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Some of the Next Steps in Botanical Science

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SCIENCE

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SOME OF THE NEXT STEPS IN BOTANICAL SCIENCE¹

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WHEN one who has worked long in any field of science speaks before an audience such as this he is expected to say something about the condition of his branch of science when he began work with meager and poorly adapted apparatus, to contrast it with its greatly improved condition to-day, and to dwell with pride upon the finely equipped laboratories with costly apparatus especially designed for particular experiments, to be found by the twentieth century scientific student. And I must confess that the temptation to do so was one difficult to resist, for we who have grown old in years are fain to dwell upon the days of long ago with the garrulity which comes with gray heads and withering muscles. It has seemed to me wiser, however, that this evening we should look into the future rather than into the past, for in that direction lies the possibility of progress, and it is of progress that I wish to speak.

THE BOTANY OF YESTERDAY

Yet in order that we may properly orient ourselves with reference to the area covered by the science of botany to-day, we shall have to go back a few decades to understand what additions have been made to its territory during this period of expansion. For the shrewd observer can not avoid the conclusion that botany has shared with the world powers in a territorial growth which has extended its boundaries far beyond those known to the fathers, and

¹ Address of the president of the American Association for the Advancement of Science, Cleveland, December, 1912.

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we have annexed much contiguous and even some remote territory in a most imperialistic fashion. It may be comforting to some people to know that during all this time there have been those who have constantly and consistently lifted up their voices in protest against this contravention of the practise of the fathers, and the breaking down and removal of the ancient landmarks. In all these years there have been botanical anti-expansionists, but like their brothers in the national field they have been overwhelmed, and the tide of expansion has swept on unchecked.

Consider for a few minutes the botany of forty years ago, when you could count on the fingers of one hand the American colleges that had chairs of botany. And here I use the term chair advisedly, for they were literally chairs and not departments, much less laboratories. And everywhere else in the colleges of the country the chairs of botany were represented by what Holmes so aptly called "settees" from the number of subjects taught therefrom. The botany dispensed from these chairs was the delightful study of the external morphology of the higher plants, especial emphasis being laid upon the structure of flowers and fruits. And it may truly be said here that often the teaching was done very well, far better than many a botanist to-day is wont to imagine. I am pretty sure that in general the teaching was as successfully done then as it is now. There were some poor teachers then as there are now, and there were some inspiring teachers then who touched their pupils with the sacred fire, as there are now some who have had a divine call to teach and inspire and help.

And with this external morphology there was always associated the classification of the higher plants, in its simpler form the pleasurable pastime of identifying the plants of the neighborhood, and in its more advanced form represented by the

work of Torrey and Gray and Vasey and Engelmann. And we should judge the systematic botany of that day by the work of these masters and not by the diversions of its amateurs; and you will agree with me that so judged the systematic botany of that period will not fall short of any standard we have set up in these later days.

The botany of that day was not without its laborious investigations and its tangible results. Every new area was a great out-of-doors laboratory to be diligently studied from border to border. That was the day of the founding of many small botanical gardens, and small local herbaria, some of which having served their purpose disappeared long since, while others have grown into the great and flourishing institutions of to-day.

This much as to the botany of the immediate past; the phase of the science in which the older living botanists were trained.

PRESENT-DAY BOTANY

And what of the botany of to-day? Let us consider for a little the present condition of the science.

It is Unorganized.—The personnel of botany has greatly increased with the great increase in the territory it now includes. This personnel, it must be said, is still quite heterogeneous. Some of us are largely self-taught, so far as the major part of the subject is concerned. We brought to our work the results of the meager teaching of the old-time college class-rooms, and year by year we have enlarged the borders of our own departments as we have added to our own knowledge of the subject by means of our laboratories and libraries. Thus we have built all kinds of superstructures upon the foundations supplied by our teachers. As a consequence the science is yet largely unorganized and lacks consistency in plan and

purpose. Here and there a dominant man has wrought out a scheme of the science for himself, but how familiar is the fact to all of us that there is yet no agreement even upon so small a question as to the content of the first year of college botany, or the mode of its presentation. There is moreover a vagueness as to the boundaries of the science, some botanical teachers wandering far across the border into the domain of some contiguous science, or still more commonly into the more or less practical applications of some portions of botany. This latter indiscretion is especially noticeable in the textbooks prepared for the secondary schools, in some instances by botanists of good standing. If this were done by the agriculturists, the agronomists, the horticulturists, the foresters and others in similar lines of work with plants, it would not be surprising, but when this is done by botanists it is significant of the unorganized condition of the science. With a fuller knowledge of the science there must come a clearer vision of what it is, and what it is not, and we shall no longer find textbooks of botany made to include so much that is not botany, while leaving out so much that is botany.

