BOTANICAL GARDENS

Botanical gardens are the institutions that maintain the living plant collections of different varieties of plants. They also maintain collections of ornamental, cultivated and economically important plants. Botanical gardens serve as ex-situ means of conservation and are meant for conservation of rare and endangered wild medicinal plants. Big botanical garden contains plant species from several corners of the globe. Botanical gardens not only have living collections of plants but also have library, herbarium, research laboratories and several miscellaneous resources including photographs, paintings, illustrations, reprints, note-books and specimens of several types. At present there are over 600 botanical gardens in the world.

Largest Botanical Garden of the World

Royal Botanical Garden KEW officially opened in 1841 and originally established in 1760 is the largest botanical garden of the world. William Aiton was the first curator of this garden. At present its herbarium has over 5 million specimens, its arboretum has over 7000 species, and its glasshouses have over 13000 species. A beautiful Alpine house, Rose garden, Bamboo garden and a Lily pond are also attached to this garden. Because of these facilities KEW gardens are called the botanical capital of the world.

Largest botanical garden of India

Indian botanical garden Kolkata, is the largest and oldest botanical garden of India. Formerly known as royal botanical garden was established in 1787 by Robert Kyd. The garden covers an area of 273 acres of land. William Roxburg the father of Indian botany was its 2nd director and founded the world's famous herbarium of this garden. The great banyan tree (*Ficus benghalensis*) which is one of the largest trees in size in the world is the main centre of attraction of this garden. The tree has over 2880 prop roots and circumference of the canopy is more than 404 meter. There are 15000 species of plants in this garden from several countries.

Role of Botanical gardens

1. Botanical gardens provide information of local flora.
2. Botanical gardens supply seeds and material for botanical investigations.
3. Botanical gardens provide information on food plants, ornamental plants, medicinal plants etc.
4. Botanical gardens provide information on the protection of endangered species and propagation of rare plants.
5. Botanical gardens supply living plant resources for research purposes.
6. Botanical gardens provide training facility to students.
7. Botanical gardens provide instruction for home gardening.
8. Botanical gardens provide aesthetically pleasant environment.

TAXONOMIC KEYS

Taxonomic keys are devices used for rapid identification of unknown plants. The keys are fundamentally based on characters, which are stable and reliable. The keys are helpful in a faster preliminary identification.

Before identification is attempted, however, it is necessary that the unknown plant is carefully studied, described and a list of its character states prepared. Based on the arrangement of characters and their utilization, two types of identification keys are differentiated:

1. Single-access or sequential keys; and
2. Multi-access or multientry keys (polyclaves).

Single Access or Sequential

The keys are based on diagnostic (important and conspicuous) characters (key characters) and as such the keys are known as diagnostic keys. Most of the keys in use are based on pairs of contrasting choices and as such are dichotomous keys. They were first introduced by J. P. Lamarck in 1778. The construction of a dichotomous key starts with the preparation of a list of reliable characters for the taxon for which the key is to be constructed. For each character the two contrasting choices are determined (e.g., habit woody or herbaceous). Each choice constitutes a lead and the two contrasting choices form a couplet. Based on the arrangement of couplets and their leads, three main types of dichotomous keys are in use: Yoked or Indented key, Bracketed or parallel key, and Serial or numbered key.

1. **Yoked** or **Indented key**: This is one of the most commonly used key. In this type of key, the statements (leads) and the taxa identified from them are arranged in visual groups or yokes and additionally the subordinate couplets are indented below the primary one at a fixed distance from the margin, the distance increasing with each subordinate couplet.
2. **Bracketed** or **Parallel key**: In this type of key the two leads of a couplet are always together and the distance from the margin is always the same.

BOTANICAL NOMENCLATURE

The system of naming objects of biological origin is called nomenclature. Nomenclature deals with the application of a correct name to a plant or a taxonomic group. In practice, nomenclature is often combined with identification, since while identifying an unknown plant specimen, the author chooses and applies the correct name. The favourite temperate plant is correctly identified whether you call it 'Seb' (vernacular Hindi name), Apple, *Pyrus malus* or *Malus malus,* but only by using the correct scientific name *Malus domestica* does one combine identification with nomenclature. The current activity of botanical nomenclature is governed by the International Code of Botanical Nomenclature (**ICBN**) published by the International Association of Plant Taxonomy (**IAPT**).

