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THE PRESENT AND FUTURE OF BOTANY IN AMERICA[1]

IF we go back a generation, say to the early '80's, we find up to this time most of the work published by American botanists was taxonomic. For some time before this, however, evidences of an awakening to other aspects of the science were evident and the next decade brought an extraordinary extension of botanical interest in other lines of work. Morphology, physiology, and especially cytology began to demand attention.

This was the period also when the government began to consider seriously the application of botanical science to the great agricultural problems of the country. Most of the agricultural experiment stations, date from this time, and it is unnecessary to point out the great influence which these have had in directing the activities of so many of the ablest workers in the field of botany.

As one looks back over this period of some thirty-five years one can not but be struck with the great increase in the number of botanical workers and the enormous number of publications recording the results of their work.

During the 70's and early 80's the opportunities for advanced work in botany, aside from purely taxonomic work, were very inadequate, even in our best universities; and students who were ambitious to avail themselves of the best instruction in botanical methods were almost perforce obliged to

[1] Presidential address of Professor Douglas H. Campbell, of Stanford University. Read before the Botanical Society of America at their dinner on December 30, 1914.

seek such instruction in Europe, and especially in Germany. The last decade of the nineteenth century probably witnessed the largest emigration of American botanical students to Germany. These men brought back German methods and German ideas, and undoubtedly these influences were on the whole of immense service to the development of science in America. However, it has sometimes happened that these foreign fashions, perhaps, have been followed a little too slavishly and the work of some of our foreign students might be criticized as somewhat lacking in originality.

In point of equipment and opportunity for research it may be asserted safely that at the present time, America can hold its own with any European country. It may be fairly asked, therefore, whether the accomplishment has been commensurate with the opportunities afforded.

There is no doubt that the quality as well as the quantity of work done in this country in the period in question has risen very much; and one could select a very considerable part of the work which will bear comparison with the best of its kind done abroad. But it must be admitted that the great bulk of the work is of mediocre character. It is perhaps asking too much to expect that all, or even a large part, of work of any kind should rise above the mediocre, and it must be confessed that much of the work published in the United States can not be considered to be of first rate quality. However, it is probable that the average here might be raised without undue exertion.

It seems to me that perhaps the principal cause of this mediocrity is the tendency to follow whatever new fad may come into fashion, instead of seeking for problems of one's own. We are, as a people, I think, more prone to adopt new fashions than are the more conservative inhabitants of the Old World. At any rate the past twenty or thirty years have seen the rise and decline of a good many botanical fashions, each one of which was all-important in its day.

Instead of a man's asking himself, "What am I especially interested in and what can I do most advantageously," the student usually through the advice of his instructor, is put to work on the latest thing that has come from Germany or France, sometimes before he has really mastered the fundamentals of the science. The results of such misdirected energy are naturally often unfortunate.

Another thing which may partly account for the rarity of work of the highest grade is the undue emphasis laid on the economic phases of the science. We Americans are preeminently a "practical" people and our achievements in applied science are notorious; is it that we are incapable of recognizing the supreme importance of pure science that accounts for our comparatively poor showing in the way of contributions to the fundamentals of science, botanical or otherwise?

It is not, however, with the past history of our science that I wish to deal, but with its present tendencies and the prospects for its future development. One who has done his work and made his mistakes may be, perhaps, permitted to criticize the present and make some suggestions for the future.

The equipment of our more important universities, as well as the liberal provision made by the government for scientific work, in connection with special private endowments for research work, offer ample opportunity to the man who would devote his life to a scientific career.

Unfortunately the very perfection of the material equipment may cause us to attach undue importance to the mere apparatus of research, and to minimize the value of

the man who is to use this elaborate paraphernalia.

I sometimes think that there is danger of our becoming slaves to our machinery. Life, alas! is too short to spend any unnecessary time in over-elaborate and complicated methods where simple and direct ones would answer every purpose. That much time is wasted in many laboratories through the employment of unnecessarily complicated methods, I firmly believe.

