# B. Sc. (Hons.) Botany IV Semester CBCS

## CC X- Plant Systematics

# UNIT -4 TAXONOMIC HEIRARCHY

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**Marriages of plants**

*Florescence*

**Public marriages**

*Flowers visible to every one*

**In one bed**

Husband and wife have the same bed

*All the flowers hermaphrodite: stamens and pistils in the same flower*

**Without affinity**

Husbands not related to each other

*Stamens not joined together in any part*

**With equality**

All the males of equal rank

*Stamens have no determinate proportion of length*

1. One male
2. Two males
3. Three males
4. Four males
5. Five males
6. Six males
7. Seven males
8. Eight males
9. Nine males
10. Ten males
11. Twelve males
12. Twenty males
13. Many males

**With subordination**

Some males above others

*Two stamens are always lower than the others*

14. Two powers
15. Four powers

**With affinity**

Husbands related to each other

*Stamens cohere with each other, or with the pistil*

16. One brotherhood
17. Two brotherhoods
18. Many brotherhoods
19. Confederate males
20. Feminine males

**In two beds**

Husband and wife have separate beds

*Male flowers and female flowers in the same species*

21. One house
22. Two houses
23. Polygamies

**Clandestine marriages**

*Flowers scarce visible to the naked eye*

24. Clandestine marriages

(a)

(b)

- The organisms are first recognized and assembled into groups on the basis of certain resemblance.
- These groups are in turn assembled into larger and more inclusive groups. The process is repeated until finally all the organisms have been assembled into a single, largest most inclusive group.
- These groups (**Taxonomic groups or Taxa**) are arranged in order of their successive inclusiveness, the least inclusive at the bottom, and the most inclusive at the top.

- The groups thus formed and arranged are next assigned to various **categories**, having a fixed sequence of arrangement (**taxonomic hierarchy**),

most inclusive group (highest category, generally a **division**)

↓

least inclusive (lowest category, usually a **species**).

- The names --indication of the category to which it is assigned.

E.g. - Rosales, Myrtales, and Malvales all belong to the **order** category and Rosaceae, Myrtaceae and Malvaceae to the **family** category.

- Once all the groups have been assigned categories and named, the process of classification is complete, or the **taxonomic structure** of the whole largest most inclusive group has been achieved.

- Because of the hierarchical arrangement of categories to which the groups are assigned, the classification achieved is known as **hierarchical classification**.

