

History of Classification

WHY TO CLASSIFY PLANTS

Classification denotes the arrangement of a single plant or group of plants in distinct category following a system of nomenclature, and in accordance with a particular and well established plan. The principles underlying any modern system of plant classification are based upon the genetical relationship existing among diverse groups of plants, and thus closely related groups are, as a rule, brought together. For the purpose of arriving at a satisfactory system of plant classification, a working knowledge in other branches of botany, even beyond the limits of taxonomy, is desirable.

The living world ranges from microbes to large oak trees. It is obvious that all the members of each group are like one another in some ways and different in some other ways. The fig. (*Ficus glomerata*), the banyan (*Ficus benghalensis*) and the peepal (*Ficus religiosa*) all belong to the same family, they are similar in so many respects but they differ in some way from each other of equal status. Even the presence and absence of flower became the distinctive feature of the plants concerned. So in consideration of grouping of plants, the knowledge of distinctive features particularly morphology of the plant is most important.

In classifying plants, the variation (e.g., herb, shrubs and trees) is an aspect of consideration. The variation may be **continuous** or **discontinuous**. The discontinuous variation becomes the tool of plant classification. Not the size and diversity of the group, it is the discontinuity (Sal is sal, oak is oak, no intermediate forms) of variation shown in the plant kingdom that became the basis of classification. To trace the origin of discontinuity, the plant has to live successfully in its particular habitat and adjusted there through the evolutionary process. The process of natural selection is favoured for those plants which have carried the combination of features most advantageous for their particular habitat. The combination of features are successful in the course of evolution. These features may be present in plants living in the past era. In the evolution of the Pteridophytes, origin has been traced from the Bryophytes (*Anthoceros*). The discontinuity in variation thus represents the knowledge of phylogeny of the entire plant kingdom. Thus, classification enables to summarise the information of present and past histories of plants.

The history of plant classification is a fascinating subject, since one can learn as to how classification evolved. From such a survey, it will be possible to know about the authors that made significant contributions.

Table

| | |
|--------------------|-----------------------------------|
| 1. Herbae (herbs) | < Imperfectae (flowerless plants) |
| Perfectae | < Dicotyledones |
| flowering plants | < Monocotyledones |
| II. Arborae | < Monocotyledones |
| (trees and shrubs) | < Dicotyledones |

Joseph Pitton de Tournefort (1656–1708) was professor of Botany at the Jardin des plantes, Paris. He was the author of **Elements de botanique** (1694) which contains the description of 698 genera and 10, 146 species along with 450 illustrations. This work was enlarged and published in Latin as *Institutions Res Herbariae* (1700). He was the first to provide characterization of genera and to define them accurately. Tournefort also traditionally classified the plants into trees and herbs but his further grouping was based on the corolla characters.

Rudolf Camerarius (1665–1721) was Director of Botanical Garden at Tübingen, Germany. He was the first to recognize sex in flowering plants and he also established through his researches that pollen was necessary for seed formation.

2. Artificial systems: These classifications are meant for identification of plants and no evolutionary significance is attached to any character. Therefore, the classifications represent artificial systems.

Carolus Linnaeus (1707–1778), a great Swedish naturalist is rightly known as the ‘father or modern botany’. He was born on 23 May, 1707 at Rashult, a small village of Southern Sweden. He became interested in the study of natural history since his childhood.

