Appendix

Floral Evolution

In the evolution of the higher plants, the greatest number of changes has come about in the reproductive organs. This makes the flower the most important part of the plant from the viewpoint of the taxonomist. Most of these changes can be classified under the following headings:

1. *Change in number plan and reduction.* Flowers low in the scale of evolution usually have many parts (an indefinite number), as for example: The Ranunculi have many stamens and many pistils, whereas the legumes usually have ten stamens and one pistil.
2. *Change in union.* Flowers low in the scale of evolution have their parts separate (not grown together), while the more advanced ones have their parts coalesced (grown together), as for example: The Ranunculi have separate petals, separate stamens, and separate pistils, whereas in the Ipomoëae, the petals are grown together, stamens are attached to the corolla, and the pistil is composed of coalesced carpels.
3. *Change in shape.* The parts of the more primitive flowers are usually simple and all of the members of a series are similar, whereas the more recent flowers tend to have complex parts and members of a series may vary in shape, as for example, the actinomorphic flowers of *Calytonia* and the zygomorphic flowers of *Scrophularia.*

4. *Change in elevation.* In the more primitive flowers, the sepals, petals, and stamens are attached below the ovary (hypogynous), while in the higher plants these are attached either around (perigynous) or on top of the ovary (epigynous).
5. *Change in arrangement.* The spiral arrangement of floral parts is considered more primitive than the cyclical (whorled) arrangement.

In summarizing these changes, it may be said that flowers low in the scale of evolution have parts *numerous* (number indefinite), *simple, separate, spirally arranged,* and *hypogynous;* while those high in the scale have parts *few* (number definite), *complex, grown together, cyclically arranged,* and *epigynous.*

Laws, Theories, and Hypotheses

These laws, theories, and hypotheses are more or less related to taxonomy, evolution, and speciation.

Bergman's Law. The maximum size of a species is found in the optimal region of its range.

Chapman's Law of Biotic Potential. The biotic potential of a species is a quantitative expression of the dynamic power of the species which is pitted against the resistance of the environment in which it lives in its struggle for existence.

Chapman, Royal N. *Animal Ecology,* p. 183. McGraw-Hill, 1931.

Darwin's Theory of Evolution. Natural selection through survival of the fittest. The species best suited to its environment has the best chance for survival.

deVries' Mutation Theory. New species and forms arise as unusual abrupt deviations from their parents, and breed true for that deviation.

Dollo's Law of Irreversibility. An organism never reverts exactly to its orignal form, even if returned to its original environment.

Fernald's Nunatak Hypotheses. Arctic-alpine plants persisted on ice-free lands in the arctic and upon small unglaciated areas (nunataks) well within or near the margins of the great ice fields.

Raup, Hugh M. Botanical problems in boreal America. I. Bot. Rev. 7., p. 183. 1941.

Haeckel's Biogenetic Law. (Recapitulation Theory). Ontogeny recapitulates phylogeny. That every organism in its individual life-history repeats the various stages through which its ancestors have passed in the course of evolution.

Hopkins' Bioclimatic Law. Other things being equal, the variation in the time of occurrence of a given periodic event in the life activity in temperate North America is at the general average rate of four days for each degree of latitude, five degrees of longitude, and 400 feet altitude; later northward, eastward, and upward in spring and early summer; and the reverse in late summer and autumn.

Hopkins, A. D. Periodical events and natural law as guides to agricultural research and practice. U.S.D.A. Monthly Weather Rev., Supp. No. 9, 42 pp. 1918.

Jordan's Law of Geminate Species. Twin species, each representing the other on opposite sides of some form of barrier.

Jordan, David Starr. Amer. Naturalist, Vol. 42, pp. 73-80. 1908.

Knight-Darwin Law. No organic being fertilizes itself for an eternity of generations. Nature abhors perpetual self-fertilization.

LeChatelier's Theorem. Every change in the direction of an intensification of the environmental conditions influencing a body or a system of bodies, augments the resistance of the latter to a further increase of this influence.

Maximov, N. R. *The Plant in Relation to Water,* p. 326. Macmillan Company, 1929.

Leibig's Law of the Minimum. When a multiplicity of factors is present and only one is near the limits of toleration, this factor will be the controlling one.

Lotsy's Theory of Hybridization. Species arise by crossing, perpetuate themselves by heredity and are gradually exterminated by the struggle for life, those last exterminated being the selected ones.

Lotsy, J. P. *Evolution by Means of Hybridization*, p. 157. Martinus Nijhoff, The Hague, 1916.

McAtee's Survival of the Ordinary. That reproduction of species, on the whole, is carried on by ordinary individuals. There are more ordinary individuals than there are other; therefore, they have more chance to survive.

McAtee, W. L. Survival of the ordinary. Quarterly Rev. of Biol., Vol. 12, pp. 47–64. 1937.