**Kingdom:** Plantae — Plant kingdom

**Division:** Magnoliophyta — Flowering plants

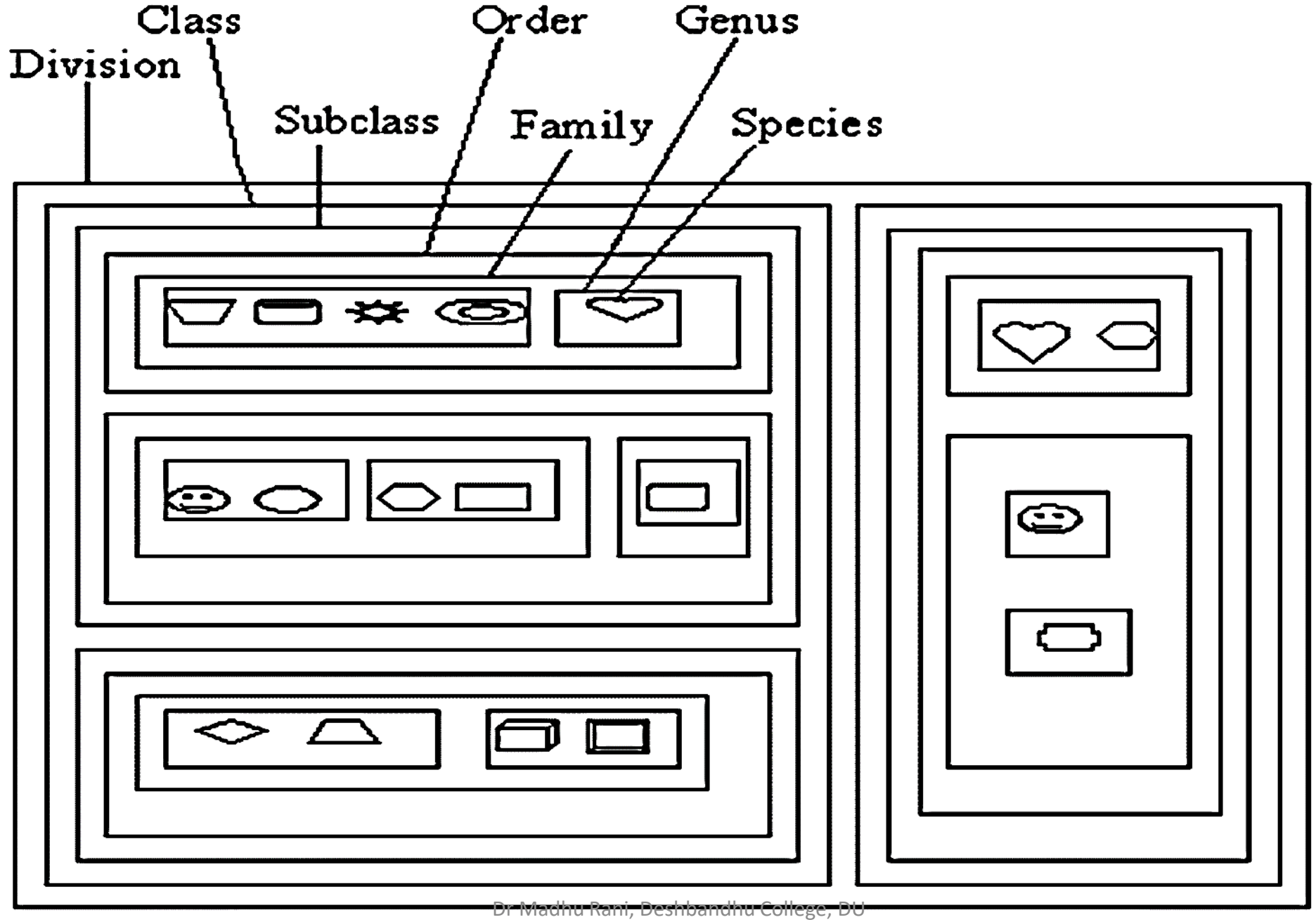
**Class:** Liliopsida — Monocots

**Order:** Liliales

**Family:** Liliaceae — Lily family

**Genus:** *Lilium* — Lilies

**Species:** *Lilium superbum L.* — Turk's Cap Lily



# The Taxonomic Hierarchy and Standard Endings

| Rank | Standard Ending | Example |
|---|---|---|
| Division (Phylum) | -phyta | Magnoliophyta |
| Class | -opsida | Liliopsida |
| Order | -ales | Liliales |
| Family | -aceae | Liliaceae |
| Genus | | *Lilium* |
| Species | | *Lilium superbum L.* |

# TAXONOMIC GROUPS, CATEGORIESAND RANKS

- Taxonomic groups, categories and ranks are inseparable once a hierarchical classification has been achieved.

## Categories

- 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.
- 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

- objective and non-arbitrary to the extent that they 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. A plant collected from the field may be identified as *Poa annua* (assigned to species category). It is a member of *Poa* (assigned to genus category), Poaceae (assigned to family category) and so on, but the plant can't be said to be belonging to the species 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. Thus, the characters shared by all the species of *Brassica* make up the characters of the genus *Brassica*. The characters shared by *Brassica* and several other genera form distinguishing characters of the family Brassicaceae.

