plant is identified accurately. **Keys are generally analytical in nature.** There are separate taxonomic keys specific for each taxonomic category such as family, genus and species.

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Example 22 : *What is a key?*

Solution : A key is an artificial analytical device, consisting of set of alternate characters of various plants and animals and is used for identification purposes.

Try Yourself

41. A taxonomical key is used for
    (1) Conserving various plant species
    (2) Identification of plants and animals
    (3) Studying geography of a plant
    (4) Nomenclature of plants and animals
42. Each statement of the key is called
    (1) Couplet (2) Taxon
    (3) Lead (4) Category

Flora, Manuals, Monographs and Catalogues

These flora, manuals, monographs, etc. are recorded descriptions of plants, animals and other organisms. They provide correct identification and description of variety of living organisms.

(i) **Flora :** It is a book containing information about plants found in a particular area. It gives the actual account of **habitat** and **distribution** of various plants of a given area. These provide the index to the plant species found in a particular area. For example, Flora of Delhi by J.K. Maheshwari.

(ii) **Manual :** It is a book containing complete listing and description of the plants growing in a particular area. They provide useful information for identification of names of various species found in an area.

(iii) **Monograph :** It contains information of any one taxon.

(iv) **Catalogue :** It includes the alphabetical arrangement of species of a particular place describing their features.

Example 23 : *Name any two means used for taxonomical studies which comprise of recorded descriptions of plants and animals without any kind of their specimens.*

Solution : Flora, manuals, monographs and catalogues.

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Try Yourself

43. Flora contains
    (1) Dead specimens of plants which are carefully preserved
    (2) Collections of skeletons of animals only
    (3) Actual account of habitat and distribution of plants of a given area
    (4) Information on any one taxon of plants
44. Information about any one taxon of plants or animals can be found in
    (1) Museum
    (2) Herbarium
    (3) Monograph
    (4) Flora

EXERCISE

11. Which one of the following group of taxa does **not** represent similar category in hierarchy ?
    (1) Potato, brinjal and tomato
    (2) Tiger, lion and leopard
    (3) Wheat, monocots and angiosperms
    (4) Wheat, rice and mango

12. Which one of the following obligate category in taxonomic hierarchy will have maximum number of common characters?
    (1) Family
    (2) Class
    (3) Order
    (4) Species

13. Select **incorrect** match w.r.t. mango
    (1) Family – Anacardiaceae
    (2) Order – Sapindaceae
    (3) Class – Dicotyledonae
    (4) Division – Angiospermae

14. Select correct statement
    (1) Tomato, dicots and plants represent same taxa at different levels
    (2) Species is genetically open system
    (3) A breed of tiger and lion is a fertile true species
    (4) Biological concept of species is based on reproductive isolation

15. Which of the following taxonomical aid is related with quick referral systems in taxonomic studies?
    (1) National Zoological Park, Delhi
    (2) NMNH, Delhi
    (3) Central National Herbarium, Calcutta
    (4) Both (1) & (2)

16. Select the odd one out w.r.t. Botanical gardens
    (1) Collection of living plants for reference
    (2) Indian Botanical garden is at Howrah
    (3) It is a method of *ex-situ* study
    (4) Collections of preserved plants and animals specimens

17. Read the following statements carefully and select correct option
    (a) In zoological parks, conditions similar to natural habitats are provided to animals
    (b) Keys are generally analytical in nature
    (c) In herbarium sheet, local names are not mentioned
    (d) Taxonomical aids are useful in knowing bioresources
    (1) Only (a) & (b)
    (2) (a), (c) & (d)
    (3) (a), (b) & (d)
    (4) All of the above

18. Which of the following includes the alphabetical arrangement of species of a particular place describing features?
    (1) Manuals
    (2) Catalogues
    (3) Monograph
    (4) Flora

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19. Match column-I with column-II

