B.Sc. CORE COURCE X - PLANT SYSTEMATICS
UNIT - 4 : CLASSIFICATION (PART-2)

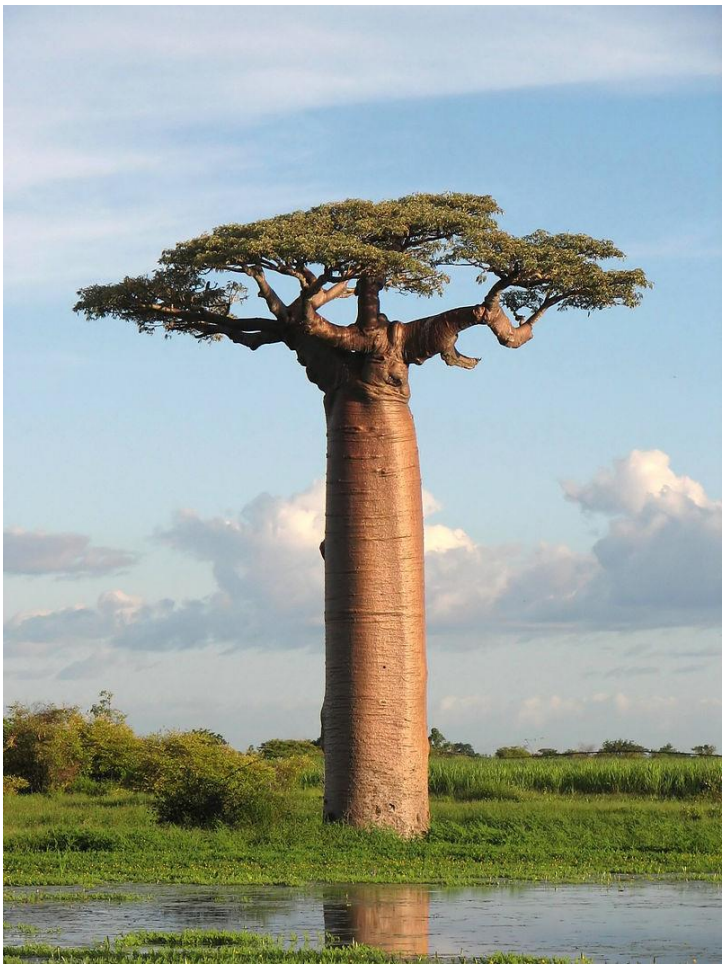
SOME OF THE MAJOR CONTRIBUTORS OF NATURAL SYSTEM OF CLASSIFICATION

MICHEL ADANSON

Michel Adanson (1727-1806), born at Aix-en-Provence, was an 18th-century French botanist and naturalist, who devised a natural system of classification and nomenclature of plants, based on all their physical characteristics, with an emphasis on families. His work on the baobabs trees results in their naming as *Adansonia* commemorating Adanson.

In 1749 Adanson left for Senegal to spend four years as an employee with the Compagnie des Indes, a trading company. He returned with a large collection of plant specimens, some of which became part of the French royal collection under the supervision of the naturalist Georges Buffon; most of them now belong to the National Museum of Natural History in Paris. He published *Histoire naturelle du Sénégal* (1757), describing the flora of Senegal, and a survey of mollusks.

Adanson's *Familles des plantes* (1763) described his classification system for plants, which was much opposed by Carolus Linnaeus, the Swedish botanist who had proposed his own classification system based on the reproductive organs of plants. Adanson also introduced the use of statistical methods in botanical classification. Although Adanson was well known to European scientists, his system of classification was not widely successful, and it was superseded by the Linnaean system.



Adansonia sp. (Baobabs tree)

Adansonia digitata trees near Doranda College, Ranchi

A.P. DE CANDOLLE

Augustin Pyramus de Candolle (1778-1841) was a Swiss botanist. His main focus was botany, also contributed to related fields such as phytogeography, agronomy, paleontology, medical botany, and economic botany.

He was a forceful advocate of the "natural system." His elaboration of this scheme of classification, especially as proposed by A. L. de Jussieu, informed all his taxonomic work. He studied in Paris and was professor of botany at the University of Montpellier. In 1816 he returned to Geneva, his birthplace, where he worked for the rest of his life. He founded the botanical garden, which became the Conservatoire et Jardin Botaniques and now houses his herbarium, separately from the general collection.

He proposed a natural system of classification in 1813 in his book ***"Theorie Elementaire de la Botanique"***. In which he divided plants into two major groups i.e. Cellulares (non-vascular plants) and Vasculares (vascular plants). De Candolle initiated the **"*Prodromus Systematis Naturalis Regni Vegetabilis*"** in 1824, a work intended as a species-level account of the world's flora. He described 58,000 species of dicotyledons belonging to 161 families. He wrote most of the first seven volumes himself. After his death his son Alphonse continued the series, as author and editor of treatments by specialists, for an additional 10 volumes; Alphonse's son Casimir was among the contributors.