   It is important to note that the higher a group is placed in the hierarchy, the fewer will be the characters shared by the subordinate units. Many higher taxa, as such (e.g. Dicots: Magnoliopsida) can only be separated by a combination of characters; no single diagnostic character may distinguish the taxa. Dicots are thus conveniently separated from monocots by possession of two cotyledons, pentamerous flowers, reticulate venation and vascular bundles in a ring as against one cotyledon, trimerous flowers, parallel venation and scattered vascular bundles in monocots. But when taken individually, *Smilax* is a monocot with reticulate venation and *Plantago* is a dicot with parallel venation.

Similarly *Nymphaea,* is a dicot with scattered bundles, and the flowers are trimerous in *Phyllanthus*, which is a dicot

(a) *Quercus phellos*
(willow oak)

(b) *Quercus rubra*
(red oak)

A genus is a group of species that share many characteristics in common. Although willow oak *(Quercus phellos)* and red oak *(Quercus rubra)* are clearly distinct species, they are both recognizable as belonging to the oak *(Quercus)* genus by the presence of acorns

# Species concept

Darwin aptly said: '**Every biologist knows approximately what is meant when we talk about species, yet no other taxon has been subjected to such violent controversies as to its definition**'.

A century and a half has passed, so much advancement in the taxonomic knowledge has been achieved, yet the statement of Darwin is as true today as it was then.

Numerous definitions of species have been proposed, making it futile to recount all of them. Some significant aspects of the problem will be discussed here.

Probably the best explanation of diversity of opinions can be explained as under.

'**The species is a concept. Concepts are constructed by the human mind, and as humans think differently we have so many definitions of a species**.'

Obviously a concept can't have a single acceptable definition.

The word species has different meaning for different botanists.

According to ICBN, which has attempted to clarify the meaning of the word species, '**species are convenient classificatory units defined by trained biologists using all information available**'.

The word species has a dual connotation in biological science.

1. the species is a naturally-occurring group of individual organisms that comprises a basic unit of evolution.

2. the species is a category within a taxonomic hierarchy governed by various rules of nomenclature.

## Species as Basic Unit of Taxonomy

The following information serves to substantiate the view that species constitutes the basic unit of classification or taxonomy (systematics):

1. Species is considered the **basic unit of taxonomy**, since in the greater majority of cases, we don't have infraspecific names. This is especially common in families such as Apiaceae (Umbelliferae) and Liliaceae.
2. Species, unlike other taxa, can be described and recognized without relating to the taxa at other ranks. Thus we can sort herbarium sheets into different species without difficulty, without knowing or bothering to know how many genera are covered by these sheets. We cannot recognize genera or describe them without reference to the included species. Species is thus the **only category dealing directly with the plants**.
3. Whether defined in terms of morphological discontinuity or restriction of gene exchange, species is unique in being non-arbitrary to both inclusion and exclusion.

inclusion - non-arbitrary group: all its members are continuous by an appropriate criterion.

arbitrary group: internal discontinuity.

exclusion - non-arbitrary group: discontinuous from any other group by the same criterion.

arbitrary group: A group not showing discontinuity with other groups.

All higher taxa - non-arbitrary to exclusion, arbitrary to inclusion,

i.e. they exhibit internal discontinuity as now species with external discontinuity form part of these taxa.

# Ideal Species

A perfect situation- **Species that can be easily distinguished and have no problem of identity**. Such species, however, are very few; common examples include Apiaceae, Asteraceae and the genera *Allium* and *Sedum*.

The following characteristics are expected in an ideal species:

1. The species poses no taxonomic problems and is easily recognized as a distinct entity on the basis of morphological characters.

2. It exhibits no discontinuity of variation within, i.e. it contains no subspecies, varieties or forms.

3. It is genetically isolated from other species.

4. It is sexually reproducing.

5. It is at least partially outbreeding.

Unfortunately, ideal species are rare among the plant kingdom and the greater majority of species pose situations contrary to one or more of the above criteria.

# Idea of Transmutation

This is an ancient Greek idea which persisted as late as the 17th century.