Another phase which I think has been overdone in America is the mania for standardizing everything. Elaborate systems of recording results are often so complicated as to be quite bewildering to the worker trained in old-fashioned ways, and he wonders sometimes at the very small output of work resulting from this imposing mass of machinery until he realizes that pretty much all of one's time must be consumed in keeping the machinery going.

While the standardization of science, like that of automobiles, may result in a good general average, and make for convenience and cheapness, it does not result in the highest type of work. The really big work in science must be done by men who are a law unto themselves. The highest type of original work can not be made to conform to fixed rules and regulations, and our American love of machinery and standardized methods is, it seems to me, detrimental to the development of originality.

A problem that is always with us is the question of teaching versus research, and how far the two are compatible. I think we must all admit that the teacher, at least in the university, should be an investigator. Indeed it is hard to see how a teacher who himself is not engaged in research can expect to inspire in his students a desire to become investigators. The vexed question of the relative importance of teaching and research can hardly be answered satisfactorily. Of course it is incumbent on every teacher to see that his teaching work is faithfully performed; but on the other hand the man who is capable of carrying on important researches and is willing to do so, has claims which every university worthy of the name is bound to respect.

So far as my own observation goes, it seems to me that the two are not incompatible, but I must also confess that it usually happens that whichever is the more congenial is likely to receive the greater attention.

I have very little faith in the assertion so often made that the time necessary for teaching is so great that no time is left for research. When one reckons up the time actually demanded of instructors in a well-equipped university and compares it with the time demanded of the average business or professional man, one must admit that the university professor has a very much greater amount of spare time at his disposal, which, if he really wishes to do so, he may devote to research. Too many of our teachers make work for themselves which is quite unnecessary and is a sad devourer of time, but which sometimes at any rate affords a convenient explanation of why they do not accomplish the great results which they would invariably do if only opportunity permitted. What a man wants to do most, he is pretty sure to accomplish, and if investigation is really what he is most interested in, he will find some means of doing it.

Of course, all men who occupy university chairs are not for that reason necessarily devotees of research, although I believe no man should be appointed to a university professorship who has not demonstrated his ability to advance knowledge in his chosen branch, and it should be expected

of him that his researches do not cease with his attainment of a professorship.

The excuse is often offered that the professor is frequently subject to interruptions which interfere with research work. I notice, however, that such interruptions are quite as often as not the fault of the man himself, whose sociable disposition or inability to concentrate his attention as well as the fatal tendency to "putter," eat up the time which ought to be devoted to investigation and which, if properly utilized, would soon show substantial results.

It is easy to find fault and criticize but when it comes to suggesting remedies for the future, the problem is a difficult one. First of all, perhaps, is getting hold of the right men, and next, after getting them, to see that they make the most of their natural talents.

In these days of commercial ideals when the value of everything is gauged by what it will bring in the market, and especially in this country where the opportunities for easy money-making are probably greater than anywhere else in this world, it is not strange that most of our young men become early infected with prevailing standards of values. One indeed must have a very strong love of science for itself to withstand the lure of the market place. To realize after years of hard work and expensive training that a man may in case he devotes himself to pure science have to serve for a lesser wage than is paid an expert bricklayer or carpenter, does not offer a very alluring prospect to most able and energetic young men. Nevertheless, if we are to develop men to do the highest type of work, we must in some way persuade them to take these chances.

Of course, before urging a young man to devote his life to a career at best pecuniarily far below what he might reasonably expect to earn in some other calling, we should be very sure that our youth gives something more than a vague promise that he is likely to accomplish something really worth while in the branch he has chosen.

This is perhaps our most difficult task. We all have seen young men, bright and alert, who are immensely interested in their investigations just so long as you set them the problem and superintend the work, giving from time to time the necessary suggestions and encouragement. The question is, will they devise problems for themselves and carry them through without some one at their elbow to give them assistance when they come to a difficult place.

It is very hard to recognize the men who have this initiative and with it the perseverance and resourcefulness which mark the born investigator; and I believe there *are* born investigators, just as truly as there are born poets and painters. You can cultivate the gift but you can not create it. How we are to discover our budding genius, however, and how we are to hold him when caught is another matter.

While undoubtedly there is much encouragement to be derived from the progress we have made during the past generation, still we may learn a lesson from this which may help us to direct the work of the next generation so as to yield still better results.