A. P. de Candolle's account of the Malpighiaceae in volume 1 (1824) of the "*Prodromus*" formed the basis for future studies of the family, especially the first family monograph by Adrien de Jussieu. De Candolle recognized 16 genera, assigned to three tribes – Tribe Malpighieae: *Malpighia, Byrsonima, Bunchosia, Galphimia, Caucanthus*; Tribe Hiptageae: *Hiptage, Tristellateia, Thryallis* (=*Galphimia*), *Gaudichaudia, Camarea*; Tribe Banisterieae: *Hiraea, Triopterys* (=*Mascagnia*), *Tetrapterys, Banisteria, Heteropterys*.

A brief outline of his plan is undermentioned:

1. *Vasculares* (plants with vascular bundles)
   - Class 1. Exogenae (Dicotyledoneae: vascular bundles in ring; 2 cotyledons)
     - (A) Diplochlamydeae (both calyx and corolla present)
       - (a) Thalamiflorae (polypetalous, hypogynous)—Orders 1–46.
       - (b) Calyciflorae (perigynous or epigynous)—Orders 47–84.
       - (c) Corolliflorae (gamopetalous and hypogynous)—Orders 85–108.
     - (B) Monochlamydeae (only calyx present)—Orders 109–128.
   - Class 2. Endogenae (Monocotyledoneae; vascular bundles scattered; cotyledon one)
     - (A) Phanerogamae (flowers present)—Orders 129–150.
     - (B) Cryptogamae (flowers absent or hidden)—Orders 151–155.
2. *Cellulares* (Plants without vascular bundles or cotyledons)
   - Class 1. Foliaceae (leafy and sexual)—Orders 156–157.
   - Class 2. Aphyllae (nonleafy and without known sexes)—Orders 158–161.

A. P. de Candolle's system of classification was simple and easy. But its major drawback was the inclusion of vascular cryptogams among monocots.

ALPHONSE PYRAME DE CANDOLLE

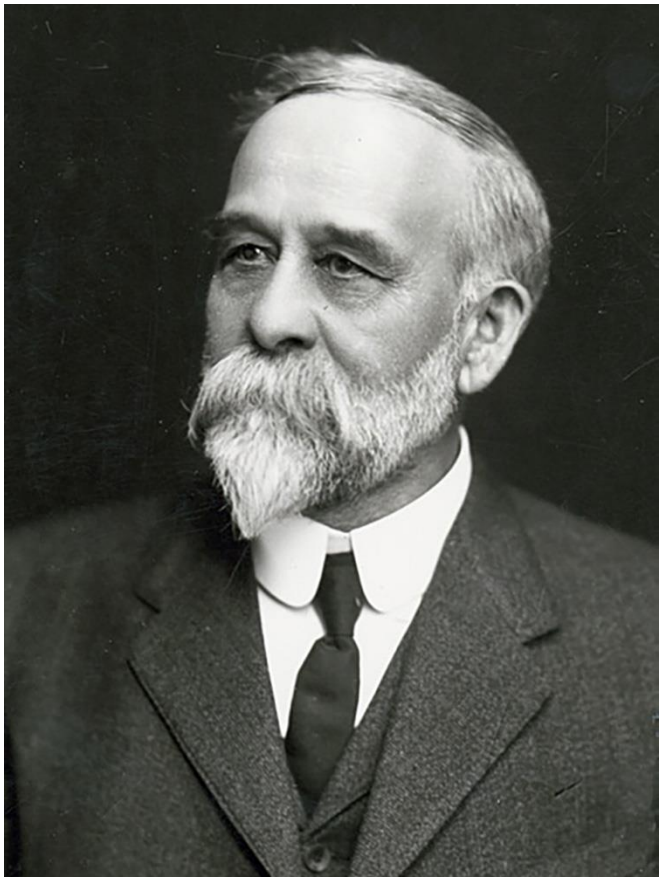
Alphonse Pyrame de Candolle (1806-1893), Swiss botanist and son of Augustin Pyramus de Candolle, introduced new methods of investigation and analysis to phytogeography, a branch of biology that deals with the geographic distribution of plants.

Candolle succeeded his father, the eminent botanist Augustin Pyrame de Candolle, to the chair of botany and as the director of the botanical gardens at the University of Geneva (1842–93). Candolle edited the last 10 volumes of the *Prodromus Systematis Naturalis Regni Vegetabilis* (17 vol., 1824–73), his father's massive attempt to classify and describe all known species of seed plants. He brought his father's laws of nomenclature to completion with *Lois de la nomenclature botanique* (1867). In 1867 Candolle called the first International Botanical Congress in Paris, which made a systematic attempt to standardize and decide nomenclatural practices in botany. Although Candolle's laws were adopted by the congress, they were not applied seriously by the botanists.

