THE IMPORTANCE OF PHYLOGENETIC TAXONOMY IN SYSTEMATIC BOTANY[1]

JOHN H. SCHAFFNER

The main interest of the older taxonomists was the discovery and description of species, which to them were units or entities self-contained and complete as they had come from the hand of the Creator. Linnaeus was so far possessed with this species idea that he wrote the well-known phrase: "The tyro makes systems, the expert makes species." However expert Linnaeus may have been in making species, he certainly was the most extreme tyro when he attempted to bring some systematic order into the chaos of the known species of his time. He made 23 classes of Phanerogamia and one class of Cryptogamia, bunching together into this class all the known Algae, Fungi, Liverworts, Mosses, Ferns, Horsetails and Lycopods.

When Darwin wrote his first great work on evolution, it was still the origin of species, the more or less discrete units of plants and animals, that was the main object of interest. But the proper study of the species should be made in its relation to all the species in the genus. When this is done the isolated species unit becomes of subordinate interest and importance both in evolution and taxonomy.

Just as when one is studying Shakespeare's Hamlet, for example, one can study the isolated words and recognize them by their letters, as one recognizes a species by its specific characters. Such a study is interesting but one does not get much insight into the real Hamlet nor into the soul of Shakespeare in this way. But after the letters, words, and sentences have all been arranged in their proper paragraphs, scenes, and acts something altogether marvelous appears to grip the intellect and the imagination. The taxonomist has in the systematic study of the plant kingdom a problem comparable to a study of Shakespeare's Hamlet in all of its literary, artistic and scientific aspects. He deals with the individual plant and its characteristics, measuring, numbering, weighing and judging of qualities; for he knows that the ancient author of the apocryphal "Wisdom of Solomon" was correct when he wrote

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that all things are ordered in measure and number and weight. But the real taxonomic problem begins when the measuring and numbering and weighing are done. If interest in taxonomy is to be continued, the student must be shown that there is something beyond the mere measuring and weighing and numbering.

The most complex problem which can be presented to the reasoning human mind is this organic system of plants and animals which surrounds us on all sides. The taxonomist is from the very beginning confronted by a bewildering array of characters, potentialities, and reactions of different magnitudes and the first fundamental problem is to make an inventory of these characteristics by placing them into their proper categories. After taking a general survey of the situation, three general classes of characteristics or potentialities can be distinguished. First are the general fundamental potentialities which form an accumulation series from the level of the lowest bacteria to the level of the angiosperms, together with additional accumulative potentialities appearing in the distinct phyletic lines. Second are the great segregative potentialities, which establish the group limits of smaller and smaller extent from the distinctive phylum characters through the series of class, order, family and genus characters or of still smaller segregative groups. Third are the nearly endless numbers of small specific and varietal characters and their potentialities which are the genes or groups of genes and the changing of which through ordinary mutations does not affect the more fundamental group characteristics or even disturb to any extent the taxonomic position of the species. But the potentialities whether general or specific in nature, can only be inferred from a study of the characters developed through the physiological activity of the cells and tissues during growth and during the general ontogenetic cycle. It soon becomes evident that a given hereditary system will often not produce the same characters in one ecological environment as in another. Thus a plant of a given variety of hemp may come to maturity when 8 inches high, or it may not attain maturity until it is 8 feet or more in height. It may begin to bloom in 2 weeks after the seedling breaks through the ground or not until it has attained an age of 8 months. It may be pure in sex expression, either staminate or carpellate, or it may be a bisporangiate individual producing both stamens and carpels. In addition to the uncertainty

produced by fluctuation the systematist is still further troubled in the study of some groups by the easy hybridization of both near and distant types, so that what he may consider as a distinct species may fall to pieces in its very first reproductive phase.

The first problem then in making a study of phyletic groups, whether great or small, is to make an inventory of the general fundamental potentialities and reactions responsible for the accumulated characteristics evolved in the plant kingdom. The fundamental potentialities are those which have been accumulated in the general plant series and are apparently never lost and very rarely inhibited by inhibitative potentialities. In a few cases they may progress to a more advanced condition, however, through the greater perfection of the given reaction system. One can without a very minute study of characters and processes easily discover at least 100 such accumulated, general, fundamental potentialities, appearing in the seven successively higher divisions or subkingdoms of the living plants as follows:

1. Protophyta—18 accumulative fundamental potentialities.
2. Nematophyta—18 + 12 = 30.
3. Bryophyta—30 + 15 = 45.
4. Pteridophyta Homosporae—45 + 15 = 60.
5. Pteridophyta Heterosporae—60 + 10 = 70.
6. Gymnospermae—70 + 15 = 85.
7. Angiospermae—85 + 15 = 100.