This difference of opinion as to what constitutes botany results in the absence of united effort. In its simplest aspect it takes the familiar form of uncertainty as to the content and value of the work done by the student elsewhere when he transfers himself from one college to another. As a matter of fact there is yet no agreement as to what is a standard first-year's course in college botany. What teacher has not been sorely puzzled to know to what courses to admit men who came from another college with credits in botany! It is quite unscientific to try to account for this condition by an excusatory reference to the individual peculiarities and the per-

sonal differences of the teachers. In science we consider the personal equation as something to be determined and eliminated, and not to be excused and tolerated. Every difference in the treatment of, say the first-year course, is just so far an indication of a more or less unscientific attitude by one or all of the teachers concerned. We work in this haphazard, disconnected way either because we do not know any better, or knowing better we think it not worth while. Either horn of this dilemma is equally unworthy of our acceptance. Ignorance is no valid excuse for the scientific man, and in science everything is worth while. It is to our shame as botanists that we acknowledge our inability hitherto to frame a standard first-year course in college botany. When the science is definitely formulated in the minds of botanists the present disagreement will no longer exist. Surely we now "see as through a glass darkly."

The Applications of Botany.—Again, it may be remarked that we are to-day placing great emphasis upon the applications of botany to some of the great human activities, especially to agriculture. Witness the agricultural experiment stations with their botanists of all kinds, from those who study weeds and poisonous plants, to the physiologists, pathologists, ecologists and plant breeders. And as we look over the work they do we are filled with admiration and pride that they have individually done so well. But it is not the cumulative work of an army of science, it is rather the disconnected, unrelated work of so many individuals. They are doing scientific work in an unscientific way. There is as yet no movement of a united army of science; it has been rather a sort of guerrilla warfare against the common enemy. We lack organization, and like unorganized soldiers we make little headway in spite of

individual learning and efficiency. Botanical science which should have guided and directed these laudable applications has not kept pace with them, and we have the spectacle of these economic botanists, physiologists, pathologists, plant breeders and others working apart from the botanists proper, and sometimes even disclaiming any allegiance to the parent science. Nothing but confusion and disaster can result from such a condition.

Lack of Cooperation.—Contrary to what is sometimes affirmed, botanists are still studying the flora of the country. In some quarters there has been expressed the fear that field botany has disappeared from the schools and colleges; but this is far from true. While it no longer claims the larger part of the student's attention, it is still an essential part of the training of every botanist, and it is probably true that in some cases there is even more field work required to-day of young botanists than its importance demands. Certainly in one kind of field work I should like to see some of the energy and ability now given to the discovery of means for splitting old species turned towards the solution of problems pertaining to growth, and development, and reproduction. But the careful field study of what plants grow here and there, and why they do so, is greatly to be commended. The sociology of plants, or as we call it, ecology, has given in the last few years a new reason, as well as a new direction to field botany.

The systematic botany of to-day continues to concern itself more with the distinction of species than with their origin, and this has brought to this department of the science an increased narrowness which has greatly injured its usefulness. On the other hand plant breeding, which should be the experimental phase of systematic botany, has had no connection with

it. And strangely, systematic botany, which should welcome plant breeding as an ally in its quest as to the meaning and origin of species, has been scarcely at all interested. It has been left to the florists, the horticulturists and the agronomists to patronize the new phase of botany, and this they have done, in spite of the new and quite unnecessarily formidable terminology so rapidly developed by the breeders. So what might have proved to be one of the most helpful aids to the solution of the greatest of biological problems—how living things have come to be what they are—is allowed to fret out its life by beating vainly against the technical bars of its Mendelian cage. I know of no better illustration of the unorganized condition of botanical science than this failure of the systematic botanists and the plant breeders to work together for a common end.

