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THE CLASSIFICATION OF PLANTS, VI.*

JOHN H. SCHAFFNER.

In a previous paper of this series, the writer defined the classes of plants† and also divided the Monocotyls and Dicotyls into ten subclasses. In the arrangement given only a moderate departure was made from the Engler and Prantl scheme, although it was recognized that present morphological knowledge would warrant greater changes. Having become accustomed to thinking along phyletic lines of classification in the meantime, through rather extensive investigations, the writer is now prepared to take a more radical position in the direction of a rational system. The time has come when present accepted facts and theories of morphology and evolutionary doctrines should be reflected in plant classification. Bessey's "A Synopsis of Plant Phyla" published in 1907 is a most important contribution to the subject of taxonomy and can readily be taken as a basis for further studies. Some of the groupings given below have been taken from the "Synopsis," while a considerable part had been worked out independently before a copy of that work was received. It was, therefore, a source of considerable satisfaction to find that the writer's own results were essentially the same as Bessey's. For if one breaks away from past "authority," the application of modern ideas to the problem of relationships should lead to more or less definite results. In so far as they represent essentially similar groups, the names adopted by Bessey have also been applied to the present classification; for the "name of a group is only a name and not a definition." The names not agreeing with Bessey's

* Contribution from the Botanical Laboratory of Ohio State University, 60.

† The Classification of Plants, IV. Ohio Nat. 9 : 446-455, 1909.

have been adapted from older classifications. In this connection it might be stated that the Bentham and Hooker scheme of classification contains certain features which should not be thrown overboard bodily without due consideration.

As stated in a previous article of this series, all possible characters and peculiarities should be considered in segregating groups. Gross and microscopic, and external and internal morphology, as well as embryology, physiology, and life cycle are important and must be taken into account if contradictions in supposed lines of descent are to be avoided. But when the groups have thus been established, one or at most, a very few definite characters in combination should give an exclusive definition.

It will be evident to anyone, who has considered the subject in some detail, that the groups of monocotyls and dicotyls cannot be segregated on the basis of the flower alone, although the flower is perhaps the most important structure in the Anthophyta to indicate relationship. There may be apocarpous and syncarpous, apetalous and choripetalous, monosporangiate and bisporangiate, and numerous other diverse developments in very closely related groups. From an evolutionary point of view, the starting-point of floral development must be sought among the homosporous and heterosporous Pteridophyta. The flower of the higher plants then seems to have come from a definite, bisporangiate strobilus or cone. This is especially apparent in the angiosperms where the monosporangiate flower usually shows vestiges of one or the other set of sporophylls. These vestiges in the angiosperm flower are very conclusive, and in deciding whether a given structure is primitive or specialized their recognition becomes of primary importance.

The general progression is then about as follows:

1. Indefinite bands of sporophylls with further growth of the axis.
2. Definite bisporangiate strobili.
3. Development of a perianth in the Anthophyta.
4. Reduction of the floral organs to definite cycles and numbers.
5. Extreme modifications in the typical floral organs and also in the parts immediately surrounding.

As often pointed out the evolutionary lines in the flower are then:

1. From spiral to cyclic and to reduced cycles, in the monocotyls mostly trimerous, occasionally tetramerous or dimerous, and in the dicotyls mostly pentamerous, but occasionally tetramerous, trimerous or dimerous.
2. From pentacyclic to tetracyclic or still fewer sets.
3. From hypogynous to perigynous and epigynous conditions.
4. From parts free to parts united, as from apocarpy to syncarpy.

5. From choripetalous to sympetalous, apetalous or naked flowers.

6. From spiral to actinomorphic flowers, and further to isobilateral, unsymmetrical, or zygomorphic types.

7. From bisporangiate to monosporangiate and further from monocious to diecious flowers.

8. From types with all the organs normal to those that show vestigial parts.

These developments are repeated again and again. Certain of these specializations show themselves even in primitive groups. In many cases no relation with the environment is evident, but advancing tendencies apparently originate in the internal constitution of the plant itself. Thus we are led to recognize tendencies which may or may not come to expression in the diverse species of a natural group. The whole phylogenetic development bears a close resemblance to the ontogenetic expression of hereditary characters in the individual.

The development of the inflorescence is equally interesting with that of the flower itself. In the primitive groups a single flower terminates a main vegetative branch and from this condition appear all gradations of reduction and clustering through racemes, corymbs, and panicles to spikes, spadixes, catkins, heads, and disks, and their various modifications.

