THE EVOLUTION OF BOTANY.[1]

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I am especially interested in the evolution of Botany in the United States because my own botanical experience has extended throughout this evolution, beginning with the primitive stage of the subject. Incidentally, I have also been interested in the evolution of botanists. I have learned to divide them into two categories: (1) those who have evolved with the subject, keeping pace with it; and (2) those who have remained static at various stages in botanical progress. The history of the subject is a succession of modern periods, and our static botanists of today were once modern, but they cast anchor and stopped, while the rest of the fleet sailed on. They may be thought of as mileposts, marking the various stages of botanical progress.

The history of Botany in this country begins with taxonomy, or classification. When I began to be a botanist, the only kind of research work was to collect and name and classify plants. In those distant days a friend of mine, whom you all know, went to a certain university as a student, wishing to become a botanist. The professor in charge warned him that Botany was practically a closed subject, since nearly all the plants had been named, and he advised him to select some other field in which much of the material had not been named.

If taxonomy represents the primitive period in our botanical evolution, it does not follow that all the taxonomists of today are static. The discovery of species and the problem of relationships are perennial, for growing knowledge of plants is always affecting their classification, and taxonomists must keep up to date in pigeon-holing our material. It must be confessed, however, that there are still living some taxonomists who are fine representatives of our primitive period. My first training, therefore, was as a taxonomist, and my teacher and guide was the outstanding taxonomist of his day, Asa Gray, whose vision of Botany extended beyond taxonomy.

Our taxonomic period presently budded out the next stage in botanical evolution, the stage of Morphology. I was young enough to respond to the call of this new field, and so became a morphologist, not a static one, I hope. Morphology, of course, is the child of Taxonomy, and it still depends much upon its mother. Since it deals with structure, it is of great service in classification, but it soon developed a great field of its own. Morphology has had an evolution which is very interesting and suggestive. It began, of course, with gross superficial structures, such as the taxonomist used, and organized them effectively, but if it had advanced no further, it would have remained merely a laboratory assistant to Taxonomy. However, not content with gross superficial structures of plants, it began to uncover their gross internal struc-

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tures, and to develop a terminology that came to be called anatomy. Then the day of microscopes dawned upon our horizon, and we applied them to the minute internal structures, culminating, as our technique developed, in what we came to call cytology. It was all morphology, although we gave different names to its various phases; that is, it was a searching for the structure of plants, all the way from gross organs to cell organs. The culmination of Morphology, however, came when morphologists turned their attention from the structures of the mature body to an investigation of the development of these structures, from egg to maturity, and we named this Embryology. This certainly solved the riddle of many mature structures. Not only that, but it gave us glimpses of possible relationships that were full of suggestion, and laid the basis for the scientific study of the evolution of the plant kingdom. The evolution of Morphology, therefore, extends from gross structures, bedded in taxonomy, through various stages, to the wonderful field of evolution. You will infer, from this statement, that a real morphologist, with any vision of his field, can hardly be static.

After Morphology had gotten under way, it began to become evident that a knowledge of structure is merely preparatory to a knowledge of function, and in this way Plant Physiology began to bud out from the morphological stock. This involved a new technique, and an equipment of chemistry and physics that was new to botany. As a consequence, sciences began to synthesize, and this marks a new epoch in the history of science, namely, the checking of disintegration or analysis, and replacing it by synthesis. It was realized that nature is a synthesis, and that any solution of its problems demands a combined attack. If morphologists had been investigating structures without any reference to their functions, too many physiologists investigated functions without adequate knowledge of the structures involved. The situation may be illustrated as follows. The morphologist was dissecting a locomotive, without seeing it in motion; while the physiologist was observing the locomotive in action, without adequate knowledge of its structure. Structure means little apart from its function; and function cannot be appreciated fully without some knowledge of the structure involved.

In the development of the field of physiology, it was discovered that a knowledge of the activities of plants, with their necessary conditions, formed a substantial basis for the effective handling of plants in agriculture; in other words, agriculture then began to be scientific rather than purely empirical. In this way Botany began to be regarded as a practical science, capable of rendering important public service, rather than a science only for investigators. In other words, it was found that it was not only "pure science," but also could be made an "impure science" by coming in contact with field operations.

