Recent Progress in Botany.

By John M. Coulter.

Mr. Chairman and Members of the Academy: When I face the Indiana Academy of Science at its twenty-fifth anniversary, I feel more like speaking of old times than upon any technical subject. However, perhaps some of these reminiscences may appear at the banquet tonight, and I will restrict myself just now to the program.

It is very hard for one who has not lived and worked through the period covered by the history of this Academy to appreciate the changes that have taken place in the science of botany. Those of you who have come into the subject during the last decade can hardly have a full appreciation of what you have missed and of what rapid development has taken place. At the time this Academy was being founded, almost all the instruction and investigation in botany was in taxonomy or classification, and that was chiefly restricted to the classification of flowering plants. I shall not weary you by recounting all of the important changes that have taken place since that time, but I wish to point out a few things that have impressed me.

The first impressive change is the tremendous development and differentiation of the subject during the period covered by the history of this Academy. In the background we have still the old historic field of taxonomy, which is being cultivated with greater zeal than ever. But the first change to note is the great development of the comparatively new science of morphology. In these days morphology has come to mean the structure and evolution of the plant kingdom as a whole, and its development has been little short of marvelous. Perhaps the first change from the old régime was brought about in this country by the appearance of Bessey's Botany in 1880, and from that date began the development of modern morphology in the United States.

In connection with the development of morphology there have grown up various expressions of it that have demanded special technique. The first of these to appear was that which is known as cytology. In collecting the facts in reference to the cell as a unit of structure, morphologists soon discovered that something must be known about cell structure, and

thus a very special technique has been developed and is still developing. Cytology might be defined, therefore, as morphology at the limit of technique.

In more recent years there has been another outgrowth from morphology and still a part of it. For many years there had been what was recognized to be a great rubbish heap of facts called anatomy. For example, the classic "Comparative Anatomy of Phanerogams and Ferns," by De Bary, contains a mass of facts, but they are inchoate. Many of them were used in instruction, for in the early days of morphological instruction facts were simply collected without reference to their relationships. Presently, as morphology began to develop ideas, it was felt that these anatomical facts might mean something when organized; but in the absence of such organization they were largely abandoned in instruction. Recently, however, there has been rescued from this rubbish heap the new subject of vascular anatomy, which has become a tremendous instrument in the development of our knowledge of plant groups and of the evolution of vascular plants in particular. Thus vascular anatomy has greatly extended morphology, which at first chiefly concerned itself with the reproductive structures. It still remains for some one to organize in a similar way the vegetative structures outside of the vascular system, and then morphology for the first time will have its facts fairly in hand.

Under the shadow of this morphological development there appeared another growth known as pathology. The progress made in plant pathology during the period covered by the life of this Academy is familiar to many of its members. It began as morphology, but as it progressed it became more and more clear that it would have to join itself to physiology, and so pathology may be called a cross between morphology and physiology in its recent development.

Another great field that came in connection with this development of morphology, even more recently, is paleobotany. There has been such a subject ever since people have uncovered plant remains and their impressions in the rocks; but its method was to match fossil fragments with living plants, so that identification was always uncertain. The technique of today, however, has enabled us to secure knowledge of structures, and since vascular anatomy has been put upon a phylogenetic basis we have a key by which the relationships of these ancestral plants may be unlocked.

I can only mention the remarkable advance that has taken place in plant physiology, and also in the new subject of plant ecology. There should be added plant breeding, which has not only its important scientific aspects in connection with theories of heredity and the origin of species, but has also such enormous practical applications that it is reaching out into the needs of men.

This gives merely a glimpse of how the old science of botany, as it really was when this Academy was founded, has branched out into its present field of achievement. The student of twenty-five years ago who had studied botany in our colleges and learned just enough about gross morphology to be able to use Gray's "Manual" intelligently, and who regarded that to represent all there was in botany, would be astonished to see the development of today.