In general then, the process of segregation, classification and arrangement should proceed on the following basis:

1. Development of the floral organs.
2. Specialization and degeneration of the floral parts.
3. Specialization and degeneration of the vegetative parts.

The segregation must be fundamentally phyletic and should follow a recognition of the gaps produced by variation, mutation, and the destruction of intermediate types, while the arrangement in series should follow the evolutionary progression as indicated by comparative morphology and complexity of life cycle, together with the presence of vestigial parts. Vestigial organs are of the highest importance in any classification of the angiosperms because of their common occurrence. It is necessary, therefore, to be able to distinguish vestigial organs or vestiges from nascent organs or primordia. Paleontological evidence would here be of paramount importance but satisfactory fossil flowers are too rare for our purpose.

Before taking up the special question of the relationships in the Anthophyta a word may be said in regard to the importance of synopses. The synopsis is commonly confused with a key for identification. A synopsis should show the supposed phyletic relationship; a key should be the easiest means for ascertaining a name whether of group or species. In most cases the synopsis does not make a satisfactory, working key. The genera of

Araceae of the northeastern United States are treated below for illustration. This synopsis is supposed to show both the natural relationships and the orderly arrangement, in series, of groups of lower and higher value. The key is simply a device for the easy recognition of the genera. The essential mark of a good key is that it makes use of such characters only as are present at a certain season of the year or a certain period of the life history.

SYNOPSIS.

- I. Flowers bisporangiate; plants without or with lactiferous cells.
 1. Without lactiferous cells; with a perianth.....POTHATAE
 - a. Without a typical spathe.....1. *Acorus*
 2. With lactiferous cells; with or without a perianth.....CALLATAE
 - a. Without a typical spathe; with a perianth....2. *Orontium*
 - b. With an open spathe; without a perianth; spadix elongated3. *Calla*
 - c. With an enveloping spathe; with a perianth; spadix globose4. *Spathyema*
- II. Flowers monosporangiate; plants with lactiferous cells; without a perianth.
 1. Spadix covered to the tip with flowers.....PHILODENDRATAE
 - a. Flowers monocious; leaves simple.....5. *Peltandra*
 2. Spadix with a sterile projection at the tip.....ARATAE
 - a. Flowers monocious or diecious; leaves compound.....6. *Arisaema*

KEY.

1. Inflorescence without an obvious spathe; flowers bisporangiate, with a perianth. 2.
1. Inflorescence with a large, expanded spathe. 3.
2. Spadix apparently lateral; scape 3-angled and grooved. *Acorus*.
2. Spadix terminal; scape cylindrical. *Orontium*.
3. Leaves compound; spadix with a prominent sterile projection at the tip. *Arisaema*.
3. Leaves simple; spadix usually without a sterile projection at the tip. 4.
4. Flowers monocious, on an elongated spadix; leaves prominently sagitate with rather distinct points. *Peltandra*.
4. Flowers bisporangiate, on an oval or globose spadix; leaves cordate or only slightly sagitate. 5.
5. Spathe open, with a slender point; spadix ovoid or somewhat elongated. *Calla*.
5. Spathe enclosing the globose spadix; not with a slender point. *Spathyema*

At present we do not possess the necessary morphological details to make a final classification, yet the broad outlines of a natural arrangement can be laid down with a fair degree of certainty. When several parallel lines are to be grouped, one can, of course, use his individual judgment, the better plan probably being to follow expediency. If the methods and principles employed are correct there should not be much change in the general scheme, in the future, except in matters of detail. The larger problem of the correct limits of families and orders cannot, of course, be considered at present. It must be recognized, however, that some of the families, like Saxifragaceae, as formerly delimited, are mere waste-baskets to receive odds and ends which

may belong elsewhere. It is believed that the segregation into sub-classes, as given below, is essentially correct and represents phyletic developments. In the older arrangements the treatment of the series is often very inconsistent, in some cases proceeding from the primitive to the specialized, in others from the most highly specialized to the most primitive, as in the case of the grass family. The arrangement must be inverted beginning with the primitive bamboos and ending with such extremely specialized genera as Indian corn.

The sub-classes at present recognized by the writer are as follows:

MONOCOTYLAE:

Helobiae.
Spadiciflorae.
Glumiflorae.
Liliiflorae.

DICOTYLAE:

Thalamiflorae.
Centrospermae.
Calyciflorae.
Amentiferae.
Myrtiflorae.
Heteromerae.
Tubiflorae.
Inferae.

