

foundly, nor against emphasis upon special lines of research in different universities, but is an argument against permitting that special research to dominate courses that presumably are for general education in botany. As Schleiden in 1849 organized the general field of botany as an inductive science, we again need for general students a presentation of the fundamentals of the science as a whole.

There are many other factors that have to do with the efficiency of the product of our botanical teaching. We need more students who in their latter college years have definite purposes in mind—as teaching, research, practise of forestry, agriculture, etc. Possibly our teaching ought to enable them to discover purposes that will absorb them as do other college interests.

More fundamental, however, is the fact that we have been too content to assume without sufficient data, and to dictate regarding the nature of the needs of general instruction in our subject rather than to make the same sort of investigation in the field of teaching that we should make in our botanical investigation. If we can devise methods of making a scientific study of botanical education, we can improve our student-product.

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III. METHODS OF BOTANICAL TEACHING

As a past master in the art of cooking botanical hares, Dr. Bessey has spent most of his time in elaborating the recipe. To me, however, the problem seems peculiarly one of making sure of getting the hare and then of keeping it long enough to cook it properly. As I see the problem, it seems almost imperative that the hare should be caught in the high school. The chief difficulty in our getting material for turning into young botanists lies at this point.

High-school students, and especially the boys, are not attracted to botany; one might say they are not attracted by the kind of botany offered. More than that, and this may be the crux of the whole question, we fail signally to enlighten the parents of the boy as to the real meaning and place of botany. Botany will not attract the attention of the high-school boy unless it meets every-day conditions—unless it puts him in touch with his every-day environment in a way that is sympathetic as well as illuminating. Moreover, it is perhaps of equal importance to bring the public to understand what a fundamental place the knowledge of plants has in every-day life, and how important a part of education it is in consequence.

So far as the high school is concerned, we have the situation entirely in our own hands. Few of us can teach anything but what we have been taught, nor can most of us teach in any way but the one by which we have been taught. If you will look over the high schools of your state you will see that the kind of botany you are teaching is the kind of botany that is being taught in your high schools. It seems to me that few botanists realize this fact. It really means that we are actually teaching high-school botany to our beginners, for this is inevitably the botany that they will carry into the high schools. When we appreciate this fact thoroughly, we shall change our elementary teaching. When we do change it in a way to attract the sympathy of our students, then the problem of catching the hare, or at least of knowing the paths that he will follow, will be solved.

The next most advantageous point for catching botanical hares is upon entrance to college. This last year, in the University of Minnesota, the College of Arts graduated 265 bachelors—most of them maids. There were 195 of the latter and only 70

men. Out of the 265, thirty-five had taken a major in science; for many of the thirty-five, this meant but three courses in science during the whole college course. This tells definitely, it seems to me, of our failure to attract freshmen to science. This failure is largely our own fault. It is the failure of botany to provide a definite avenue to a position, such as is offered by courses in law, medicine, engineering, agriculture and forestry. The boy does not enter botany, because he knows of no such opportunity in it. There is no definite course set forth in the catalogue for the training of professional botanists, such as we find everywhere in colleges of agriculture, engineering, etc.

Our second failure, and the most significant one, it seems to me, is to hold our hare long enough to make a plausible instructor of him—to make even the beginner that Dr. Bessey has in mind, one who knows enough to find out what he must do to learn how to bud pecan trees. It seems to me the signal failure we are all guilty of in teaching elementary botany is the failure to catch the students' point of view—of realizing that it is what the student needs and likes in his own peculiar environment that must determine the method of teaching and the matter that we use. I can not see that the materials for our courses should be assembled, as they have been, from the standpoint of the professor, upon the obvious assumption that what the professor likes to teach the student is the best thing for him to learn. This seems to me the chief reason why we fail to hold students in any considerable number for advanced work. Naturally, this does not apply to the two or three universities which attract students from all over the country for graduate work. It concerns the majority of botanical departments, however, in which the hope of advanced students must

be realized chiefly from the beginning classes.