Candolle and his son, Anne-Casimir de Candolle (1836–1918), edited a series of monographs dealing with seed plants, *Monographiae Phanerogamarum*, 7 vol. (1879–91). Best known for his contributions to the study of the geographical distribution of plants, Alphonse wrote *Géographie botanique raisonée*, 2 vol. (1855), still a key work of phytogeography. In *Origine des plantes cultivées* (1883) Candolle sought to establish centres of plant origins by using historical, linguistic, and archaeological, as well as botanical, data.

SOME OF THE MAJOR CONTRIBUTORS OF PHYLOGENETIC SYSTEM OF CLASSIFICATION

CHARLES EDWIN BESSEY



Charles Edwin Bessey (1845-1915), an American botanist and Professor at the University of Nebraska, proposed a pure phylogenetic system of plant classification in 1894. He was highly impressed by the evolutionary ideas of Darwin. It could be published in the final form in 1915, shortly after his death. Bessey closely followed Bentham and Hooker's system of classification. His system was based on certain guiding principles of primitive and advance characters called dicta. He considered angiosperms monophyletic and derived from cycadeoid-like ancestors having bisexual strobili.

Bessey's works include *Botany for High Schools and Colleges* (1880), *The Essentials of Botany* (1884), and *Essentials of College Botany* (1914), all widely popular textbooks that dominated botanical instruction in the United States for more than half a century.

According to Bessey (1915), Ranales were the primitive angiosperms. One branch of Ranales developed into monocots and the other into dicots. This system is often called 'Ranalian concept of evolution'.

In this system of classification, the *angiosperms* are divided as under:

Class—ALTERNIFOLIAE (Monocotyledoneae)

Subclass—*Strobiloideae*

Orders—Alismatales (Families 1–9), Liliales (Fam. 10–22), Arales (Fam. 23–25), Palmales (Fam. 26), Graminales (Fam. 27–31).

Subclass—*Cotyloideae*

Orders—Hydrales (Fam. 32), Iridales (Fam. 33–43), Orchidales (Fam. 44–45).

Class—OPPOSITIFOLIAE (Dicotyledoneae)

Subclass—*Strobiloideae*

Superorder—*Apopetalae—Polycarpellatae*

Orders—Ranales (Fam. 46–69). Malvales (Fam. 70–81), Sarraceniales (Fam. 82–83), Geraniales (Fam. 84–105), Guttiferales (Fam. 106–125), Rhoeadales (Fam. 126–132), Caryophyllales (Fam. 133–149).

Superorder—*Sympetalae—Polycarpellatae*

Orders—Ebenales (Fam. 150–154), Ericales (Fam. 155–160), Primulales (Fam. 161–165).

Superorder—*Sympetalae—Dicarpellatae*

Orders—Gentianales (Fam. 166–171), Polemoniales (Fam. 172–177), Scrophulariales (Fam. 178–187), Lamiales (188–191).

Subclass—*Cotyloideae*

Superorder—*Apopetalae*

Orders—Rosales (Fam. 192–214), Myrtales (Fam. 215–229), Loasales (Fam. 230–234), Cactales (Fam. 235), Celastrales (Fam. 236–259), Sapindales (Fam. 260–274), Umbellales (Fam. 275–277).

Superorder—*Sympetalae*

Order—Rubiales (Fam. 278–282), Campanulales (Fam. 283–286), Asterales (Fam. 287–300).

Merits of the System of Bessey

1. Bentham and Hooker placed Gymnosperms in between Dicotyledons and Monocotyledons. Such is not the case in Bessey's system of classification.
2. Monochlamydeae has been completely abolished by Bessey. Families of Monochlamydeae have been distributed near their allies in Dicotyledons (Oppositifoliae).
3. Ranales are the starting point among Dicotyledons.
4. In Bessey's system the families with an inferior ovary follow the families possessing a superior ovary.

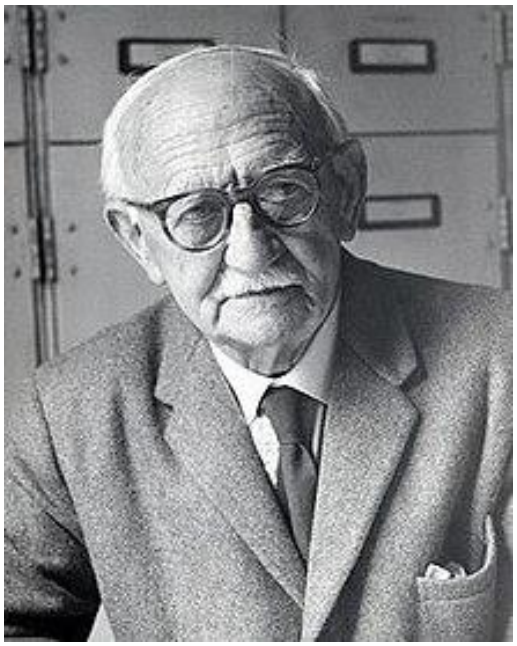
Demerits of the System of Bessey

1. Monocots have been assigned a position prior to dicots, which is not proper.
2. Hypogyny, perigyny and epigyny have been emphasized too much in this system.