While he was a student at the University of Uppsala, he published his first paper on the sexuality of plants in 1729 under the guidance of Professor Olof Rudbeck. In 1730 he published **Hortus Uplandicus** wherein he enumerated the plants of the Uppsala Botanical Garden growing at that time. Linnaeus travelled to Holland in 1735 and obtained his degree in medicine from Harderwijk. In Holland, his **Systema Naturae** appeared in 1735, the publication of which was financed by the famous Dutch botanist F. Gronovius. Later in 1737 he published his famous **Hortus Cliffortianus**, based on the collection of plants in the garden of George Clifford at Hartecamp. His **Genera Plantarum** and **Classes Plantarum** appeared in 1737 and 1738 respectively. Linnaeus **Philosophia Botanica** appeared in 1751 which contained a revised version of his system published previously in his **Classes Plantarum** (1738) and **Systema Naturae** (1735). His **Species Plantarum** was published in 1753, where some 7,300 species were described and arranged according to his sexual system of classification. In this book Linnaeus introduced the consistent use of the **binomial system** of plant names, i.e., he gave each plant a name consisting of two words, the first representing generic epithet and the second specific epithet. This famous work was subsequently selected by the modern botanists as the starting point of binomial system of nomenclature. Linnaeus returned to Stockholm in 1738 where he established a very large medical practice. In 1741, he was appointed Professor at the University of Uppsala, a position he held until 1775. After the death of Linnaeus his personal herbarium and library were sold by his widow to an English botanist **Dr. James Edward Smith**. Later, these collections were purchased by the Linnean Society of London, where they are still preserved.

Linnaeus proposed a system of classification called “**sexual system**”, focussing the attention on the floral characters, the stamens, their number, cohesion and adhesion were given an extraordinary importance. He also gave importance to hypogyny, perigyny and epigyny. Besides this, he was the first person to have effectively used the binomial system of nomenclature to a perfection. His definition of a genus and species made the binomial nomenclature a fixed rule. (It was not effectively used by Bauhin and Ray).

The defect of his classification was that, importance was not given to the number of cotyledons and to the polypetalous and gamopetalous conditions, the main features on which the modern systems of classifications are built up. Hence the system of Linnaeus freely mixes up the Dicots Monocots and polypetalous families with gamopetalous ones.

Linnaeus’ system of classification though artificial, he was the first to recognise the significance of flower and fruit structure, he largely emphasised the numerical relationships of the sex organs. He recognised 24 classes determined on the basis of the number, size and union of stamens. The classes were subdivided into orders based, not on characters, but on his idea of their relationships. Twenty four classes of Linnaeus are as follows :

1. Monandria (stamen one)
2. Diandria (stamens Two)
3. Triandria (stamens three)
4. Tetrandria (stamens four)
5. Pentandria (stamens five)
6. Hexandria (stamens six)
7. Heptandria (stamens seven)
8. Octandria (stamens eight)
9. Enneandria (stamens nine)
10. Decandria (stamens ten)
11. Dodecandria (stamens eleven to nineteen)
12. Icosandria (stamens twenty or more, attached to the calyx)
13. Polyandria (stamens twenty or more, attached to the receptacle)
14. Didynamia (stamens didynamous)
15. Tetradynamia (stamens tetradynamous)
16. Monadelphia (stamens monadelphous)
17. Diadelphia (stamens diadelphous)
18. Polyadelphia (stamens polyadelphous)
19. Syngenesia (stamens syngenesious)
20. Gynandria (stamens adrate to the gynoecium)
21. Monoecia (plants monoecious)
22. Dioecia (plants dioecious)
23. Polygamia (plants polygamous)
24. Cryptogamia (flowers concealed i.e., algae, fungi, mosses, ferns)

The system of Linnaeus which largely depended on the number of stamens and carpels in the flower was very simple and convenient and became very popular. It remained dominant for over 75 years until it was replaced by the systems of de Jussieu and de Candolle.

These classes were further divided into 100 natural orders (equivalent to our present day families). The orders derived their names from some genera which he regarded as a typical illustration of their general structure, de Jussieu abandoned the Aristotalian concept of habit and he gave emphasis on the number of cotyledons, the presence and absence of petals and the position of petals and stamens.

Robert Brown (1773–1858), a Scottish botanist, although did not publish any system of his own, he contributed a lot to the better understanding of the morphology of the flower and seed. He was the first person to demonstrate conclusively that the Gymnosperms were a discrete group from the Angiosperms as they have naked ovules and seeds.

Brown published **Prodromus Florae Novae Hollandiae** in 1827, and in this work he followed de Jussieu's system of classification. He considered most of his orders being truly natural but his classes often artificial and founded on doubtful principles.