To become concrete, it would seem that the microscope is responsible to a very large measure for our difficulty. No hard-headed boy of freshmen age expects to carry a microscope around in his pocket throughout his life. He is interested in things that go and things that work, and I believe that we shall get his sympathy and interest and succeed in holding him for advanced work only as we give him what he wants and needs in this respect. Last year a freshman girl opened our eyes somewhat more widely on this very point. She was working with the germination of seeds in the greenhouse; after describing the steps in germination, she added naïvely as an afterthought, "the seeds we worked with were real peas such as you see on the table." The microscope has made the student feel that he is dealing with an unreal world, and that the plants we use in botany are none of them of the least importance in every-day life. Not only is the microscope far too special an instrument for the beginner, but this specialized tendency also permeates nearly all elementary botanical teaching. I recently encountered a sentence which will illustrate this fact. It is taken from a book which "is addressed to pupils in their first or second year in the high school." The sentence is the following:

The change from free parts of hypogynous flowers to union of parts as shown in perigynous, epigynous, epipetalous, sympetalous and synsepalous flowers, reaching the climax in the composites.

I find it difficult enough to get such ideas into the heads of college sophomores, with any real understanding of their meaning. In the case of high-school students, it indicates clearly that we are shooting far over their heads. While I admit that a good drill-master can make a student memorize

a statement like this, I feel that it is practically impossible to give him any real understanding of the many concepts in it, in any beginning course. We succeed in making our beginners feel, as a consequence, that botany is nothing but a lot of long hard names.

Now what is the remedy for the dearth of advanced students? In the first place, I recognize fully that we will hold students for advanced work only as we gain their interest and sympathy in the general courses. The test of our general courses in college botany must be—what does the student need, and what must he use in every-day life. To many of you this practical outlook upon the subject seems to be in conflict with what we call a scientific presentation. To me, scientific botany means presenting the important facts about plants from the standpoint of their every-day behavior and use, in a thorough, accurate and systematic fashion. While it is a time-worn truism to say that we must proceed from the known to the unknown, yet we must realize that no one ever succeeded in learning in any other manner. We must take the student in his every-day plant environment, set him to work puzzling about it, and point out the way by which he can solve his own puzzles. I think it is as unfortunate as it is illogical, that our education should be built upon the assumption that the early years are for memorizing, and the later years for reasoning. Until parents and teachers have stifled the spirit of curiosity, which is only the research spirit in an earlier form, the child is constantly reaching out for new experiences, asking endless questions, and taking endless clocks and dolls to pieces. I will admit that this spirit of inquiry has almost disappeared by the time the student enters college, but it can be fanned into an active flame again in many cases. Still

more important than this, however, is to find a way to keep it alive.

For the most practical of all remedies, we must give our attention to the difficulties arising out of the fact that the school year runs the wrong way around. If the student is to deal with live plants, with plants as agents and materials in every-day life, as he must to be interested and benefited, we must realize that these things can be obtained only by the most careful planning. We must not only find means for stretching the plant season at both ends, in the spring and in the fall, but much more important still, we must confront the fact that beginning botany can not be properly taught without adequate greenhouses, as well as gardens. The greenhouse means constant contact with the most interesting and the most useful plants throughout the whole school year. It lends itself readily to the task of bringing the student into touch with the uses and applications of plants in a natural way. Indeed, the most indispensable feature of real botanical study, that of independent first-hand work with the living plant, is hardly possible without adequate greenhouses. The every-day relations between man and plants are of vastly more importance than all of the other things that we teach under the name of botany. They will not only crowd to overflowing the two years of beginning botany, but they will fill up a large part of the advanced courses.

One of our most signal failures arises from our feeling that a record in the form of drawings or notes constitutes knowledge—that the record indicates that the student really understands what he is recording. Nothing is further from the truth; as a rule. The record has no value; indeed, it rather does harm, except to indicate to what extent the beginner observes correctly and thoroughly. As something to be

crammed for quiz or examination, it is downright pernicious; hence the formal record should be reduced to a minimum, and the real emphasis laid upon first-hand contact with live plants, correct and thorough observation, and independent reasoning.

Again, as botanists familiar with an enormous amount of detail, we try to make the college course in botany cover just as many things as possible. One can admit that it should do this in so far as it can, and still realize that it can do this in only a small degree. Nearly every course, and every text-book without exception, contains several times as much matter as the student can assimilate. Indeed, if we remember that we ourselves learn little except by experience and experiment, we shall see that this must apply much more forcibly to beginners in botany. For this reason I do not believe in text-books, or in lectures in any general course whatsoever; I would have none of them. This no longer seems to be a mere opinion, but the logical conclusion from actual and definite experiments in teaching botany. Listening to talks about plants can not lead to real learning in any sense of the word, and reading about them is in some respects worse rather than better, so far as the beginner is concerned.