	Column-I		Column-II
a.	Museum	(i)	Information on one taxon
b.	Herbaria	(ii)	Couplet
c.	Botanical gardens	(iii)	Arranged on universally accepted classification system
d.	Taxonomic key	(iv)	Educational institutes
		(v)	Records of local flora for monographic work

(1) a(iv), b(iii), c(v), d(ii) (2) a(iii), b(v), c(i), d(ii)

(3) a(iv), b(i), c(iii), d(v) (4) a(v), b(iii), c(iv), d(ii)

20. Select the **incorrect** statement

(1) Museums often have collections of skeletons

(2) Separate taxonomic keys are required for each taxonomic category

(3) Taxonomic keys are based on the contrasting characters

(4) Monograph is useful in providing information for identifications of names of species found in an area

Some Important Definitions

- **Metabolism :** It is the sum total of all chemical reactions occurring in an organism due to specific interactions amongst different types of molecules within the cells.
- **Reproduction :** It is the process of formation of new individuals of similar kind by an organism.
- **Evolution :** A gradual process in which something changes into a different and usually complex or better form. It may result in formation of new species from the pre-existing ones.
- **Biodiversity :** It refers to the various types of organisms on the earth.
- **Nomenclature :** It provides proper, specific and distinguishing name to each and every organism.
- **Taxonomy :** The branch of science dealing with the study of principles and procedures of classification.
- **Classification :** It is grouping of organisms into convenient categories on the basis of easily observable characters.
- **Binomial nomenclature :** It is a system of providing distinct and proper scientific names to organisms, each consisting of two words, first generic and second specific epithet.
- **Systematics :** It is the discipline of biology which deals with the kind and diversity of all organisms and the existing relationships amongst them.
- **Species :** It is a group of naturally interbreeding population with the ability to produce fertile offsprings.
- **Herbarium :** It is a storehouse of collected plant specimens that are dried, pressed and preserved on sheets.
- **Botanical garden :** It is an institution which grows numerous types of plants obtained from different places for botanical studies.
- **Zoological parks :** These are enclosed lands where animals are kept in protected environment similar to their natural habitat.

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- **Key :** The scheme for identification of plants and animals based upon the set of contrasting characters is known as keys.
- **Taxon :** It is a unit of classification which may represent any level of grouping of organisms based on certain easily observable common characteristics.
- **Seasonal breeders :** Seasonal breeders are plants or animals species that successfully mate only during certain time of the year.

Quick Recap

1. Our living world consists of wide range of life forms, some of which are identified and described while a large number still remains unknown.
2. 1.7–1.8 million species have been scientifically named and classified yet.
3. The living organisms are of different size, colour, habit, habitat, physiology and morphological features, with many defining characters of life, like metabolism and consciousness.
4. The biodiversity is studied through certain rules and principles which are accepted universally, for identification, nomenclature and classification of organisms.
5. The science which deals with the study of principles and procedures of classification is called **taxonomy**. Such studies help human beings in fields of agriculture, forestry, industry etc., and in general for knowing and locating different bio-resources and help in exploring this biodiversity with ease.
6. The basics of taxonomy like identification, naming and classification of organisms are universally evolved under International Codes.
7. International Code for nomenclature assign correct scientific names that comprises of two words. Such scientific names which are kept under binomial nomenclature provide unique and proper name to each and every organism.
8. Proper identification and nomenclature is followed by system of classification which involves hierarchy of steps that provides unique position to every organism.
9. In taxonomical studies, each step represents a rank or category and each category forms a part of taxonomical hierarchy.
10. Taxonomists have developed variety of taxonomic aids which include herbarium, botanical gardens, zoological parks, museums, etc.
11. In herbarium and museums, actual specimens of different living organisms are collected from the field and preserved by special techniques while in botanical gardens and zoological parks, living plants and animals are kept in protected areas, under human care, respectively.
12. Flora, manuals, monographs and catalogues are some other taxonomical aids which provide information about habitat and distribution of plants and animals in a particular area.
13. Key is the scheme for identification of plants and animals based upon similarities and dissimilarities.

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