Augustin Pyrame de Candolle (1778–1841), a French botanist, was born and carried most of his work in Switzerland. He published his views on classification in his classic work, **Theorie elementaire de la botanique**, published in 1813 in Paris. In this work he set forth the principles of a natural system of classification and further developed morphological approach to classification.

The system of de Candolle was similar to that of de Jussieu in many respects but it was certainly an improvement over that of the latter particularly in the treatment of the Dicotyledons. He divided the Dicotyledons into two groups on the basis of presence or absence of petals, the one with petals was subdivided on the basis of free or fused petals and the former was further divided on the basis of the position of ovary.

The plan of de Candolle's system is as follows:

I. Vasculares (plants with vascular bundles/cotyledons).

Class 1. Exogena (Dicotyledoneae ; vascular bundles arranged in a ring, cotyledons two).

A. Diplochlamydeae (flowers with a double whorl of perianth, calyx and corolla both present).

a. Thalamiflorae (polypetalous and hypogynous).

b. Calyciflorae (perigynous or epigynous).

c. Corolliflorae (gamopetalous and hypogynous).

B. Monochlamydeae (flowers with a single whorl of perianth).

Class 2. Endogena (Monocotyledoneae vascular bundles scattered, cotyledon one).

A. Phanerogamae (flowers present).

B. Cryptogamae (flowers absent, hidden or unknown).

II. Cellulares (plants without vascular bundles/cotyledons).

Class 1. Foliaceae (leafy and sexual includes mosses and liverworts)

Class 2. Aphyllae (leafless and without known sexes algae, fungi and lichens).

One of the serious drawbacks of the Candolle's system was the inclusion of vascular cryptogams among Monocotyledons.

De Candolle's monumental work was **Prodromus Systematis Naturalis Regni Vegetabilis** which was published between 1824 and 1873 wherein he has given description of

6. In a phylum the holophytic (chlorophyll-green) plants precede the colourless (hystrophytic) plants, and the latter are derived from the former.
7. Plant relationships are up and down the genetic lines, and these must constitute the framework of phylogenetic taxonomy.

B. Dicta having special reference to the general structure of the flowering plants

8. The stem structure with collateral vascular bundles arranged in a cylinder is more primitive than that with scattered bundles, and the latter are to be regarded as derived from the former.
9. Woody stems (as of trees) are more primitive than herbaceous stems, and herbs are held to have been derived from trees.
10. The simple, unbranched stem is an earlier type, from which branching stems have been derived.
11. Historically the arrangement of leaves in pairs on the stem is held to have preceded the spiral arrangement in which the leaves are solitary at the nodes.
12. Historically simple leaves preceded branched ("compound") leaves.
13. Historically leaves were first persistent ("evergreen") and later deciduous.
14. The reticulate venation of leaves is the normal structure and the parallel venation of some leaves is a special modification derived from it.
15. The polymeric flower structure precedes, and the oligomeric structure follows from it, and this is accompanied by a progressive sterilization of sporophylls.
16. Petaly is the normal perianth structure, and apetalous is the result of perianth reduction (aphanisis).
17. The apochlamydeous perianth is earlier and the gamochlamydeous perianth is derived from it by a symphysis of the members of perianth whorls.
18. Actinomorphy is an earlier structure than zygomorphy, and the latter resulted from a change from a similar to a dissimilar growth of the members of the perianth whorls.
19. Hypogyny is the more primitive structure, and from it epigyny was derived later.
20. Apocarpous is the primitive structure, and from it syncarpous was derived later.
21. Polycarpous is the earlier condition, and oligocarpous was derived from it later.
22. The endospermous seed is primitive and lower, while the seed without endosperm is derived and higher.
23. Consequently, the seed with a small embryo (in endosperm) is more primitive than the seed with a large embryo (in scanty or no endosperm).
24. In earlier (primitive) flowers there are many stamens (polystemonous) while in later flowers there are fewer stamens (oligostemonous).
25. The stamens of primitive flowers are separate (apostemonous), while those of derived flowers are often united (systemonous).
26. The condition of powdery pollen is more primitive than that with coherent or massed pollen.
27. Flowers with both stamens and carpels (monoclinous) precede those in which these occur on separate flowers (diclinous).
28. In diclinous plants the monoecious conditions is the earlier, and the dioecious later.