I would replace text-book and lecture wholly by first-hand contact with plants. I would do away with all set quizzes and examinations, and make the student face the test of his work just as often as he faces the work itself. Moreover, even by this method, students can learn little by single contact. To take up a plant or a function or a structure once, and then to leave it, not only wastes time, but it also fixes an unfortunate habit. A tandem arrangement of materials and courses can never give the beginner real understanding.

Every course should telescope the one before it, touching the major points again and from different angles, broadening and deepening the student's knowledge upon a sure foundation, not upon the mere assumption that he recalls or understands anything that he has had.

To some teachers the universal remedy for lack of knowledge or understanding on the part of the student is what is called the intensive course. The latter has certain apparent advantages. One covers more ground, without question, and the student's handling of the subject matter seems a little more certain. The real test of an intensive course, however, can be made only by unexpected quizzes at intervals of a month or two after the course has been completed. Any one who applies such a test to an intensive course will need no further argument in regard to it. One who has applied such a test can not feel like giving any more time to discussing its value.

I wish to emphasize the point Dr. Bessey has made as to the need of using young botanists just as early as possible. We are now trying out a plan by which sophomores, who plan to specialize in the subject, are put in charge of small groups of freshmen in greenhouse work. The plan during the first year has proved much more successful than we anticipated, and it will be extended just as rapidly as possible. It has been a splendid thing for the sophomores, and it has not proved fatal to the freshmen.

I can not close without pleading that we make the teaching of botany a matter of experiment. We should be ecologists who study the student, the method, the matter and the results, both as to knowledge and to training, in an exact, quantitative manner. If we do this, we shall get rid of our loose opinions that for the beginner in bot-

any any method is as good as any other method, and that the results must be good because *we* have done the work. I feel sure that the use of experiment in connection with our methods of teaching, and the measurement of results will go a long way toward changing our present methods and improving upon our present results.

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DISCUSSION

Professor John M. Coulter, University of Chicago:

As Dr. Bessey says, some of us began botany a good while ago, when facts were so few that they were pieced out with enthusiasm, and our knowledge of the subject was chiefly enthusiasm; but now the facts have multiplied so enormously that it is a problem how to present them.

I have been in discussions of this kind for a good many more years than I should like to acknowledge. They have all sounded alike to me, but the thing I learn from them is this: that no matter how much thought we give to the technique of teaching botany, or how many devices we suggest as to methods of presenting it, a gratifying group of successful botanists continue to surmount all the obstructions we manage to place in their way. My definition of a successful teacher has long been one who places the fewest obstructions in the way of the student.

It is clear that we must encourage independence and originality in our students if they are to become investigators or only teachers. This attitude is appearing in the teaching of botany, for teachers are becoming more independent, and are thinking more for themselves. No teacher, however successful, has the right to prescribe for others a detailed method of teaching. It is only a stupid teacher who copies some other

teacher. Every one must have his own way, and if the text-book is the only way for him, let him use it; if he can do better without it, let him throw it away.

In brief, the problem is this. We are confronted by all sorts of suggestions as to teaching. Our subject has grown to be so vast and is still growing so rapidly that we know not how to deal with it in detail. There are just two general things that a teacher must keep in mind, and the details can be left to shift for themselves.

In the first place, there must be developed a general perspective of the subject. It is a vast plexus, and each of us in his own individual way must develop for the student some conception of the extent and interrelationships of this plexus we call botany, so that he may leave us with no narrow vision.

In the second place, in addition to the perspective, there must be developed what we call the scientific method, which is a certain attitude of mind. This is absolutely fundamental. There are many ways of doing this and every teacher has his own way of enforcing the training that demands the truth, and knows what it takes to reach the truth.

It is my conviction that any one cultivating this perspective and this scientific attitude of mind, by whatever detail of method they have been reached, is likely to prove successful in any form of botanical activity, whether it be teaching or investigating, with the scientific motive or with the practical motive. The details have become too numerous to include in instruction, but it will always be possible to train a spirit that will be able to master any details.

Professor F. C. Newcombe, University of Michigan:

I will say that I feel considerably cheered up since the last two addresses. No doubt