Comparison of Englerian and Besseyan Concepts

1. Englerian school believed the *primitive flowers* to be apetalous and unisexual, while Besseyan school believed them polypetalous and bisexual.
2. Englerian school believed the wind pollination primitive while it was the insect pollination according to Besseyan school.
3. According to Englerian concept, *dicots began with* Amentiferae while according to Besseyan concept they began with Ranales.
4. Englerian school believed that *monocots were derived from a gymnospermous* stock while according to Besseyan school they derived from some primitive dicots.
5. The main philosophy of Englerian school is that simple flowers are primitive while Besseyan school believed that flowers with complex structures are more so.

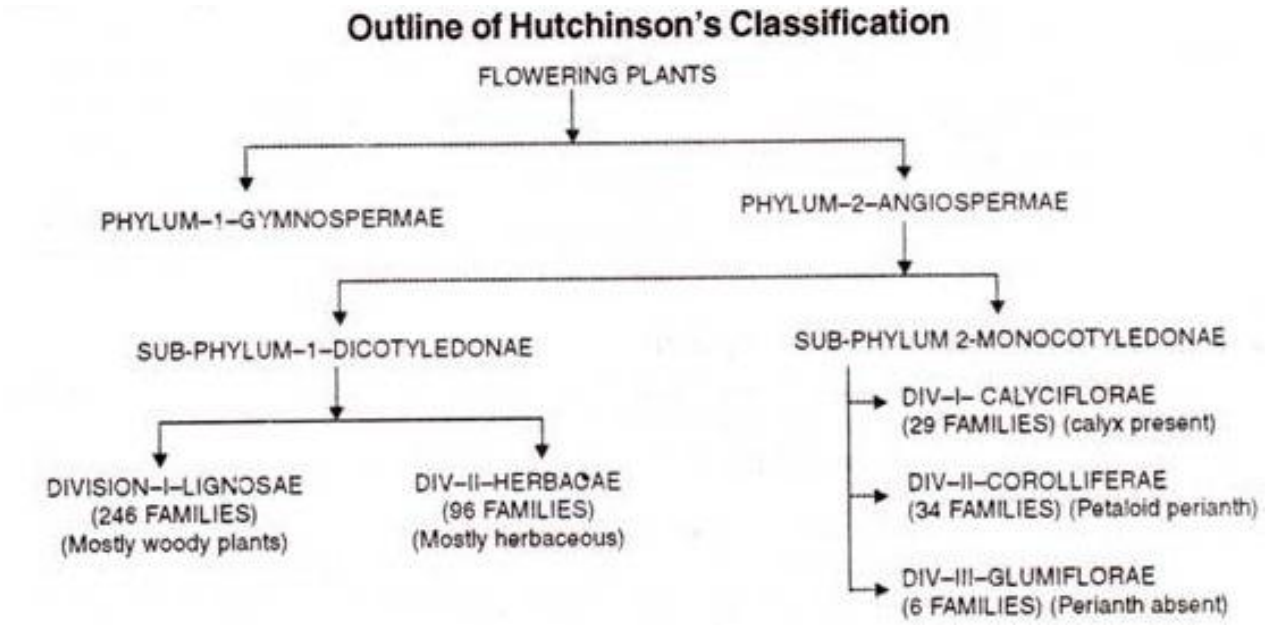
JOHN HUTCHINSON



- John Hutchinson (1884-1972) was a British botanist associated with Royal Botanic Gardens, Kew, England. He developed and proposed his system based on Bentham and Hooker and also on Bessey. His phylogenetic system first appeared as "The Families of Flowering Plants" in two volumes.
- The first volume contains Dicotyledons (published in 1926) and second volume contains Monocotyledons (published in 1934). He made several revisions in different years. • The final revision of "The Families of Flowering Plants" was made just before his death on 2nd September 1972 and the 3rd i.e., the final edition, was published in 1973.
- The following principles were adopted by Hutchinson to classify the flowering plants:

1) Evolution takes place in both upward and downward direction.
2) During evolution all organs do not evolve at the same time.
3) Generally, evolution has been consistent.
4) Trees and shrubs are more primitive than herbs in a group like genus or family.
5) Trees and shrubs are primitive than climbers.
6) Perennials are older than annuals and biennials.
7) Terrestrial angiosperms are primitive than aquatic angiosperms.
8) Dicotyledonous plants are primitive than monocotyledonous plants.
9) Spiral arrangement of vegetative and floral members are primitive than cyclic arrange- ments.
10) Normally, simple leaves are more primitive than compound leaves.
11) Bisexual plants are primitive than unisexual plants and monoecious plants are primitive than dioecious plants.
12) Solitary flowers are primitive than flowers on inflorescence.
13) Types of aestivation gradually evolved from contorted to imbricate to valvate.