After such a general study, the problem must be restricted to the special subdivisions, to the segregative characters of the main phyletic groups; but each higher division is to be considered in relation to all the divisions in the general group until one has disposed of this group system as far as the genus. At this point the most important problem is reached. For the genus contributes part of the name of a plant and this is of fundamental concern to society in general, often much greater than to the systematic botanist himself. Because of this universal and practical aspect, the specialist should consider the effect of his work on society in general and not merely determine whether his segregations and lumpings seem reasonable to himself. In this respect phylogenetic thinking can aid decidedly in the establishment of rational genera. The question will then arise as to the harmoneous treatment of the particular

group in relation to the whole, and in relation to the segregations in other similar families. How shall any one decide what is a good and reasonable genus? Shall there be but a single distinctive character or shall there be a greater or smaller aggregate of characters considered in the establishment of a genus and what shall be the magnitude or importance of the characters? Is there not some way that we might come to a fairly scientific conception of the genus group, or must we be ever at the mercy of the genus "splitters" until every linneon becomes a "genus"? For example, it does not seem sensible to put the red maple and the silver maple into two genera. One shudders to think of the consequences if all genera were divided up to the same extent as Acer has been recently. But whatever the degree of splitting or lumping, it seems reasonable to segregate both genera and species on fewer and smaller characters in the lower plants than in the higher.

The phylogenetic viewpoint is also of very great importance in the segregation of species and in determining their relative positions in the genus. In a study of Equisetum, it becomes evident that the internodal ridge with a double row of tubercles or with a bicarinate condition has been attained independently in at least four distinct phyletic lines. So in a comparative study of *E. praealtum* Raf. and *E. hiemale* L. it becomes obvious that the simple internodal ridge of *E. praealtum* with a single line of tubercles is the more primitive condition. The internodal ridge of *E. hiemale* with a double row of tubercles indicates the addition of an important new progressive potentiality, and the plant is thus a distinct step in advance of *E. praealtum*. Both are good species but if one is to be regarded as a variety of the other the phylogenetic point of view will require that *E. hiemale* be considered a variety of *E. praealtum*.

The phylogenetic treatment of the species of a genus is a great aid in the study of geographic distribution. In the case of Equisetum there is quite a remarkable correspondence between the present geographic distribution of the species and the ascertained phylogenetic relation.

Because of a lack of knowledge of the general evolutionary sequence and because the whole grass series was topsy-turvy, with *Zea Mays* L. at the bottom instead of at the top where it belongs, there have been all sorts of odd hypotheses in relation to the nature and origin of this very important economic species. But when the grass series is put right side up, with the bamboos

at the bottom and Indian Corn at the top, the problem of relationship and origin takes on a very different aspect from what it had before.

Just as the grass series was entirely upside down so also was the Equisetum series in practically all modern treatments. These arrangements came down from botanists who neither believed in any evolutionary process nor had any definite conception of how to evaluate simple and complex reaction systems properly. Thus *E. arvense* L. was at the base of the series and when it was discovered that its gametophytes were more or less unisexual, the conclusion was immediately drawn that all Equiseta have unisexual gametophytes. But it has been found to be contrary to the facts. Now when the phyletic series is properly arranged, in accordance with both the evidence from paleobotany and the comparative study of the reaction systems of the living species, *E. arvense* comes out at the end of the line and its unisexuality appears as a final step leading toward the higher heterosporous level.

The same kind of taxonomic confusion arises when such a genus as Onoclea is placed at the base of the Polypodiaceae, as is still commonly the practice. When a comparative study of its potentialities is made, it stands out as one of the most complicated of ferns. Now just as in Equisetum, it is found that Onoclea has unisexual gametophytes and has thus advanced decidedly toward the condition of the heterosporous plants, a flat contradiction of its supposed position at the base of the Polypodiaceae.

When taxonomy is taught to the more advanced students from the phylogenetic point of view it never fails to arouse a most profound interest and curiosity. After all has been said, taxonomy is still the real study of plants. Taxonomy is the central ring of the main circus-tent of botany; other aspects of the subject are the side rings and the side shows. So whenever taxonomy is neglected botany must suffer severe loss in its standing as a fundamental science. It is therefore important that both those who practice taxonomy and those who teach it consider methods of procedure most carefully and hold fast that which is good.