THE BOTANY OF TO-MORROW

But I have dwelt enough upon the past and the present, and I feel inclined to apologize to you for having turned your faces so long backward. For while we must consider what has been, we can make progress only by planning for what is to be. So let us turn now to the future of botanical science, and endeavor to trace its more profitable course of development during the next one or two decades. What are seemingly to be the demands of modern society upon this science? What are to be some of the next steps in its evolution? For whatever we may say in regard to the independence of science we can not escape the fact that it must serve its "day and generation." No science can hope for support or recognition that does not respond to the demands of its age. And yet we must not ignore the labors of those pioneers in every science who foresee possibilities that are hidden from the mass of men.

There must always be place provided for the few seers who see to-day what is now hidden from mankind in general, and may continue to be so hidden for generations, or centuries. All honor to these prophets who prepare the way for the oncoming of scientific truth, but it is true, nevertheless, that it is only when such truth has permeated contemporary society that science thrives.

Its Content.—Looking forward, then, let us try to see the trend of that branch of science which deals with plants, the science which I have the honor of representing on this platform this evening. And my first inquiry may well concern itself with the content of botanical science in the immediate future. As we become better acquainted with it and recognize more clearly its relations to the activities of the community we shall be able to define its proper content with more accuracy. And let no man attempt to belittle the importance of such an undertaking. It is not useless to attempt to fix the boundaries of any field of human endeavor, especially in such a one as this which deals with so vast a number of individual objects, each having many possible relations to one another and to ourselves. I am well aware of the impossibility of absolutely delimiting botany from every other science, and especially of doing so with reference to many of its applications, and I am fully aware of the fact that the limits of any science are subject to change with the progress of human knowledge. Now and then there must be a "rectification of the frontier" in respect to the boundaries of a science, as with the boundaries of a great empire, as its farther provinces and the exact location of rivers and mountain ranges become better known. So without doubt we shall have to add to or subtract from the area now allotted to botany; and yet I feel that it is worth our

while to spend a little time in indicating its present boundaries and content.

With all the details that may be insisted upon by some specialists it still is true that the field of botany may be considered in three parts, structure, physiology and taxonomy. Beginning with such structures as are obvious to our unaided eyes we have carried our studies to the minute structure of the tissues, and the cells which compose them. We are able now to peer into the protoplasmic recesses of the living cell, and while we can not say that we have seen life, we have seen where life is, and what it does. Cytology, histology and morphology in our modern laboratories have greatly changed our conception of the structure of the plant. It is no longer made up of forms to be compared because of their general similarity of outline, or of position in the plant body. The plant as a whole is a community of variously differentiated living units, just as is each of its organs. It is a complex community in which there is a measure of individual independence of the units, along with much of mutual dependence.

This leads me easily to that portion of the field of botany that has to do with the activities of plants and their organs—physiology—whose scope has been so greatly extended in these later years. Here such inquiries as those pertaining to nutrition, growth, sensibility, reproduction are of primary importance. The introduction of the experimental method of inquiry has made this a favorite department of the science. Who does not enjoy catching a plant, tying it up in a corner and compelling it to do something, while we watch for the result? This kind of study appeals especially to those who are looking for demonstrations, and for this reason plant physiology has been increasingly popular. Some botanists indeed have gone so far as to insist upon

giving first place to physiology, probably because of its ready appeal to our senses. It is easy to interest a boy in the thing that responds, whether it be a kicking frog stimulated by an electrical discharge, or a green plant whose stimulation is a properly directed beam of sunlight. And yet it is well for us to remember that the plant is first of all a structure, whose complexity may well challenge the most acute minds. We find it far easier to record the responses of plants to our planned stimuli than to unravel a structural complex, and so no doubt we shall continue to entertain ourselves and our students with what are too often futile experiments.

In this part of the botanical field are pathology, which grew up from our observation that organs may not respond normally; ecology, which developed from the observation that plants tend to live in communities; and phytogeography, having to do with the means for and the results of distribution. There are signs that for economic reasons pathology may become rather sharply set off from physiology, of which it is properly a part, much as through the zeal and enthusiasm of the ecologists there was once the suggestion of a physiological schism. The latter is happily no longer imminent, and it may be hoped that it will not again threaten the unity of plant physiology. And so it may be hoped that the pathologists will not wholly secede from association with the physiologists.