Need for Scientific Names

Scientific names formulated in Latin are preferred over vernacular or common names since the latter pose a number of problems:

1. Vernacular names are not available for all the species known to man.
2. Vernacular names are restricted in their usage and are applicable in a single or a few languages only. They are not universal in their application.
3. Common names usually do not provide information indicating family or generic relationship.
4. Frequently, especially in widely distributed plants, many common names may exist for the same species in the same language in the same or different localities.
5. Often, two or more unrelated species are known by the same common name.

Development of Botanical Code

For several centuries, the names of plants appeared as polynomials—long descriptive phrases, often difficult to remember. A species of willow, for example, was named *Salix pumila angustifolia altera* by Clusius in his herbal (1583). Casper Bauhin (1623) introduced the concept of **Binomial nomenclature** under which the name of a species consists of two parts, the first the name of the genus to which it belongs and the second the **specific epithet**. Onion is thus appropriately named *Allium cepa*, *Allium* being the generic name and *cepa* the specific epithet. Bauhin, however, did not use binomial nomenclature for all the species and it was left to Carolus Linnaeus to firmly establish this system of naming.

Contents of Botanical Code

The Code is divided into 3 divisions:

I. Principles
II. Rules and recommendations
III. Provisions for the governance of the Code

Principles of ICBN

The International Code of Botanical Nomenclature is based on the following set of six principles, which are the philosophical basis of the Code:

1. Botanical Nomenclature is independent of Zoological Nomenclature. The Code applies equally to the names of taxonomic groups treated as plants whether or not these groups were originally so treated.
2. The application of names of taxonomic groups is determined by means of nomenclatural types.
3. Nomenclature of a taxonomic group is based upon priority of publication.
4. Each taxonomic group with a particular circumscription, position and rank can bear only one correct name, the earliest that is in accordance with the rules.
5. Scientific names of taxonomic groups are treated as Latin, regardless of derivation.
6. The rules of nomenclature are retroactive, unless expressly limited.

TAXONOMY AND SYSTEMATICS

Taxonomy is defined as the branch of science dealing with the classification of organisms according to their similarities and differences. Systematics is often used synonymously with taxonomy, but sometimes interpreted more widely to include also identification, practice of classification and nomenclature. Andrew Sugden in (1986) defined taxonomy as "the science of classification and relationships of organisms" and systematics as "the part of classification that involves the arrangement of organisms into related groups". Some botanists treat taxonomy and systematics as two separate branches. According to these botanists systematics is "the study of diversity of plants and their identification, naming, classification and evolution" while taxonomy is "restricted to the study of classification". However the terms taxonomy and systematics have been so loosely and interchangeably used in the past to establish a proper delineation between the two is extremely difficult. In actual practice, the two terms are used synonymously and deal with the study of classification, its principles, procedures and rules.

Basic components of taxonomy

Classification, identification, nomenclature and description are the four basic components of taxonomy. Classification is an arrangement of organisms into groups on the basis of similarities. Identification is the determination of similarities or dissimilarities between the two elements. Description is the orderly recording of maximum possible characters of a taxon, individual plant, plant part or object. Nomenclature deals with scientific naming of plants.

CLASSIFICATION

Classification is an arrangement of organisms into groups on the basis of similarities.
Taxonomic entities are classified in different fashions:

1. **Artificial classification:** These classifications are based on convenience. In these systems only one or a few external characters are taken into consideration for plant identification. These classifications are based on arbitrary, easily observable characters such as habit, colour, number, form or similar features. The first artificial system was proposed by Theophrastus in 300 BC and he classified plants on the basis of habit into Herbs, Undershrubs, Shrubs and Trees. The **sexual system of classification** proposed by Linnaeus, is the best artificial system. This system of classification is based on the number of stamens, it is also called "numerical system of classification".
2. **Natural classification:** These systems of classifications used as many taxonomic characters as possible to group taxa. In these systems maximum external characters are taken in consideration. These systems use overall similarity in grouping taxa. Natural system of classification was initiated by M. Adanson and culminating in the extensively used classification of Bentham and Hooker. Natural systems of the eighteenth and nineteenth centuries used morphology in delimiting the overall similarity.
3. **Phylogenetic classification:** These systems of classification used as many taxonomic characters as possible in addition to the phylogenetic (evolutionary) history. Phylogenic systems are based on the evolutionary descent of a group of organisms, the relationship depicted either through a **phylogram, phylogenetic tree** or a **cladogram**. The first

phylogenetic system was proposed by Eichler. Some other phylogenetic systems of classification were proposed by Englar and Prantl, Bessey, Hutchinson, Takhtajan.