Greeks believed in the transmutation of wheat into barley, *Crocus* into *Gladiolus*, barley into oats, and many other plants, under certain conditions.

The supporters of this notion often included professional botanists like Bobart (who swore that *Crocus* and *Gladiolus*, as likewise the *Leucojum*, and *Hyacinths* by a long standing without replanting have in his garden changed from one kind to the other) as reported by Robert Sharrock (1660) in his book ***History of the propagation and improvement of vegetables by the concurrence of art and nature***.

Sharrock fortunately, however, on investigation did not find any proof of this in the field.

So called transmutation can be explained as nothing other than the result of unintentional mixing of seeds or other propagules of another plant with a particular crop before plantation.

## Nominalistic Species Concept

This nominalistic species concept is also only of academic interest now. For the purpose of nomenclature, all organisms must be referable to species.

Species, by this concept, can be defined by the language of formal relations and not by property of their organisms. The concept considers species to be a category in taxonomic hierarchy and may correspond to a specific name in the binomial system of nomenclature.

The concept is logically sound but scientifically irrelevant since the ultimate aim is to place a particular group of individuals in a species.

## Typological Species Concept

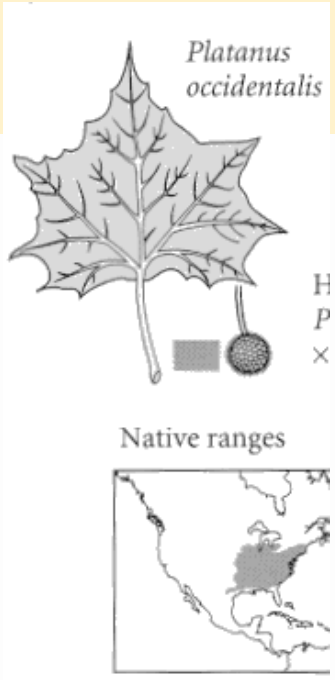
- This concept was first proposed by John Ray (1686) and further elaborated by C. Linnaeus in Critica botanica (1737).
- Linnaeus refuted the idea of transmutation of species. Linnaeus believed that although there is some variation within a species, the species by themselves are fixed (fixity of species) as created by the Almighty Creator. The species, according to the concept, is a group of plants which breed true within their limits of variation. Towards the later part of his life, however, Linnaeus moved away from idea of fixity of species and was convinced that species can arise by hybridization. In his later publication (*Fundamenta fructificationis*, 1762), Linnaeus imagined that at the time of creation, there arose as many genera as were the individuals. These, in the course of time, were fertilized by others and thus arose species until so many were produced as now exist. These species were sometimes fertilized by other species of the same genus, giving rise to varieties. The typological concept, however, should not be confused with typification, which is a distinct methodology of nomenclature, providing names to taxonomic groups.

## Taxonomic Species Concept

- The doctrine of fixity was challenged by Lamarck (1809) and finally Darwin (1859), who recognized continuous and discontinuous variation and developed his taxonomic species concept based on morphology, more appropriately known as the Morphological **species concept**.
- According to this concept, the species is regarded as ***an assemblage of individuals with morphological features in common, and separable from other such assemblages by correlated morphological discontinuity in a number of features***.
- The supporters of this view believe in the concept of continuous and discontinuous variations. The individuals of a species show continuous variation, share certain characters and show a distinct discontinuity with individuals belonging to another species, with respect to all or some of these characters.
- Du Rietz (1930) modified the taxonomic species concept by also incorporating the role of geographic distribution of populations and developed the **morpho-geographical species concept.** The species was defined as ***the smallest population that is permanently separated from other populations by distinct discontinuity in a series of biotypes***.