14) Polymerous flowers precede oligomerous flowers.
15) Polypetalous flowers are more primitive than gamopetalous flowers.
16) Flowers with petals are more primitive than apetalous flowers.
17) Actinomorphic flowers are more primitive than zygomorphic flowers.
18) Hypogyny is considered as more primitive from which perigyny and epigyny gradually evolved.
19) Apocarpous pistil is more primitive than syncarpous pistil.
20) Polycarpy is more primitive than gynoecium with few carpels.
21) Flowers with many stamens are primitive than flowers with few stamens.
22) Flowers with separate anthers are primitive than flowers with fused anthers and/filaments.
23) Endospermic seeds with small embryo is primitive than non-endospermic one with a large embryo.
24) Single fruits are primitive than aggregate fruits.



- He divided the Phylum Angiospermae into two Subphyla Dicotyledones and Monocotyledones. The Dicotyledones are further divided into two divisions — Lignosae (arboreal) and Herbaceae (herbaceous). The Lignosae includes, fundamentally, the woody representatives derived from Magnoliales and Herbaceae includes most of the predominantly herbaceous families derived from Ranales. The subphylum Monocotyledones are divided into three divisions — Calyciferae, Corolliferae and Glumiflorae.
- The division Lignosae was further divided into 54 orders beginning with Magnoliales and ending in Verbenales. The division Herbaceae was divided into 28 orders beginning with Ranales and ending in Lamiales. The division Calyciferae was divided into 12 orders beginning with Butamales and ending in Zingiberales. The division Corolliferae was divided into 14 orders beginning with Liliales and ending in Orchidales. The division Glumiflorae was divided into 3 orders beginning with Juncales and ending in Graminales.

- In the latest system of Hutchinson, the Dicotyledones consists of 83 orders and 349 families and Monocotyledones consists of 29 orders and 69 families.

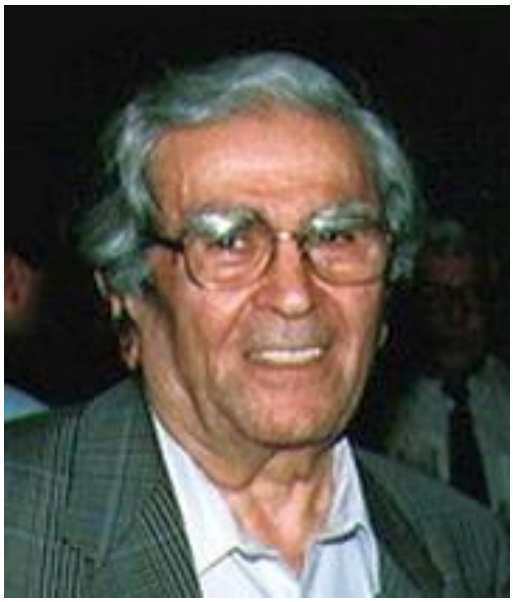
MERITS OF HUTCHINSON'S SYSYTEM OF CLASSIFICATION:

(i) Hutchinson proposed the monophyletic origin of angiosperms from some hypothetical Proangiosperms having Bennettitalean characteristics.
(ii) He made a valuable contribution in phylogenetic classification by his careful and critical studies.
(iii) Monocots have been derived from Dicots.
(iv) According to him, the definitions of orders and families are mostly precise, particularly in case of subphylum Monocotyledones.
(v) This system is in confirmity with the modern views of the phylogeny of angiosperms as it considers the Ranales and Magnoliales at the starting points among dicots.

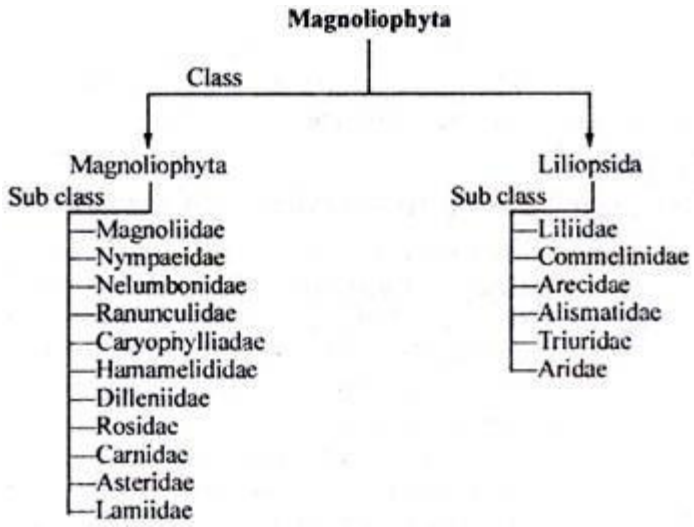
DEMERITS OF HUTCHINSON'S SYSYTEM OF CLASSIFICATION:

(i) From the point of view of plant identification this system is not of much utility.
(ii) There is undue fragmentation of families.
(iii) Too much emphasis is laid on habit and habitat. Thus, creation of Lignosae and Herbaceae is thought to be a defect reflecting the Aristotelean view.
(iv) The origin of angiosperms from Bennettitalean-like ancestor is criticised by many, because the anatomical structures of the early dicotyledons are not tenable with such ancestry.