I can not but feel that we very much need to have the importance of pure scientific work as an end in itself strongly insisted upon. This I believe is one of our hardest problems. In the face of the constant demand for men trained in technical lines and the indisputable importance of the many economic problems that confront us, it is hard to make the average hard-headed young American see the beauty of science for its own sake. Our whole social system and modern trend of educational methods both tend to magnify the importance of

technical training when compared with education as an end itself. Every one can appreciate the value of making two blades of grass grow where before there was but one, but the man who makes new ideas sprout is too apt to be looked upon as a harmless crank, if indeed he is regarded at all.

It may be that a reform in our educational system is necessary. There are symptoms of a revolt against the extreme utilitarian views now current, and it is possible that we may see a tendency to return, in part at least, to the older educational ideals. There can be no question that greater attention paid to the humanities would encourage a love for pure science as contrasted with applied science. The student who has had a sound training in literature, history, language, and in the whole range of what we term the "humanities" will certainly have a broader outlook than the man whose training has been severely vocational. Such a student will be far more likely to appreciate the value of purely scientific work whose importance is to be measured in terms of intellectual satisfaction rather than in dollars and cents.

This, then, I believe, is one way by which we may hope to recruit the ranks of investigators in the higher lines of science. Another benefit which would result from a more liberal training of the majority of our university students would be a far greater appreciation of the results of such scientific work by men who are not themselves scientists. It may be hoped after we pass beyond the era of great accumulation of wealth that there will be a greater appreciation of the less material results of the higher education. Just now, it must be confessed, this era does not appear to be imminent.

Having secured our special man, our next concern is to see that his efficiency is developed to the utmost. While, of course, it is essential that our man must first receive a thorough training in the fundamentals of botany, when the time comes for him to venture on original research every effort should be made to discover where his special ability lies, and we should not try to force him to work along lines which are especially attractive to ourselves, should he show a strong bent for work in some other direction. Here is where the danger of trying to follow the latest fashion comes in. It is very likely that our student may have a very lukewarm interest in Karyokinesis, Mendelism, Mutation, or whatever the latest thing may be, and an effort to force him into these subjects contrary to his own preference may result disastrously.

Of course, in directing the work of students, and we might also say in the selection of our own subjects for research, we have to consider not only the importance of the topics, but also—and this is very important—their practicability. I do not mean by this that we are to look for easy subjects, but there are too many fascinating problems, such for instance as the physical basis of hereditary transmission, which from their very complexity seem almost hopeless of solution, although we can make no end of ingenious hypotheses, almost as many indeed as there are investigators. Such investigations are almost certain to be inconclusive and it is very questionable whether, in many cases, time devoted to these might not better have been dedicated to something more likely to yield more tangible results. In this connection it may not, perhaps, be impertinent to call attention to the very loose way in which much of the work now so popular on the problems of heredity is carried on. The tendencies to assume that the phenomena observed, in animals for example, are also immediately applicable to plants and *vice versa* has led to a great deal of inaccurate thinking and writing.

It can hardly be said that any special

phase of botany is urgently demanding attention or is being noticeably neglected; nor can it be said that there is not abundant material awaiting the botanist in pretty much any line he may choose. One might, however, urge that our botanists seek out problems for themselves rather than borrow them from our foreign colleagues. There are surely enough original problems awaiting solution at home to keep our botanists fully occupied. The United States with its varied flora and extraordinary range of conditions gives the American botanists a great advantage over their European colleagues, advantages which, perhaps, have not always been appreciated to their full extent.

The flora itself, even the vascular plants, is very far from being even fully catalogued and a wide field is open to the trained botanist for investigation of its distribution and relations. These problems of geographical distribution, and of the origins of the different floral elements of our country are full of interest and deserve much more attention than has yet been given them. The man who will write a compendious and well-balanced account of the distribution of the plants of the United States will deserve well of his botanical brethren.

While the vascular plants of this country have received much attention from the systematists and there are numerous excellent manuals dealing with them, the lower plants have not, perhaps, received a corresponding amount of attention. There is still room for handbooks dealing with most of the lower groups of plants, which can be used by the student to identify them. Perhaps more than anything else a manual of the marine algæ is needed.