- The populations recognized as distinct species and occurring in separate geographical areas are generally quite stable and remain so even when grown together.
- There are, however, examples of a few species pairs which are morphologically quite distinct, well adapted to respective climates, but when grown together, they readily interbreed and form intermediate fertile hybrids, bridging the discontinuity gap between the species.
- Examples are *Platanus orientalis* of the Mediterranean region and *P. occidentalis* of E. United States.
- Another well-known pair is *Catalpa ovata* of Japan and China and *C. bignonioides* of America. Such pairs of species are known as **vicarious species** or **vicariants** and the **phenomenon** as **vicariance** or **vicariism**.

*Platanus occidentalis*
(American Sycamor)





*Platanus orientalis*
(India- Chinaar)

- Another well-known pair is bean tree species *Catalpa ovata* of Japan and China and *C. bignonioides* of America. Such pairs of species are known as **vicarious species** or **vicariants** and the **phenomenon** as **vicariance** or **vicariism**.

*Catalpa ovata* of Japan and China

*Catalpa bignonioides* of America

Morphological and morpho-geographical types of taxonomic species have been widely accepted by taxonomists who even take into account the data from genetics, cytology, ecology, etc., but firmly believe that species recognized must be delimited by morphological characters.

**Advantages of the taxonomic species concept** :

1. It is useful for general taxonomic purposes especially the field and herbarium identification of plants.
2. The concept is very widely applied and most species have been recognized using this concept.
3. The morphological and geographical features used in the application of this concept can be easily observed in populations.
4. Even experimental taxonomists who do not recognize this concept, apply this concept in cryptic form.
5. The greater majority of species recognized through this concept correspond to those established after experimental confirmation.

**Drawbacks**:

1. It is highly subjective and different sets of characters are used in different groups of plants.
2. It requires much experience to practice this concept because only after considerable observation and experience can a taxonomist decide the characters which are reliable in a particular taxonomic group.
3. The concept does not take into account the genetic relationships between plants.

## Biological Species Concept

The biological species concept was first developed by Mayr (1942) who defined species as ***groups of actually or potentially interbreeding natural populations, which are reproductively isolated from other such groups***.

The words 'actually or potentially', being meaningless, were subsequently dropped by Mayr (1969).

Based on the same criteria, Grant (1957) defined species as a community of cross-fertilizing individuals linked together by bonds of mating and reproductively isolated from other species by barriers to mating.

The recognition of biological species thus involve:

(a) interbreeding among populations of the same species; and

(b) reproductive isolation between populations of different species.

Valentine and Love (1958) pointed out that species could be defined in terms of gene exchange.

***If two populations are capable of exchanging genes freely either under natural or artificial conditions, the two are said to be conspecific (belonging to the same species).***

***On the other hand, if the two populations are not capable of exchanging genes freely and are reproductively isolated, they should be considered specifically distinct***.

## Advantages:

1. It is objective, and the same criterion is used for all the groups of plants.

2. It has a scientific basis as the populations showing reproductive isolation do not intermix and the morphological differences are maintained even if the species grow in the same area.

3. The concept is based on the analysis of features and does not need experience to put it into practice.

The concept, first developed for animals, holds true because animals as a rule are sexually differentiated and polyploidy is very rare.

When applying this concept to plants, however, a number of problems are encountered:

1. A good majority of plants show only vegetative reproduction, and hence the concept of reproductive isolation as such cannot be applied.

2. Reproductive isolation is commonly verified under experimental conditions, usually under cultivation. It may have no relevance for wild populations.

3. Genetic changes causing morphological differentiation and those causing reproductive barriers do not always go hand in hand.

*Salvia mellifera* and *S. apiana* are morphologically distinct (two separate species according to the taxonomic species concept) but not reproductively isolated (single species according to the biological species concept).

Such species are known as **compilospecies**.

*Salvia mellifera*
Black Sage

*Salvia apiana*
White Sage

Contrary to this, *Gilia inconspicua* and *G. transmontana* are reproductively isolated (two separate species according to the biological species concept) but morphologically similar (single species according to the taxonomic species concept).

Such species are known as **sibling species**.