In connection with the development of physiology, another field of work began to bud out. The physiologist was investigating the activitives of plants in handling materials provided by nature; but it remained to investigate the external conditions which enabled plants to work, to carry on their activities. In this way plant environment began to be investigated, and the responses of plants observed, and the field

of Ecology began to develop. It began with observation of the responses of individual plants to various environments, but it soon developed into what may be called plant sociology, dealing with plants, not as individuals, but as communities. This field has developed wonderfully, for the various kinds of communities are now known to indicate definite sets of conditions for plant activity, and so they are coming to be called "crop indicators," meaning that a natural plant community can be used to indicate the kind of crop that will yield the maximum return on that area. Here again, Botany has entered the field of public service.

Perhaps the most important practical development of Ecology has been in the field of Forestry, which is really the application of Ecology to the handling of forests. It will be noticed that with these successive steps our subject is becoming more and more synthetic. If the physiologists had to call in chemistry and physics, the ecologist has had to call in geography and geology.

While these newer phases of Botany were beginning to make our science useful, another phase budded out in connection with the study of plant diseases, or Plant Pathology. The destruction of crops by various diseases was of course serious enough to command attention, but this merely introduced the pathologists to the general field of plant diseases, whether they attacked useful plants or other plants. It became a fascinating subject, travelling along obscure and apparently disconnected trails. The parasites, mostly other plants, were so interesting that at first the pathologists studied only the parasite, and paid but little attention to the victim. The disease-producing organism was so interesting that the patient was neglected. Here is where physiology called a halt, and showed that the important thing was to study the physiological response of the patient to the invading organism. Here again the problem called for a synthesis of sciences, the life history or morphology of the parasite being merely an introduction to the physiological reactions of the patient. This kind of investigation was necessary to clear the field of the numerous nostrums for curing crop diseases, nostrums that always take advantage of ignorance as to the real cause of disease. Of course the disease-producing organisms must be discovered, and their life histories traced, just as we must have police records of the undesirables in our population, but this is the taxonomy and morphology of the group, the basis of our physiological attack, and pathology is really the investigation of the abnormal physiology of the patient responding to the presence of the parasite.

Finally, after this succession of steps in the evolution of Botany, making us realize that it is a huge continent that we have just begun to explore, rather than a single highway along which we can travel, there emerged gradually the newest member of our community of subjects, and that is Genetics, commonly spoken of as "plant breeding," so far as it applies to plants. Plants were being studied from the standpoint of their relationships, their bodily equipment, their activities, their responses to environment, their susceptibility to diseases; and then the question was suggested, from what source does the plant obtain all this functioning equipment? In the attempt to answer this question the field of Genetics began to get busy, through experimental control

searching for the laws of inheritance, popularly called "heredity". We all realize how rapidly it has developed, and how increasingly intricate it is becoming, the generalizations of one day becoming the exceptions of the next day. It has made also an increasing synthetic demand on science in general, calling in mathematics, even higher mathematics; and before it is through it may use astronomy. Even in the turmoil stage of this wonderful field, it has already shown itself to be of great practical service, as has been every advance into the continent we are exploring. It is evident that while knowledge for its own sake is our ideal of botanical research, as we open up the trails into unexplored territory, we are also discovering gold mines. Of course, to us, captured by the enthusiasm of explorers, the gold mines are merely incidents by the way, but to the human population in general they mean great national assets.

Genetics has enabled us to improve the races of useful plants, to secure new desirable races, to combat drought by developing drought-resistant races, to fight disease by developing immune races, and all this as an incident in the search for knowledge of the laws of inheritance.

This bare outline of the evolution of Botany in my own botanical lifetime is but a prophecy of the days that lie before us. I shall not venture upon a prophecy, for my subject deals only with history; but history is a basis of prophecy, and we all are asking the question, what is coming next? Botany is a perennial, putting out an endless succession of shoots. The thing we must emphasize is that none of us shall become static and go into camp when the train is moving on. All the subjects mentioned, from taxonomy to genetics, are live subjects, all the more alive on account of their association with one another. The point is that we must keep developing our perspective as our science develops. We must work in our own particular field on a mountain top that will take in the whole landscape, and not dig ourselves into a pit and lose all the botanical perspective.

An organization like the Indiana Academy of Science is primarily intended to secure perspective. It is at these meetings we bring our fields together, and discover that they form one landscape. As one of the group that planted the seed from which this Academy has grown, I can wish nothing better for you than that your threefold ideal shall be: (1) the advancement of knowledge, that man may live in an ever-widening horizon; (2) the application of knowledge to the service of man, that his life may be fuller of opportunity; and (3) the training of man in the methods of science, that he may solve his problems and not be their victim.