Taxonomy, or as we used to call it, classification, occupying the third division of the field of botany, long received the almost exclusive attention of botanists. And even to-day it is the pretty general opinion of our non-botanical friends that we are constantly employed in collecting specimens, and in some intricate and mysterious way determining their classification and affix-

ing to them their proper Latin names. And it must be admitted that every botanist does a good deal of just such work, quite as every chemist makes many analyses, and tries to arrange in orderly sequence the chemical substances which he has in his cabinet, and the astronomer classifies and names the heavenly bodies with which his science deals. At first even the botanists knew but few plants, just as now most men know scarcely more than a score. But as the botanists came to know a larger number of plants, it was imperative that they should be named, and then grouped conveniently for easier reference. Thus arose such crude, primitive classes as herbs, shrubs and trees, which served their purpose until the numbers became too great again, when additional structural differences were brought in to help separate the large numbers into smaller groups. This was the earlier classification, based upon structure alone. It was taxonomy without doubt, and it was helpful, since it enabled us to arrange plants in an orderly fashion, but it ignored the fact that plants have ancestors, and that the plants of to-day are what they are through their inheritance of ancestral characters, accompanied by modifications peculiar to them alone. When, however, the doctrine of evolution came into botany it brought with it the idea of descent, and thereafter taxonomy included phylogeny. To-day the taxonomist is no longer content to stop with a knowledge of the structural differences between plants; he must know how this structure arose from that; he must know which is the primitive structure and which the derived. Phylogeny has so far entered into taxonomy that it has given new meaning to the work of the systematic botanist, and it is bringing into this department of the science something of the philosophical aspect which was nearly

wanting heretofore. That this must be the direction of the development of the taxonomy of the future is without question, and we may look confidently for a marked expansion and enlargement of the phyletic idea in botanical taxonomy.

And here I may pause for a moment to advert to a part of taxonomy with which some biologists have little patience, without good reason, as it seems to me. I refer to the matter of taxonomic nomenclature which has vexed the souls of many botanists, especially during the past one or two decades. However, since every science must have its nomenclature it is childish for us to wish to ignore it in botany. It is a part of the science, and we must give it consideration if we are to do our full duty. I have been surprised many times when men have spoken disparagingly of the whole matter of nomenclature, and of those who are giving time and effort to its stabilization. While it may be granted that not every botanist is in duty bound to help to settle questions of nomenclature, or even to take part in framing the general rules of procedure, it is the duty of every one to appreciate and encourage those who are so engaged. It has sometimes seemed to me as I have heard wholesale denunciations of nomenclature and nomenclaturists that instead of being botanists we are only cytologists, morphologists, physiologists, pathologists, ecologists.

This contempt for nomenclatural questions is symptomatic of a much-to-be-deprecated state of mind, quite too common among scientific men, especially those who have engaged in special lines of work. I believe in specialization in botany, but specialization should not degenerate into narrow bigotry. A wise man long ago admonished his friends in words which I am tempted to repeat here as most fitting:

But now they are many members, but one body. And the eye can not say to the hand "I have no need of thee"; or again the head to the feet, "I have no need of you." Nay, much rather, those members of the body which seem to be more feeble are necessary; and those parts of the body, which we think to be less honorable, upon these we bestow more abundant honor, and our uncomely parts have more abundant comeliness; whereas our comely parts have no need: but God tempered the body together, giving more abundant honor to that part which lacked, that there should be no schism in the body, but that the members should have the same care one for another.

Wiser words of counsel for the workers in different parts of the field of a science were never written, and I beseech you, my botanical brethren, to heed them, "that there should be no schism in the body" of botany.

Personality of the Botanist.—Quite easily the foregoing leads to a consideration of the personality of the botanist of the immediate future. What manner of man will he be? What will be his training? In other words, what will the future demand of the botanist? For it does not need argument to show that the men engaged in botanical work in the future will be developed and fashioned in response to the demands of the community.

If I interpret aright the movement of modern society as a whole, it is going to result in a demand for two things that by many are thought to be opposite and antagonistic—specialization and breadth. The first it will demand of its experts, the men who are set aside to solve particular problems for the community. In most cases these will be economic problems of immediate importance to the community, but there is no reason why in the most intelligent communities they should not be scientific problems, of more remote importance. No doubt there will be a demand for many such experts, each of whose tasks will be

restricted to but one problem. The only requirement laid upon these men will be that they can do the work to which they have been assigned, and the more restricted the problem the narrower may be the preparation of the expert. Such men will be demanded in increasing numbers by the scientific bureaus of the general government, by the state experiment stations and by large private establishments engaged in beet growing, cane growing, fruit growing, potato growing, hop growing, etc., and it will be the duty of the teachers of botany to produce an adequate supply of such botanical experts.