There can be little question but that the Helobiae represent the lowest monocotyls and the Thalamiflorae the lowest dicotyls. Any comparative morphology based on phyletic ideas must come to this conclusion. The lower types of these two subclasses are about on a level. There is little point, therefore, to the discussions as to whether monocotyls or dicotyls are the higher group. Since the highest dicotyls go far beyond the highest monocotyls in floral specialization, it is more convenient to place the monocotyls first in the list, even though the gametophytes of their highest members, the Orchidaceae, probably represent the most extreme reduction and specialization. The classification of the vascular plants should be based primarily upon the sporophyte.

Finally, it should be clear that generalizations as to primitive conditions and evolutions can not be based upon such extremely specialized forms as *Welwitschia* (Tumboa), Piperaceae, Casuarina, and other peculiar groups. The gametophytes and the minute morphology have undergone specialization as well as the more exposed parts.

A general representation of the supposed relationship is given in Figure 1. The Helobiae begin with the Alismaceae and related forms and end with the Vallisneriaceae which are highly special-

ized, monosporangiate, and epigynous. The Nymphaeaceae are an intermediate lateral branch of the Helobiae. The morphological evidence for this view is overwhelming. There is no reason for separating the Hydrocharitales from the Helobiae as is frequently done, for their morphology and cytology show the relationship conclusively.

Whether the Spadiciflorae represent more than one subclass may be a question, but they nevertheless show a closer relationship among themselves than to either the Helobiae or Liliiflorae.

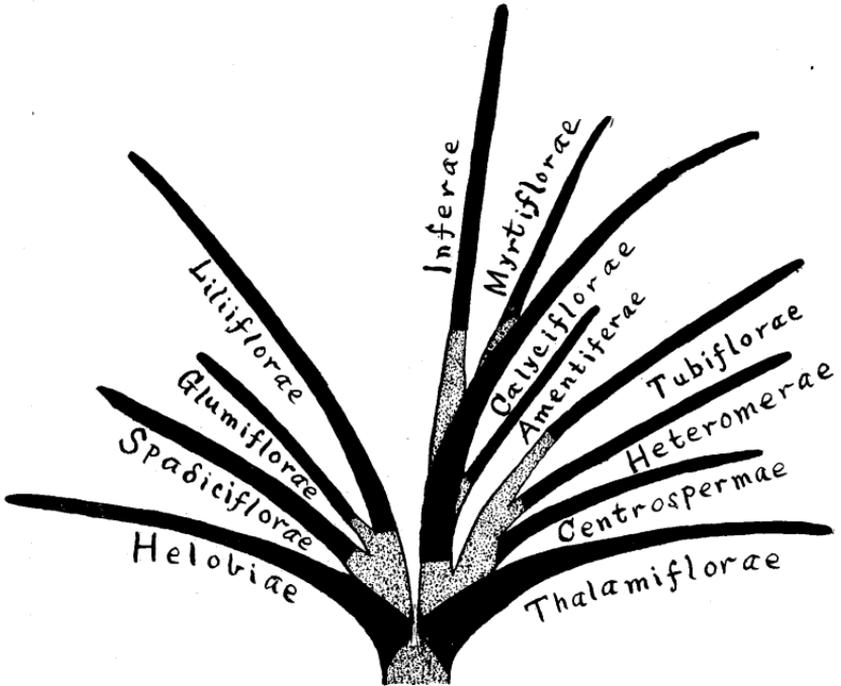


Fig. 1. Diagram of the Subclasses of Monocotylae and Dicotylae.

The Glumiflorae may be an offshoot from either the Spadiciflorae or Liliiflorae. They have thus been placed in a neutral position, in the diagram, between the two. They represent extreme specializations as indicated by the numerous vestigial structures.

The main families of the Liliiflorae make a natural group extending from the Liliaceae to the Orchidaceae. The Liliales may need some further rearrangement from that indicated below, but it is not considered advisable to separate them into two orders as is frequently done.

In the Dicotylae the problem of classification is, of course, much more difficult than in the Monocotylae, because of the far

greater numbers involved, and the complexity of structure. This is especially true of the choripetalous families, where it is almost impossible for the mind to grasp the enormous number of types to be considered.

The Thalamiflorae are the lowest dicotyls. The first order, the Ranales, constitute a parallel group to the hypogynous Helobiae. The Ranales are closely followed by the Sarraceniales, Brassicales, and the lower Gerianales and Malvales.