4. Fertility-sterility is only of theoretical value in allopatric populations.

5. It is difficult and time consuming to carry out fertility-sterility tests.

6. Occurrence of reproductive barriers has no meaning in apomicts.

7. Necessary genetic and experimental data are available for only very few species.

*Gilia inconspicua*

*Gilia transmontana*

Stebbins (1950), it would appear, combined two concepts when he stated that species must consist of systems of populations that are separated from each other by complete or at least sharp discontinuities in the variation pattern, and that these discontinuities must have a genetic basis.

These populations with isolating mechanisms (different species) may occur either in the same region (sympatric species) or in different regions (allopatric species).

Fortunately, although the taxonomic and biological concepts are based upon different principles, the species recognized by one concept, in the majority of cases, stand the test of the other.

Morphology provides the evidence for putting the genetic definition into practice.

## Evolutionary Species Concept

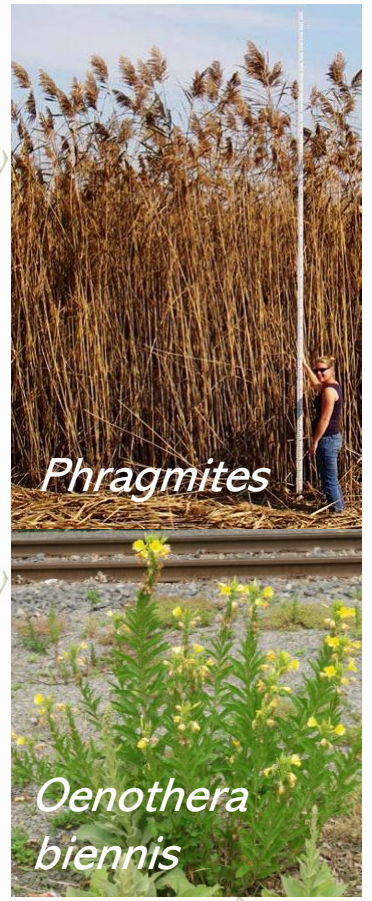
- This concept was developed by Meglitsch (1954), Simpson (1961) and Wiley (1978).
- Although maintaining that interbreeding among sexually reproducing individuals is an important component in species cohesion, this concept is compatible with a broad range of reproductive modes.
- Wiley (1978) defines: **an evolutionary species is a single lineage of ancestor-descendant populations which maintains its identity from other such lineages, and which has its own evolutionary tendencies and historical fate**.
- This concept avoids many of the problems of the biological concept. Lineage is a single series of demes (populations) that share a common history of descent, not shared by other demes.

- The identity of species is based on recognition systems that operate at various levels.
- In sexually reproducing species, such systems include recognition because of phenotypic, behavioral and biochemical differences.
- In asexual species phenotypic, genotypic differences maintain the identity of species. Identity in both sexual and asexual species may also be due to distinct ecological roles.
- Viewed from the standpoint of evolutionary species concept, however, the important question is not whether two species hybridize, but whether two species do or do not lose their distinct ecological and evolutionary roles.
- If, despite some hybridization, they do not merge, then they remain separate species in the evolutionary perspective.
- Several other terms have been proposed to distinguish species based on specific criteria.

- Grant (1981) recognizes **microspecies** as '**populations of predominantly uniparental plant groups which are themselves uniform and are slightly differentiated morphologically from one another**'; they are often restricted to a limited geographical area.
- Microspecies develop in inbreeding species but are usually not stable over longer periods.
- They may undergo cross-fertilization sooner or later forming recombinant types which themselves become new microspecies.
- Several microspecies have been found in *Erophila verna* mostly representing single biotypes or groups of similar biotypes some of which are marked by only one or two characters.
- These may be distinguished as
  - **clonal microspecies** (reproducing by vegetative propagation, e.g. *Phragmites*),
  - **agamospermous microspecies** (reproducing by agamospermy, e.g. *Rubus*),
  - **heterogamic microspecies** (reproducing by genetic systems, e.g. *Oenothera biennis* or *Rosa canina*), and
  - **autogamous microspecies** (predominantly autogamous and chromosomally homozygous, e.g. *Erophila*).