ARMEN LEONOVICH TAKHTAJAN



1. Armen Leonovich Takhtajan (1910-2009) who was the head of the department of higher plants at the Komarov Botanical Institute in Leningrad, Russia, presented a system of classification, which was first published in a very preliminary form in 1942.
2. Takhtajan was inspired by Hailier's attempt to create a synthetic evolutionary classification of flowering plants based on Darwinian philosophy and his approach was very much similar to that of Cronquist.
3. Takhtajan's system of classification was basically of Bessey-Hallier tradition which considered all evidences from different fields including morphological, anatomical, embryological, cytological, palynological, paleobotanical, chemical and ultrastructural evidences while classifying Angiosperms.
4. In 1980, Takhtajan divided the Magnoliophyta (Angiosperms) into two classes - Magnoliopsida (Dicotyledons) and Liliopsida (Monocotyledons), of which Magnoliopsida is considered primitive and Liliopsida to have been derived from Magnoliales under Magnoloiopsida. The two classes have been further divided in to 10 subclasses, 7 under the Magnoliopsida and 3 under Liliopsida.
5. However according to Takhtajan's latest system of classification (1997), the two classes have been divided into 17 sub classes, 11 under the Magnoliopsida and 6 under Liliopsida, which are as follows:



6. Among the sub classes, Takhtajan considered Magnoliidae to be the most primitive, forming basal group from which all other subclasses have been derived. Subclass Liliidae among monocots were considered primitive. Among dicots Lamiidae and among monocots Aridae was considered to be most advance hence were placed last in the classification.
7. Takhtajan's system is based on 67 phyletic principles. Some of the important criteria used by him to evaluate the relative degree of advancement of flowering plants are as follows:

(i) Woody plants are primitive than herbaceous plants.
(ii) Deciduous woody plants are considered evolved from ever green plants.
(iii) Alternate leaf arrangement is primitive.
(iv) Parallel venation is most advanced.
(v) Stomata with subsidiary cells are primitive than those lacking subsidiary cells.
(vi) Trilacunar or pentalacunar nodes are primitive to unilacunar nodes.
(vii) Xylem fiber evolved from tracheids to libriform fibers, through fiber tracheids.
(viii) Cymose inflorescence is primitive than racemose.
(ix) Flowers with an indefinite or variable number of floral parts are primitive.
(x) Pollen with unsculptured exine is primitive to sculptured pollen.
(xi) Apocarpous gynoecium is primitive.
(xii) Bitegmic ovules are primitive than unitegmic ovules.
(xiii) Anatropous ovule is most primitive, all others are derived ones.
(xiv) 8-nucleated polygonum type female gametophyte is most primitive.
(xv) Mesogamy and Chalazogamy conditions have evolved from Porogamy conditions.
(xvi) Among fruits many seeded follicle is most primitive.

MERITS OF TAKHTAJAN'S SYSTEM OF CLASSIFICATION:

(i) The Dicots (Magnoliopsida) has been discussed prior to Monocots (Liliopsida).
(ii) The Dicots begin with Magnoliales, which is highly satisfactory as Magnoiliales are universally considered to be the most primitive living Angiosperms.
(iii) The families are small homogenous units made up of closely related genera.

(iv) Problems such as monophyly and polyphyly, interrelationships of Dicots and Monocots, primitive position of Magnoliales, the secondary nature of anemophilous families with reduced unisexual flowers, etc. have been satisfactorily settled.
(v) Engler and Prantl's division of Dicots into two traditional groups- Archichlamydae and Metachlamydae, has been abolished in this system.

DEMERITS OF TAKHTAJAN'S SYSTEM OF CLASSIFICATION:

(i) The extremely narrowly defined taxa in this system have resulted in the unwarranted splitting of related groups.
(ii) The main objection to Takhtajan's system is his derivation of Monocotyledons from the stocks of ancestral to the Nymphaeales.

ARTHUR JOHN CRONQUIST

Arthur John Cronquist (1919-1992), the North American botanist, was the Senior Curator of New York Botanic Garden and Adjunct Professor of Columbia University. He was specialist on Asteraceae. He is considered one of the most influential botanist of 20th century. Two plant genera in the *Aster* – family have been named in his honour: these are *Cronquistia* and *Cronquistianthus.*

He presented an elaborate interpretation of his concept of phylogenetic classification in "**The Evolution and Classification of Flowering Plants**" in 1968. The further edition of his classification was published in "**An Integrated System of Classification of Flowering Plants**" (1981).The latest revision of his classification was published in the 2nd edition in 1988 in "**The Evolution and Classification of Flowering Plants**".