The Centrospermae are a small branch having its origin in the Thalamiflorae. Its lowest family, the Caryophyllaceae, indicates the relationship while the higher forms are greatly specialized, passing over into reduced apetalous and naked flowers with high development of the inflorescence.

The Calyciflorae represent another great, fundamental branch of choripetalous dicotyls arising from near the Ranales, but somewhat more specialized. The lower genera of Rosaceae show marked resemblances to some Ranunculaceae. The other families placed in this subclass are fairly certain and there may be families and genera at present associated with other subclasses that properly belong here.

The Amentiferae are a small but important group whose relationship may be traced from the lower Calyciflorae through the Hamamelidaceae, Platanaceae, Ulmaceae, Moraceae, etc., up to the Salicaceae. A number of families now included are uncertain. One of the structures of the group is the highly specialized flower cluster, the catkin, and there are other significant features as chalazogamy besides various peculiarities of buds, twigs and leaves.

The Myrtiflorae are an epigynous branch, mostly of chori-petalous dicotyls, probably derived from the Calyciflorae, from the vicinity of the Saxifragales. Some of the families may be excluded in the future but the main mass represents a distinct type of floral development and appears to be phylogenetically related, excepting, perhaps the cactales which may even belong to the Centrospermae.

The Heteromerae appear to have come from near the same region as the Centrospermae. The strong resemblance of certain Caryophyllaceae to Primulaceae is very suggestive and gives support to this view. The Heteromerae also show their primitive character by frequent choripetaly and other peculiarities.

From the lower Heteromerae it is but a step to the Tubiflorae, the lowest forms of which are represented by the Convolvulaceae and Polemoniaceae. The families of the Tubiflorae are for the most part quite certain, except perhaps the Plantaginaceae.

The last and highest subclass of Dicotylae, the Inferae, appears to be an offshoot from the lower Calyciflorae, the line leading almost directly from the Saxifragales to the Umbellales, Rubiales, Campanulales, and Compositales.

The application of the preceding scheme of classification to the families of Anthophyta represented in the northeastern United States will give the following arrangement:

Phylum, ANTHOPHYTA.

Class, MONOCOTYLAE.

Subclass I. HELOBIAE.

1. **Alismales**—Alismaceae, Scheuchzeriaceae, Potamogetonaceae Naiadaceae.
2. **Nymphaeales**—Nymphaeaceae (Nelumbonatae, Nymphaeatae).
3. **Hydrocharitales**—Vallisneriaceae.

Subclass II. SPADICIFLORAE.

4. **Pandanales**—Sparganiaceae, Typhaceae.
5. **Arales**—Araceae (Pothatae, Callatae, Philodendratae, Aratae), Lemnaceae.

Subclass III. GLUMIFLORAE.

6. **Graminales**—Cyperaceae (Scirpatae, Rhynchosporatae, Caricatae), Graminaceae (Poacatae, Panicatae).

Subclass IV. LILIFLORAE.

7. **Liliales**—Liliaceae (Melanthatae, Liliatae, Convallariatae), Smilacaceae, Juncaceae, Commelinaceae, Pontederiaceae, Mayacaceae, Xyridaceae, Eriocaulaceae.
8. **Iridales**—Amaryllidaceae, Haemodoraceae, Iridaceae, Dioscoreaceae, Bromeliaceae.
9. **Scitaminales**—Marantaceae.
10. **Orchidales**—Burmanniaceae, Orchidaceae (Cypripediatae, Orchidatae).

Class, DICOTYLAE.

Subclass I. THALAMIFLORAE.

1. **Ranales**—Magnoliaceae, Anonaceae, Ranunculaceae, Cera-
tophyllaceae, Berberidaceae, Menispermaceae, Lauraceae.
2. **Sarraceniales**—Sarraceniaceae, Droseraceae.
3. **Brassicales**—Papaveraceae, Fumariaceae, Brassicaceae, Cap-
paridaceae, Resedaceae?
4. **Geraniales**—Geraniaceae, Oxalidaceae, Balsaminaceae, Tro-
paolaceae, Linaceae, Zygophyllaceae, Rutaceae, Sima-
rubaceae, Polygalaceae, Euphorbiaceae, Callitrichaceae.
5. **Malvales**—Malvaceae, Tiliaceae.
6. **Guttiferales**—Theaceae, Hypericaceae, Cistaceae, Vio-
laceae, Passifloraceae.

Subclass II. CENTROSPERMAE.