Microspecies are distinct from **cryptic species**, which are morphologically similar but cytologically or physiologically different.






## Biosystematic Species Concept

- The term biosystematic species has been used by Grant (1981) to refer to **the categories based on fertility relationships as determined by artificial hybridization experiments**.
- **Ecotype** refers to all members of a species that 'represent a product of genetic response of a species towards a particular habitat'.
- The ecotypes, which are able to exchange genes freely without loss of fertility or vigour in the off-springs, form an **ecospecies**.
- An ecospecies corresponds to a **taxonomic species**.
- A group of ecospecies capable of limited genetic exchange constitutes a **coenospecies**.
- A coenospecies is considered equivalent to a **subgenus**.
- A group of related coenospecies between which hybridization is possible — directly or through intermediates— constitutes a **comparium**, which is considered equal to a **genus**.
- Complete sterility barriers exist between genera.

# Infraspecific ranks

The species is regarded as the basic unit of classification and many works, including the Flora of USSR, do not recognize infraspecific taxa.

Many European, American and Asian Floras, however, do recognize taxa below the rank of species.

The international Code of Botanical Nomenclature recognizes five infraspecific ranks: subspecies, variety (Latin, varietas), subvariety, form (Latin, forma) and subform.

Of these, three (subspecies, variety and form) have been widely used in the literature.

Du Rietz (1930) defined **subspecies** as a **population of several biotypes forming more or less a distinct regional facies of a species**.

Morphologically distinct but interfertile populations of a species growing in different geographical regions are maintained as distinct subspecies due to the geographical isolation of the species.

Du Rietz defined variety as a ***population of several biotypes, forming more or less a local facies of a species***. The term variety is commonly used for morphologically distinct populations occupying a restricted geographical area.

Several varieties are often recognized within a subspecies. The term variety is also used for variations whose precise nature is not understood, a treatment often necessary in the pioneer phase of taxonomy.

**Forma** is often regarded as **sporadic variant distinguished by a single or a few linked characters**.

Example:

## Genus

The concept of genus is as old as folk science itself as represented by names rose, oak, daffodils, pine and so on.

A genus represents a group of **closely-related species**.

According to Rollins (1953), the function of the genus concept is to bring together species in a phylogenetic manner by placing the closest related species within the general classification.

Mayr (1957) defined genus as **a taxonomic category which contains either one species or a monophyletic group of species, and is separable from other genera by a decided discontinuity gap**.

It was earlier believed that a genus should always be readily definable on the basis of a few technical floral characters.

A more rational recognition should take the following criteria into consideration:

1. The group, as far as possible, should be a natural one. The monophyletic nature of the group should be deduced by cytogenetic and geographic information in relation to morphology.

2. The genera should not be distinguished on a single character but a sum total of several characters. In a number of cases, genera are easily recognized on the basis of adaptive characters (adaptations in response to ecological niches), as in the case of establishing aquatic species of *Ranunculus* under a separate genus *Batrachium*.

3. There is no size requirement for a genus.

   It may include a single species (monotypic genus) as *Leitneria*, *Ginkgo*, *Milula* or many (Polytypic genus): *Euphorbia* (2100 species), *Astragalus* (2000) *Carex* (1800), *Senecio* (1500) and *Acacia* (1300) being the examples of large genera. The genus *Senecio* was earlier included more than 2500 species, but it has now been split into several genera.