His system is more or less parallel to Takhtajan's system. He discussed a wide range of characteristics important to phylogenetic classification. He also provided synoptic keys designed to bring the taxa in an appropriate alignment. He also represented his classification in charts to show the relationships of the orders within the various subclasses. He considered the Pteridosperms (seed ferns) as probable ancestors of angiosperm.

Some of the important phylogenetic ideas about angiosperms put forward by Cronquist are as follows:

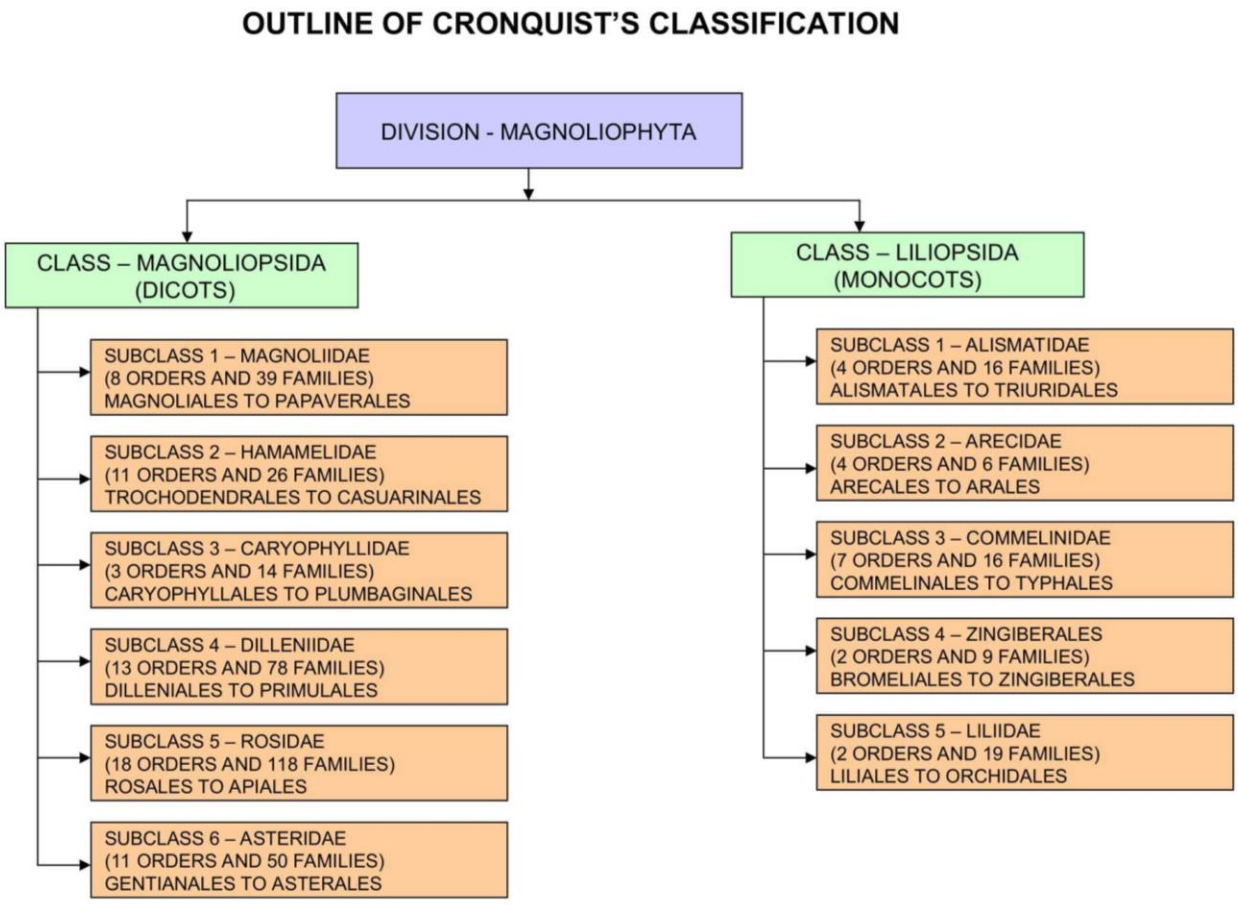
1. The earliest angiosperms were shrubs rather than trees.
2. The simple leaf is primitive than compound leaf.
3. Reticulate venation is primitive than parallel venation.