II. Principles (After Thorne, 1958)

1. Existing species have descended with change from pre-existing species, and are therefore the products of evolutionary forces.
2. Ancestral conditions and trends of specialization are often recognizable in the organs, tissues, and cells of living and fossil angiosperms.
3. The primitive, ancestral condition of any given characteristic can be no more specialized than its conditions in a derived, existing species most primitive for that characteristic.
4. The presence of vestigial rudiments of organs, or sometimes the presence of vestigial vascular supply to greatly modified or missing organs, often furnishes evidence of evolutionary reduction, loss, fusion, or other major modification of structures.
5. The prevalence of parallel and convergent evolution in habit, function, and structure is predictable consequence of the relatively limited means angiosperms have for effective reproduction and for adaptation to available environmental niches.
6. All parts of plants at all stages of their development may produce evidence that is valuable in establishing relationships.
7. Evolution may tend toward elaboration and diversity or toward reduction and simplicity.
8. The rate and direction of evolution may vary in the different organs and tissues of plants.
9. Most existing angiosperms are highly specialized and greatly modified from their primitive, generalized ancestors.
10. Evolutionary trends are sometimes reversible under the influence of changes in environmental factors.
11. Once lost, organs usually are not regained.
12. New angiospermous structures have arisen as modifications of or as outgrowths from pre-existing structures.
13. The sporadic or restricted occurrence of unusual or uncommon characteristics lacking apparent evolutionary significance is often an indication of relationship when correlated with other characteristics.
14. The occasional attainment of certain characteristics of certain levels of evolutionary development is frequently valuable in determining the affinities of families and orders.
15. Embryos and seedlings of related though dissimilar plants often resemble each other more than do the adult plants because of their apparent retention of primitive characteristics.

III. Evolutionary Trends in Angiosperms

A. General trends (Expanded from Smith, 1967)

| Primitive | Advanced |
|----------------------------------|--------------------------------|
| 1. Tropical plants | Temperate plants |
| 2. Woody plants | Climbing or herbaceous plants |
| 3. Wood homoxyulous (vesselless) | Wood heteroxyulous (vesselled) |
| 4. Perennial habit | Biennial or annual habit |

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| 5. Terrestrial habit | Aquatic, epiphytic, saprophytic or parasitic habit |
| 6. Vascular bundles in cylinder (Dicotyledons) | Vascular bundles scattered (Monocotyledons) |
| 7. Chlorophyll present | Chlorophyll absent |
| 8. Evergreen plants | Deciduous-Leaved plants |
| 9. Stipules present | Stipules absent |
| 10. Node unilacunar with two | Node variously altered traces |
| 11. Leaves spiralled | Leaves opposite or whorled |
| 12. Leaves simple | Leaves compound |
| 13. Flowers hermaphrodite | Flowers unisexual |
| 14. Flowers solitary | Flowers in inflorescences |
| 15. Flowers entomophilous | Flowers anemophilous |
| 16. Floral parts spirally imbricate | Floral parts whorled or valvate |
| 17. Flowers polimerous | Flowers oligomerous |
| 18. Perianth undifferentiated | Perianth differentiated into calyx and corolla, or further reduced |
| 19. Flowers with petals | Flowers without petals |
| 20. Petals free | Petals connate |
| 21. Actinomorphy | Zygomorphy |
| 22. Hypogyny | Perigyny, epigyny |
| 23. Stamens many | Stamens few |
| 24. Stamens separate | Stamens connate |
| 25. Stamens 3-veined microsporophylls with linear embedded sporangia | Stamens variously modified |
| 26. Pollen monocolpate (or derived) | Pollen tricolpate (or derived) |
| 27. Carpels many | Carpels few |
| 28. Carpels free | Carpels connate |
| 29. Carpels conduplicate, | Carpels variously modified unsealed, styleless |
| 30. Placentation laminar | Placentation submarginal to axile to parietal, etc. |
| 31. Fruits single | Fruits aggregate |
| 32. Fruit a follicle | Fruit a capsule, berry, drupe, etc. |
| 33. Seeds large; embryo small; endosperm abundant | Seeds small; embryo well developed; endosperm little or none |
| 34. Cotyledons 2 | Cotyledons 1 or 3 (or more) |
| 35. Anatropous ovules | Other types |
| 36. Two integuments | One integument |
| 37. Nuclear endosperm | Cellular or helobial endosperm |
| 38. Crassinucellar ovule | Tenuinucellar ovule |
| 39. Long, slender sieve cells with scattered sieve areas | Shorter sieve tube elements with specialized sieve plates |
| 40. Chromosome number low; | Higher numbers |