The Doctrine of Signatures. An old belief that medicinal plants were marked in some way to indicate their value to man; the problem was to discover the sign and interpret it properly. In application, any part of a plant that resembled a part of the human body in form, texture, or color was usually considered to have curative qualities for all of the ills of that organ.

The Law of Compensating Factors. A factor that is weak or functionless in a complex organism is often supplemented or replaced by the modification of other factors when it is advantageous to the species.

Vavilov's Distribution of Variabilities. The greatest concentrations of variability in genera or species are found in their areas of origin, where differentiation has been taking place for the longest time. At the periphery of the area occupied by a plant and in places of natural isolation one is most likely to find unusual forms of that plant, due to inbreeding or mutation.

Vavilov's Law of Homologous Series. "Species and genera that are genetically closely related are characterized by similar series of heritable variations with such regularity that, knowing the series of forms within the limits of one species, we can predict the occurrence of parallel forms in other species and genera. The more closely related the species in the general system, the more resemblance will there be in the series of variations. Whole families of plants in general are characterized by definite cycles of variability occurring through all genera and species making up the family."

English translation in *Selected Work of N. I. Vavilov* (K. Starr Chester, Chronica Botanica Publication, 1949).

Wagner's Isolation Theory (As stated by Jordan and Kellog). Given any species, in any region, the nearest related species is not to be found in the same region nor in a remote region, but in a neighboring district separated from the first by a barrier of some sort or at least a belt of country, the breadth of which gives the effect of a barrier.

Jordan, David Starr, and Vernon L. Kellog. *Evolution and Animal Life,* p. 120. D. Appleton Co., 1908.

Willis's Age and Area Hypothesis. In general, the area occupied by a species depends upon its age, or, conversely, the age of a species is proportional to its geographical area.

Willis, John C. The age and area hypothesis. Science, Vol. 47, pp. 626–28. June, 1918.

Zalenski's Law. The anatomical structure of the individual leaves of a shoot is a function of their distance from the root system.

Arber, Agnes. *The Gramineae,* p. 305. Macmillan Company, 1934.

Phyllotaxy

(Leaf Arrangement)

The disposition of leaves on stems usually follows some definite arrangement. Plants with only one leaf at a node are said to be *alternate.* Those with two or more are termed *whorled* or *verticillate.* The simplest whorl consisting of two leaves is said to be *opposite.*

Alternate leaves are usually arranged spirally. This spiral may turn clockwise on some species and counterclockwise on others. Sometimes the spiral may be interrupted, but it is sufficiently constant to convince one that there must be some rule involved.

The Italian mathematician, Leonardo of Pisa, surnamed Fibonacci, formulated a series of numbers known as the Fibonacci summation series. This series, 0, 1, 1, 2, 3, 5, 8, 13, 21, etc., is formed by using the sum of the last two consecutive numbers as the next higher number of the series. M. A. Brown, with other prominent European botanists who were studying the arrangement of leaves on stems, found that by combining the Fibonacci summation series and the principle of the "Spirals of Archimedes," they had a fractional series that would apply to most of the alternate leaf arrangements. This series is known as the Fibonacci fractional series. The fractions are: 1/2, 1/3, 2/5, 3/8, 5/13, 8/21, 13/34, 21/55, etc., and are formed by taking the series twice, placing one above the other and two places to the right. This will make the first "1" in the top series appear above the "2" in the bottom series, the second "1" above the "3," etc. The sum of any two consecutive numerators equals the next higher one in the scale, and the same is true for the denominators.

In application of the fraction series, the numerator indicates the number of complete turns the spiral makes and the denominator the number of consecutive leaves touched by the spiral. For instance, corn has leaves in two ranks. If a spiral is started at one leaf and continued up the stem touching all leaves in order of their elevation until one is reached that is directly above the first, the spiral will have made one complete turn and included two leaves (not counting the top one): thus the phyllotaxy of corn would be represented by the fraction ½. In the case of poplars, the end of the spiral at one complete turn does not stop on a leaf, so it is necessary to continue the spiral until it does stop on a leaf directly above the one used as a starting point. This is accomplished at the completion of the second complete turn. In making the two turns, five leaves are passed, thus making it a ⅖ arrangement. The following are some examples of the above series.

1/2-*Ulmus, Betula, Gramineae*
1/3-*Alnus,* sedges
2/5-*Quercus, Populus*
3/8-Holly, aconite, *Ailanthus*
5/13-*Pinus strobus* cone, rosettes of houseleek
8/21-Uncommon
13/34-Some pine cones
21/55-Some pine cones

Some less common leaf arrangements belong to other series, such as 1/4, 1/5, 2/9, 3/14, etc., but they follow the same law of the summation of the last two figures being the next higher one in the series.