4. Stipules originated among primitive angiosperms as stipular flanges.
5. Paracytic stomata is primitive than the other types.
6. Slender, elongated, long tracheids with numerous scalariform pits are primitive. Further specialisation leads to shorter broad vessels with somewhat thinner walls and transverse end walls with few larger perforations. Later on, the perforation becomes single and large.
7. Long and slender sieve elements with very oblique end walls where the sieve areas scattered along the longitudinal wall with groups of minute pores are primitive. Whereas, the phloem with short sieve tube elements where end walls having a single transverse sieve plate with large openings is a derived condition.
8. The area and activity of cambium and also the length of fusiform initial is more in primitive form which gradually becomes reduced in advanced one.
9. Plants with vascular bundles arranged in a ring are primitive rather than scattered vascular bundle as found in monocots.
10. Plants with large and terminal flowers are primitive; those may be arranged in monochasia or dichasia. Other types of inflorescences have been derived from these types.
11. The primitive angiosperm flowers has numerous spirally arranged, large and free petals, and numerous spirally arranged laminar stamens and unsealed carpels as in the Magnoliales. Aggregation, reduction, elaboration and differentiation of floral parts occurred during evolution.
12. Plants with unisexual flowers are evolved from bisexual floral ancestors.
13. The large and indefinite number of floral parts are primitive than the small and definite numbers.
14. Androecium with many stamens is primitive than the reduced numbers.
15. Laminar stamens with embedded pollen sacs, as found in *Degeneria* and some other Magnolian genera is a primitive type.
16. Uniaperturate pollen grains are considered as primitive and the triaperturate type are derived from it.
17. Insect pollinated plants are considered as primitive from which wind pollinated plants got evolved.
18. The gynoecium comprising of many carpels arranged spirally on a more or less elongated receptacle is considered as primitive. Further evolution leads to the reduction in the number of carpels which are arranged in a single whorl and then undergo further fusion.
19. Axial placentation is primitive from which other types have been evolved.
20. Anatropous ovule is primitive from which other types have been evolved.
21. Ovule with two integuments (bitegmic) is primitive and, either by fusion or abortion, unitegmic condition has been evolved.
22. 8-nuclei Polygonum-type embryosac is primitive from which 4-nuclei Oenothera-type embyosac has been derived through reduction.

23. Monocotyledons have been developed from dicotyledons through abortion of one cotyledon.
24. The follicle fruit is considered as primitive. Further, dry and dehiscent fruit is more primitive than fleshy and indehiscent fruit.

According to him “many of the evolutionary trends bear little apparent relation to survival value and that there are some reversals”.

The outline of Cronquist’s system of classification laid out in 1981, in “An Integrated System of Classification of Flowering Plants” is as follows:



He divided the Division Magnoliophyta (Angiosperms) into two classes Magnoliopsida (Dicotyledons) and Liliopsida (Monocotyledons). Class Magnoliopsida was further divided into 6 subclasses and 64 orders, of which Magnoliales is the primitive and Asterales is the advanced taxa. On the other hand, the class Liliopsida has been divided into 5 subclasses and 19 orders, of which Alismatales is the primitive and Orchidales is the advanced taxa. The class Magnoliopsida consists of 325 families and Liliopsida with 66 families.

Merits and Demerits

Merits

- There is general agreement of Cronquist's system with that of other contemporary systems like Takhtajan, Dahlgren and Thorne.
- Detailed information on anatomy, ultra structure, phytochemistry and chromosome morphology was presented in the revision of the classification in 1981 and 1988.
- The system is highly phylogenetic.
- Nomenclature is in accordance with the ICBN.
- The family Asteraceae in Dicotyledons and Orchidaceae in Monocotyledons are generally regarded as advanced and are rightly placed towards the end of respective groups.
- The relationships of different groups have been described with diagrams which provide valuable information on relative advancement and size of the various subclasses.
- The family Winteraceae (vessel-less wood present similar to Pteridosperms) placed at the beginning of dicotyledons is favoured by many authors.
- The subclass Magnoliidae is considered as the most primitive group of Dicotyledons. The placement of Dicotyledons before Monocotyledons finds general agreements with modern authors.
- As the text is in English, the system has been readily adopted in different books.

Demerits:

1. Though highly phylogenetic and popular in U.S.A., this system is not very useful for identification and adoption in Herbaria since Indented keys for genera are not provided.
2. Dahlgren (1983, 1989) and Thorne (1980, 1983) treated angiosperms in the rank of a class and not that of a division.
3. Superorder as a rank above order has not been recognised here, though it is present in other contemporary classifications like Takhtajan, Thorne and Dahlgren.
4. The subclass Asteridae represents a loose assemblage of several diverse sympetalous families.
5. Ehrendorfer (1983) pointed out that the subclass Hamamelidae does not represent an ancient side branch of the subclass Magnoliidae, but is remnant of a transition from Magnoliidae to Dilleniidae, Rosidae, and Asteridae.
6. There is a difference in opinion with other authors regarding the systematic position of some orders like Typhales, Arales. Urticales etc.