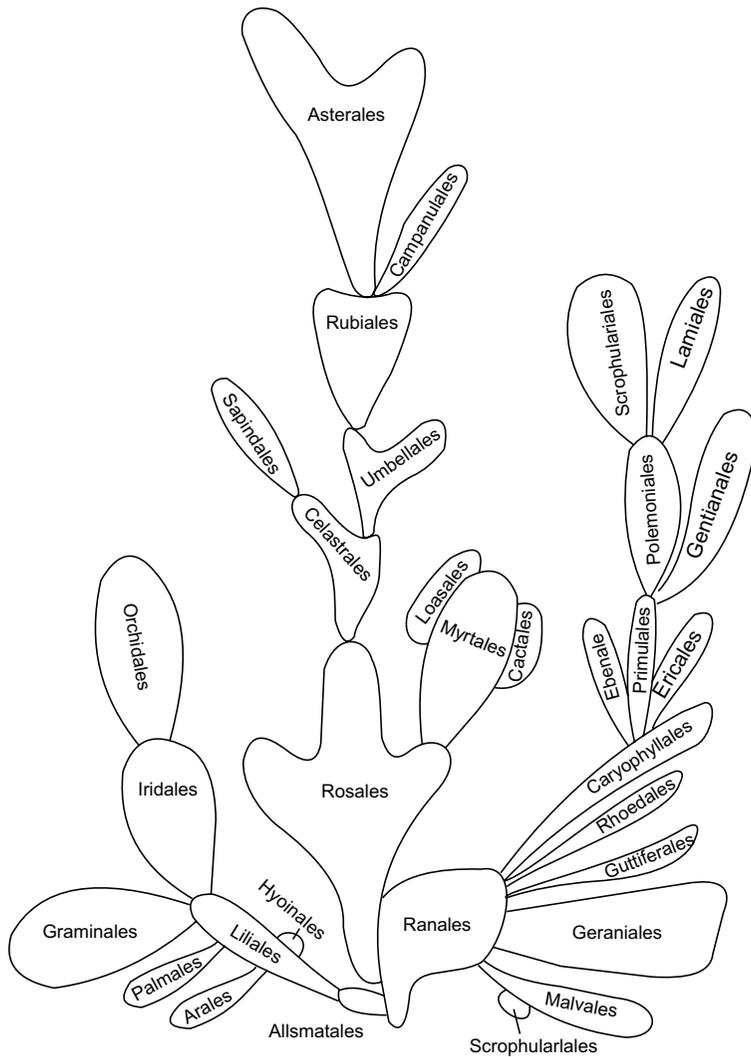


Fig. 2.1 Diagram showing relationships of orders recognised by Bessey. The areas are approximately to the number of species in the orders. Monocotyledons are to the left, perigynous and epigynous Dicotyledons in the centre and hypogynous Dicotyledons to the right (modified after Bessy, 1915).