7. **Caryophyllales**—Caryophyllaceae, Elatinaceae, Aizoaceae, Portulacaceae, Nyctaginaceae, Phytolaccaceae.
8. **Chenopodiales**—Illecebraceae, Amaranthaceae, Chenopodiaceae.
9. **Polygonales**—Polygonaceae.
10. **Piperales**—Saururaceae.

Subclass III. CALYCIFLORAE.

11. **Rosales**—Rosaceae (Rosatae, Pomatae, Drupatae), Calycanthaceae, Fabaceae (Mimosatae, Cassiatae, Papilionatae).
12. **Saxifragales**—Crassulaceae (Crassulatae, Penthoratae), Podostemaceae, Parnassiaceae, Saxifragaceae, Iteaceae.
13. **Celastrales**—Rhamnaceae, Vitaceae, Celastraceae, Buxaceae, Ilicaceae, Cyrillaceae, Staphyleaceae, Thymeleaceae, Elaeagnaceae.
14. **Sapindales**—Sapindaceae, Hippocastanaceae, Aceraceae, Empetraceae, Limnanthaceae, Anacardiaceae.

Subclass IV. AMENTIFERAE.

15. **Platanales**—Hamamelidaceae, Platanaceae.
16. **Urticales**—Ulmaceae, Moraceae (Moratae, Cannabatae), Urticaceae.
17. **Fagales**—Fagaceae, Betulaceae, Juglandaceae, Leitneriaceae, Myricaceae.
18. **Salicales**—Salicaceae.

Subclass V. MYRTIFLORAE.

19. **Cactales**—Cactaceae.
20. **Myrtales**—Lythraceae? Hydrangeaceae, Grossulariaceae, Melastomaceae, Onagraceae, Trapaceae, Haloragidaceae, Hippuridaceae.
21. **Loasales**—Loasaceae, Cucurbitaceae.
22. **Aristolochiales**—Aristolochiaceae.
23. **Santalales**—Santalaceae, Loranthaceae.

Subclass VI. HETEROMERAE.

24. **Primulales**—Primulaceae, Plumbaginaceae.
25. **Ericales**—Clethraceae, Pyrolaceae, Monotropaceae, Diapensiaceae, Ericaceae, Vacciniaceae.
26. **Ebenales**—Sapotaceae, Ebenaceae, Symplocaceae, Styracaceae.

Subclass VII. TUBIFLORAE.

27. **Polemoniales**—Convolvulaceae, Cuscutaceae, Polemoniaceae, Hydrophyllaceae.
28. **Gentianales**—Oleaceae, Loganiaceae, Gentianaceae, Menyanthaceae, Apocynaceae, Asclepiadaceae.
29. **Scrophulariales**—Solanaceae, Scrophulariaceae, Orobanchaceae, Bignoniaceae, Martyniaceae, Lentibulariaceae, Acanthaceae.
30. **Lamiales**—Boraginaceae, Verbenaceae, Lamiaceae, Phrymaceae.
31. **Plantaginales**—Plantaginaceae.

Subclass VIII. INFERRAE.

32. **Umbellales**—Araliaceae, Ammiaceae, Cornaceae.
33. **Rubiales**—Rubiaceae, Adoxaceae, Caprifoliaceae, Valerianaceae.
34. **Campanulales**—Campanulaceae (Campanulatae, Lobeliatae).
35. **Compositales**—Dipsacaceae, Ambrosiaceae, Helianthaceae, Cichoriaceae.

A COLLECTION OF ATLASES. There recently came to the library of Ohio State University a two volume work of 1600 pages, giving titles, for, and in some cases short notes about, the atlases now in the library of Congress at Washington. There are over 3,400 of these atlases covering a very wide range of data. It would seem that nearly everything could be reduced to a map. There are atlases astronomical, cartographical, commercial, ecclesiastical, geological, historical, ethnographical, physical and political; business, real estate and military atlases; general atlases, atlases of discovery, of exploration, of boundaries, of oceans, rivers, harbors, crops, and many resources; atlases of population, diseases, and many vital statistics.

Twelve pages and ninety titles are devoted to the atlases of Ohio, beginning with Walling's Atlas of Ohio in 1868, followed by the Geological Survey Atlas, and Hardesty's historical and military encyclopedias each with an extensive atlas. Then come most of the counties with atlases and plat-books, followed by a series of city atlases.

For New York State there are 137 atlases, including 28 devoted to the city alone.

Almost any scientist or philosopher could find basal material for research, charted here and ready for comparative studies.

G. D. HUBBARD,