HERBARIUM

Collection of dried and pressed plants arranged according to a classification system is known as herbarium. The name herbarium was first used by Linnaeus. Plant specimens are usually mounted on a sheet of high quality paper. Properly dried, pressed and identified plant specimens are placed in thin paper folders which are kept together in thicker paper folders. The specimens are finally incorporated into the herbarium cupboards in their proper position. Fleshy members (Cactaceae) are preserved in liquid preservatives. Herbarium may contain a few hundred locally collected plant specimens kept in a small place or it may contain millions of specimens collected from different parts of the world and housed in a very big building. Herbaria remain associated with colleges, universities, scientific societies, research institutes, botanical gardens. Herbaria may contain a local collection, or flora of a district, state, country, continent or several continents.

The world's largest herbarium is at Royal Botanical Garden, Kew, Richmond, England containing over 5 million specimens. The largest herbarium of India is the central national herbarium at Kolkata holding over 1.3 million specimens.

Functions of herbaria

Some of the general functions of herbaria are mentioned below:

1. Plant specimens are permanently stored in herbaria.
2. Specimens of herbaria are used in almost all types of taxonomic research.
3. A picture of all species of a genus, or all the genera of a family may be gathered only in the herbarium.
4. The classification of the world's flora is based mainly on the herbarium material.
5. List of endangered species of any region may be prepared only by herbarium specimens.
6. Monographs are prepared only by the herbarium specimens.
7. Herbaria provide training to young students.
8. Herbaria preserve type specimens, and thus serve as a repository of chromosomes and experimental voucher specimens.

The Taxonomic Hierarchy

In biology, hierarchy refers to the taxonomical classification of living organisms in successive levels of complexity. The kingdom is the highest rank in such a classification while species is the lowest. The meaning of hierarchy is the arrangement of the categories in an increasing order from species to the kingdom or in a decreasing order from kingdom to species. **Taxonomic hierarchy** is the arrangement of various categories in successive levels of the biological classification. Each of this level or hierarchy is called as the taxonomic category or rank. In **Taxonomic hierarchy Taxonomic groups or Taxa** are first formed and then are arranged in order of their successive inclusiveness, the least inclusive at the bottom (species), and the most inclusive at the top (kingdom). The groups are then assigned to various **categories**, having a fixed sequence of arrangement (**taxonomic hierarchy**), the most inclusive group assigned to the highest category (generally a **division**) and the least inclusive to the lowest category (usually a **species**). The names are assigned to the taxonomic groups in such a way that the name gives an indication of the category to which it is assigned. Rosales, Myrtales, and Malvales all belong to the **order** category and Rosaceae, Myrtaceae and Malvaceae to the **family** category. Because of the hierarchical arrangement of categories to which the groups are assigned, the classification achieved is known as **hierarchical classification**. Species are grouped into genera, genera into families, families into orders, orders into classes, and classes into phyla.

TAXONOMIC GROUPS, CATEGORIES AND RANKS

Taxonomic groups, categories and ranks are inseparable once a hierarchical classification has been achieved. The **categories** are like shelves of an almirah, having no significance when empty, and importance and meaning only after something has been placed in them. Thereafter, the shelves will be known by their contents: books, toys, clothes, shoes etc. Categories in that sense are artificial and subjective and have no basis in reality. They correspond to nothing in nature. However, they have a fixed position in the hierarchy in relation to other categories. But once a group has been assigned to a particular category the two are inseparable and the category gets a definite meaning because it now includes something actually occurring in nature. The word genus does not carry a specific meaning but the genus *Rosa* says a lot. There is practically no difference between **category** and **rank**, except in the grammatical sense. *Rosa* thus belongs to the **category genus**, and has **generic rank**. If categories are like shelves, ranks are like partitions, each separating the given category from the category above. **Taxonomic groups**, on the other hand, represent discrete sets of organisms in nature. Groups are biological entities or a collection of such entities. By assigning them to a category and providing an appropriate ending to the name (Rosaceae with ending –**aceae** signifies a family which among others also includes roses, belonging to the genus *Rosa*) we establish the position of taxonomic groups in the hierarchical system of classification.