Following this outline of the expansion of botany in general, I wish to speak of three or four of the most notable advances made in my own special region of morphology, and that is the morphology of vascular plants. To me the most striking feature of morphological progress during the last twenty-five years has been the breaking down of the old barrier set up between what were called cryptogams and phanerogams, the barrier that separated fern plants from seed plants. Not only was this felt to be a solid barrier, but even in universities chairs of botany have been distinguished on the basis of this division of plants. If there is any place in the whole series of plants where there is no gap between great groups it is this very place. I can call attention only to two conspicuous facts that stand out in this connection. One is the discovery a few years ago that certain gymnosperms (cycads) possess fern-like swimming sperms, a feature that associates these seed plants very closely with ferns. The second is the discovery during the present decade of the great paleozoic group of fern-like seed plants. All are familiar with the fact that the coal vegetation was thought to be largely a fern vegetation because the preserved leaves looked like fern leaves; but it is now recognized that all of these great frond groups of the coal vegetation were seed-bearing plants. In fact, paleobotanists are sure now of only one family of paleozoic ferns.

Another fact of equal interest is the uncovering of the so-called mesozoic cycads. These have proved to be far removed from the other gymnosperms in their essential characters. We have a sort of national pride in

the uncovering of this singular group, because the greatest deposits are in this country. The work of Wieland in revealing the rich deposits of these plants in the Black Hills region and in sectioning the cones with admirable skill and patience is well known. For the last five months Wieland has been exploring southern Mexico, and has discovered a section 2,000 feet in thickness that is packed with the remains of this peculiar group, making it undoubtedly the greatest deposit of these plants in the world. They are regarded now as of great interest because the peculiar structure of their cones has suggested the possibility that they may be a group of gymnosperms that has given rise to angiosperms.

Perhaps another notable change that deserves mention is the practical demonstration of the relationship between the two groups of angiosperms. It was thought once that the monocotyledons were the more primitive angiosperms, and that the dicotyledons were the more recent. We feel assured now that the monocotyledons have been derived from dicotyledons, for every monocotyledon starts with the vascular system of a dicotyledon; and if there is anything true in the old theory of recapitulation, the relationship of these two groups is evident.

Perhaps the most notable change in morphology is the change in mental attitude, and particularly in reference to the construction of phylogenies. I remember that at the early meetings of this Academy we were in the habit of constructing very complete and satisfactory phylogenies. We were sure just how one plant group descended from another. That is always easy when the facts are few; but now that facts are numerous, no one is able to construct a satisfactory phylogeny. No one imagines now that any living group has descended from any other living group.

Another marked advance is the change of mental attitude in connection with morphological work, in which morphology has clasped hands with physiology. I can only indicate some of its results. It has destroyed the old rigid categories. Botany was once largely an extensive system of terminology. Now we have passed from the days of terminology to the days of knowledge, and terminology no longer masquerades as knowledge. Not one of the old definitions has stood the test of experimental morphology. Experimental morphology has also helped to rid us of that old, Calvinistic notion of predestination in plant organs. Once it was thought that every primordium was destined to be one particular structure and nothing else. Now we know that a primordium may become almost

anything under appropriate conditions, and is not destined to be some particular structure.

One of the most interesting recent results of experimental morphology has been that obtained in experimental work on heterospory. It has been shown that it is possible to develop megaspores from cells that ordinarily develop microspores. It is such results that are playing fast and loose with our old conceptions of rigidity of structure and function.

I can merely mention the field of plant physiology. If I speak of the changes that have taken place within the last twenty-five years, I must show the atmosphere in which we are living by assuring you that I am not the one to make such a presentation. In the old days one man taught all there was of botany, and probably he taught all there was of science. Today I have been compelled to ask a competent plant physiologist concerning the notable changes. He tells me that there are two conspicuous changes in the point of view. One is the gradual passing of the old vitalistic idea, which implied that there was some such thing as vital force that explained most things. Now the facts are explained, not in terms of vital force, but in terms of chemistry and physics. Another shifting point of view is a change from the old idea that form and structure are the result of some mysterious law of development, to the idea that form and structure are entirely expressions of the conditions under which growth has been conducted.

The very new field of ecology at present is in the condition of these other fields more than a decade ago. Young fields are largely jokes to the older ones; but there has been a change in ecology during the last few years. It has passed from the stage of inchoate observation, in which instruction in ecology could not be differentiated with distinctness from a holiday excursion, to methods of precision.

In conclusion, as one looks out over this great progress, he finds that it is all really an inevitable evolution from the stimulus that was given first by Hofmeister in 1898 to morphology, and ten years later by Charles Darwin to biology in general.

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