Passing to another phase of taxonomy, attention may be called to the need for a radical revision of the classification of the seed plants. Perhaps the time is not yet ripe for this, but it is abundantly clear that the classification now in use is very far from indicating all the real relations. Among the Angiospermous plants, for instance, I believe it will soon be generally admitted that the present division into Monocotyledons and Dicotyledons is a more or less artificial one. It is very necessary that the lower and more generalized families of both Monocotyledons and Dicotyledons should be studied critically with a view to determining the relations of these to the more specialized ones. Any one who has done any practical work in this direction realizes the difficulties of the problem, but I do not believe these difficulties are insuperable. The work calls for much laborious research, often ending in negative results; but from my own experience, I believe that finally we shall arrive in this way at a much clearer understanding of the relations existing between the families of both Monocotyledons and Dicotyledons than we now possess, and that we may hope for a final clearing up of the relations of these two groups to each other.

It is to be hoped that our students of fossil plants by patient searching may finally bring to light material which will do for the Angiospermous plants what has been done by the brilliant researches of the past few years on the geological history of the Pteridophytes and Gymnosperms.

Just at present there is great interest taken in the question of the so-called "mutations" and much inquiry as to their real meaning and their bearing upon the origin of species, one writer—Lotsy—going so far as to claim that all new species originate as hybrids, a hypothesis which few would be willing to accept without many reservations, although there is no question that what are apparently good species have so originated in nature. This study of natural hybrids has been but little pursued in

this country and offers a very fertile field for investigation.

Another phase of the origin of new forms is one which opens up a large field for research and ought to yield valuable results. This is the study of the changes in naturalized plants. In all the older parts of this country there are very many naturalized plants, principally weeds, which have been brought from abroad and are mostly of European origin. Many of these must have been introduced very early in the settlement of the country, so that some of them have been subjected to new environmental conditions for a period of nearly three hundred years. This ought in some cases to have resulted in perceptible changes, especially as these plants have not been subjected to the same keen struggle for existence which exists in their native habitat, and sometimes at least, grow in their new home with a vigor that one does not see in their native land. It seems to me that a careful study of some of these introduced weeds in their new environment and a comparison with the same species at home ought to furnish some valuable data in regard to some of the factors concerned in the origin of new species.

Finally, a critical study of variation in our native plants and the conditions associated with these should be of value in this same connection. In California, especially, the variations within the species are sometimes very marked and make the separation of species extremely difficult. While some of these variations can be explained by the difference in the conditions under which they grow, this is not always the case, and undoubtedly there are marked individual variations which can not be so explained. Such studies made upon plants in their natural surroundings should be more valuable than those based on plants growing under artificial conditions.

What then is the present outlook for botany in America? Facilities are certainly not wanting; equipment and aids to research are equal to those anywhere, and there surely is no lack of material and of problems awaiting the right men.

Are we going to attract to our profession men of such capacity that the next generation is to win results commensurate with the opportunities furnished by this rich and generous country? Let us hope that we shall soon become educated sufficiently to appreciate the labors of the scientist apart from their immediate pecuniary value, and that the men who are endeavoring to extend the boundaries of knowledge shall receive adequate recognition. When this is true, I think we may count on adding able recruits to our forces, and these botanists of a later day will be no mere adopters of ideas borrowed from foreign sources, but will be original investigators in the truest sense of the word. These men will appreciate the wealth of material lying immediately to hand and the important problems of American botany will receive full attention. Of course, I would not urge narrow provincialism in the choice of subjects—that is as far as possible from my thought—but I mean that the investigator should seek inspiration from the sources to which he has immediate access and not get it second hand, no matter how illustrious the source of inspiration may be.

Only by this reliance upon himself by the investigator can work of the highest kind be accomplished.

DOUGLAS H. CAMPBELL

THE CARNEGIE INSTITUTION OF WASHINGTON[1]

NEARLY thirteen years have now elapsed since the foundation of the institution in

[1] From the report of the president, Dr. R. S. Woodward, for the year ending October 31, 1914.