Some important characteristics, which enable a better understanding of the hierarchical system of classification, are enumerated below.

1. Different categories of the hierarchy are higher or lower according to whether they are occupied by more inclusive or less inclusive groups. Higher categories are occupied by more inclusive groups than those occupying lower categories.
2. Plants are not classified into categories but into groups. It is important to note that a plant may be a member of several taxonomic groups, each of which is assigned to a taxonomic category, but is not itself a member of any taxonomic category.

3. A taxon may belong to other taxa, but it can be a member of only one category. *Urtica dioica*, thus, is a member of *Urtica*, Urticaceae, Urticales, and so on, but it belongs only to species category.
4. Categories are not made up of lower categories. The category family is not made up of the genus category, since there is only one genus category.
5. The characters shared by all members of a taxon placed in a lower category provide the characters for the taxon immediately above.

The Type Method

The names of different taxonomic groups are based on the **type method**, by which a certain representative of the group is the source of the name for the group. This representative is called the **nomenclatural type** or simply the **type**, and methodology as **typification**. The type need not be the most typical member of the group, it only fixes the name of a particular taxon and the two are permanently associated. **Type may be correct name or even a synonym.** Thus the tea family name (Theaceae) is derived from synonym *Thea* although the correct name for the genus is *Camellia*. *Mimosa* is the type for family Mimosaceae, but unlike most representatives of the family that have pentamerous flowers, the genus *Mimosa* has tetramerous flowers. The family Urticaceae, similarly, has *Urtica* as its type. When the originally large family was split into a number of smaller natural families, the name Urticaceae was retained for the group containing the genus *Urtica,* since the two cannot be separated. The other splitter groups with family rank got the names Moraceae, Ulmaceae and Cannabaceae with type genera *Morus, Ulmus* and *Cannabis,* respectively.

The type of a family and the higher groups is ultimately a genus, as indicated above. A type of a particular genus is a species, e.g. *Poa pratensis* for *Poa.* The type of name of a species or infraspecific taxon, where it exists, is a single type specimen, preserved in a known herbarium and identified by the place of collection, name of the collector and his collection number. It may also be an illustration of the plant. The Code recognizes several kinds of type, depending upon the way in which a type specimen is selected.

These include:

1. **Holotype:** A particular specimen or illustration designated by the author of the species to represent type of a species.

For the purpose of typification, a specimen is a gathering, or part of a gathering, of a single species or infraspecific taxon made at one time. It may consist of a single plant, parts of one or several plants, or of multiple small plants.

2. **Isotype:** A specimen which is a duplicate of the holotype, collected from the same place, at the same time and by the same person. Often the collection number is also the same, differentiated as a, b, c, etc.

3. **Syntype:** Any one of the two or more specimens cited by the author when no holotype was designated, or any one of the two or more specimens simultaneously designated as types. Duplicate of a syntype is an isosyntype.

4. **Paratype:** A paratype is a specimen cited in the protologue that is neither the holotype nor an isotype, nor one of the syntypes if two or more specimens were simultaneously designated as types.

5. **Lectotype:** A specimen or any other element selected from the original material cited by the author when no holotype was originally selected or when it no longer exists. A lectotype is selected from isotypes or syntypes.

6. **Neotype:** A specimen or illustration selected to serve as nomenclatural type as long as all of the material on which the name of the taxon was based is missing; a specimen or an illustration selected when no holotype, isotype, paratype or syntype exists.

7. **Epitype:** A specimen or illustration selected to serve as an interpretative type when the holotype, lectotype or previously designated neotype, or all original material associated with a validly published name, is demonstrably ambiguous and cannot be critically identified for purposes of the precise application of the name of a taxon.

Topotype is often the name given to a specimen collected from the same locality from which the holotype was originally collected.