B. Sporne (1954, 1971) has discussed the statistical correlation between floral and vegetative characters in the dicotyledons. According to him the most reliable indicators of primitiveness are the following :

1. Woody habit
2. Presence of secretory cells
3. Leaves alternate
4. Stipules Present
5. Flower actnomorphic
6. Petals free
7. Stamens Pleiomerous
8. Carpels pleimeous

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| 9. Seeds arillate pitting | 10. Two integuments Apotracheal wood parenchyma |
| 11. Integumentary vascular bundles unstoried wood. | 12. Nuclear endosperm |
| 13. Carpels free | 14. Axile placentation |
| 15. Unisexual Flower | 16. Leuco-anthocyanins present |
| 17. Small number of seeds | 18. Scalariform perforation plates |
| 19. Scalariform intervacular | 20. Pollen binucleate. |

Bessey considered the flowering plants to have originated from strobiliferous cycad ancestors, probably from the Bennettitales. He divided the Anthophyta (Angiosperm) into two groups, *Oppositifollae* (Dicotyledons) and *Alternifollae* (Monocotyledons). The Ranales were considered by him to be the most primitive angiosperms from which Monocotyledons and other groups of Dicotyledons have evolved. The relationships and relative position of the relatively few orders recognised by Bessey is given in (Fig. 2.1).

Besides change in the names of a number of groups, Bessey's system differs from that of Bentham and Hooker in the rearrangement of Monocotyledons, the distribution of Monochlamydeae among the other orders, the exclusion of the Gymnosperms and placing the *inferae* above the *Heteromerae*.

Richard von Wettstein (1862–1931), an Austrian botanist, published a system of classification in the fourth edition of **Handbuch der systematischen Botanik** (1930–1935) which was similar in most respects to that of Engler. However he rearranged the relative position of many dicotyledonous families. He considered Dicotyledons to be primitive and that the Monocotyledons were derived from them through Ranales. Following Engler, he also considered naked flowers to be primitive from which petaliferous elements were derived.

Hans Hallier (1868–1932) proposed a phylogenetic system according to which seed plants comprise 2 phyla, each being monophyletic in its evolution. The monocots were considered to be more advanced than dicots. Like Bessey, he considered the strobiloid type of flower as primitive and held polycarpy and spiral arrangement as primitive over syncarpy and cyclic arrangement. He divided the dicots into 4 main groups, containing 29 orders. He regarded the monocots as derived from *Lardizabaleae* (a Ranalian dicot). The treatment of monocots is incomplete and it contains seven orders in which *Liliflorae* was considered to be most primitive. He also separated the *Gramineae* and *Cyperaceae* into different orders.

John Hutchinson (1884–1972), a British botanist who was associated with the Royal Botanic Gardens at Kew, England proposed a system of classification which was based on those of Bentham and Hooker and Bessey. He originally presented the system in his two volume work, **The Families of Flowering Plants**. The first volume dealing with the Dicotyledons appeared in 1926 and the second volume dealing with the Monocotyledons in 1934. It was revised in 1948 in his *British Flowering Plants* and then again in 1959 in the second edition of **The Families of Flowering Plants**.

Some very minor alterations were made in the third edition of the *Families of Flowering Plants* appeared in 1973. He finished the version of this edition just before his death on the 2nd September 1972 at the age of 88.

The following general principles were adopted by Hutchinson (1959) for the classification of flowering plants :

In the monocots, Calyciferae, Corolliferae, and Glumiflorae were distinguished. In a dicots, unisexuality and perianthless condition were supposed to have been derived by reduction.

The above system was revised by Hutchinson in 1959. This system is entirely new in its concept. He considered that dicots are primitive and monocots as advanced. Phylogenetically, he recognised woody arboreal groups (Lignosae) as primitive than the herbaceous groups (Herbaceae). Lignosae consisting of 64 orders beginning with Mognoliales and Herbaceae with 28 orders beginning with Ranales. The Monocotyledons were derived from Ranales. He abolished the division of dicots into Archichlamydeae and Metachlamydeae and therefore, in the revised classification, Polypetalous and Sympetalous orders were intermixed.

The Monocotyledons were classified mostly as for his earlier proposition. The Calyciferae, the Corolliferae and Glumiflorae were recognised according to the nature-of perianth.