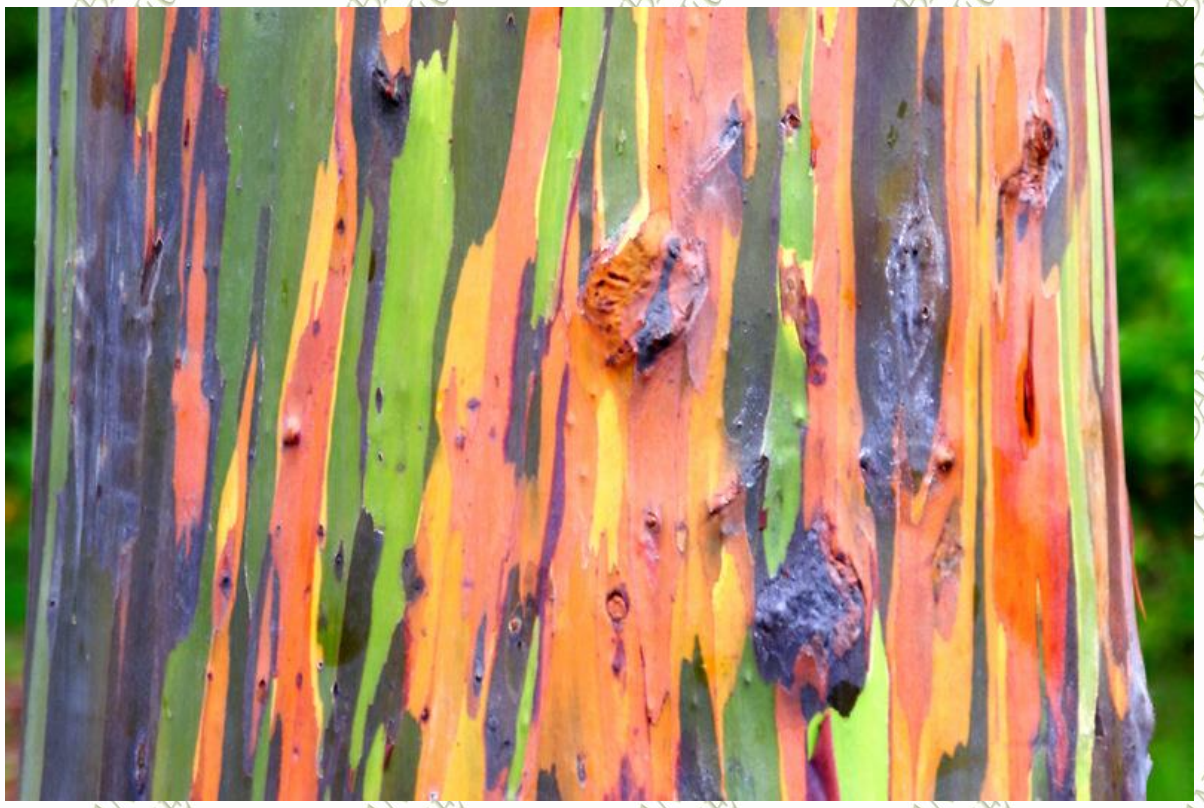
   The only important criterion is that there should be a decided gap between the species of two genera. If the two genera are not readily separable, then they can be merged into one and distinguished as subgenera or sections. Such an exercise should take into consideration the concept in other genera of the family, size of the genus (it is more convenient to have subgenera and sections in a larger genus) and traditional usage.

4. When generic limits are being drawn, it is absolutely necessary that the group of species should be studied throughout the range distribution of the group, because characters stable in one region may break down elsewhere.

## Family

- A family, similarly, represents a group of closely-related genera. Like genus, it is also a very ancient concept because the natural groups now known as families, such as legumes, crucifers, umbels, grasses have been recognized by laymen and taxonomists alike for centuries.
- Ideally, families should be monophyletic groups. Like the genus, the family may represent a single genus (Podophyllaceae, Hypecoaceae, etc.) or several genera (Asteraceae: nearly 1100).
- Most taxonomists favour broadly-conceived family concepts that lend stability to classification.
- Although there is no marked discontinuity between Lamiaceae (Labiatae) and Verbenaceae, the two are maintained as distinct families.
- The same tradition prevents taxonomists from splitting Rosaceae, which exhibits considerable internal differences.

# THANK YOU

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