But while the community is certain to increase its demand for botanical experts we must not overlook the fact that with this demand will come another, much more imperative, for men of far greater breadth and depth of knowledge, who in addition to training the botanical experts of various kinds for the community, are able to bring the science as a whole before the youth of the land as a part of the scientific culture which modern society requires. These must be men of the broadest training; men whose sympathies are not bounded by the one science which they know, much less by one phase of botanical science; men who, knowing well their one science, know also much of the related sciences; men who in addition to a knowledge of science bring to their students and their community the results of that broader view which relates botany to the life and activities of the community. Such men bear the name of botanists worthily, and justify the contention of scientific men that science may contribute more than material good to the community. These are Lord Bacon's "Lamps," and "Interpreters of Nature."

And my vision is by no means unrealizable. Already among botanists there are those who measure up to this ideal.

Already there are those who to a wide and deep knowledge of plants add that breadth of culture that brings them into sympathetic relations with the company of scholars throughout the world. As I speak these words there will come to you the names of those of our number who are known and honored as botanists, but whose beneficent influence extends far beyond the limits of their science. And I am confident that this high standard, now reached by some, will be demanded for all by the community of the future. Such botanists will be the leaders of their students, guiding wisely their early steps in science; they will be the leaders of the experts whose results they will be able to relate to other parts of the botanical field; and they will be the leaders of the community, not only in the applications of botany to the solution of material problems, but in a larger and nobler manner they will be able to help them in the higher things that make for culture and spiritual uplift.

The Teaching Institutions.—Turning now to the institutions of learning—the colleges and universities—where botany holds a place as one of the sciences, let us ask what we may look for in regard to its development. In every proper college the department of botany exists primarily for its teaching function, and this is true also for nearly every university. And while we may hope to make every such department a center of investigation also, it is true now, and it must always be true that in our educational institutions the teaching of the science must be the primary object of every one of its scientific departments. So the future will call for much more of definiteness as to the content and sequence of the science, as well as the manner of its presentation; its pedagogics, if you please.

The college and university departments of botany in the near future will arrive at

a clearer notion as to the essentials of the science as a subject of study. It seems to one who carefully looks over the field that there is often only the most vague notion of the relative importance of the known facts in regard to plants, those of trivial importance receiving as much weight, perhaps, as those of profound significance. Especially is this true of the more elementary courses, in which there is also the greatest diversity in the presentation of the subject matter. This condition argues incompleteness of knowledge either as to the science as a whole, or as to its pedagogies. We have all heard the excusatory remark that "it makes little difference how or where we begin the study of plants, and in what sequence we pursue it." Yet none of us would admit such a contention in regard to any other matter. The more we know of a country, the more definite are our ideas as to what are its more important mountains, rivers, cities and institutions, and it is these that we feel the traveler should see. We particularize when we know; we generalize, and are vague, when we do not. It should not be long until this vagueness and doubtfulness as to substance and manner in the presentation of botany in the high school, and in the college, and in the university, will be a thing of the past. In the near future we shall certainly have the lower work clearly defined, as it is in mathematics and language, and on this the higher work will be based, to the great saving of the time and energy of teacher and student, now needlessly wasted. And I appeal to you, botanists, to take up seriously the task of so arranging and coordinating our work that botany shall no longer suffer the reproach of being the most chaotic of the primary sciences. Do not tell me that we can not agree. *We must agree.* If we know our science sufficiently well we can easily discern the more important parts. Let him

whose knowledge is too limited to enable him to see over the whole field step aside. Let him who has no adequate perception of the pedagogical aspects of the problem step aside. Then let the select few make a pronouncement, subject to periodical revision. This is the way that scientific men should settle the question. This is the way it will be settled some day, in the not very distant future.

The Botanical Stations.—But the college and university departments are by no means all that are engaged in botanical work. Within the past twenty-five years many stations have arisen in which botanical investigations are made. Under various local names they are in fact "investigation stations" and while their results have not been uniformly reliable it is a most hopeful sign of progress that they exist at all. Foremost among these are the fifty or more agricultural experiment stations to which I have already briefly referred, with assured support from the states and the national government for all time to come, in which botanical investigation forms no inconsiderable part of the work undertaken. Hampered as they generally were in their earlier years by incompetent direction, and often by still more incompetent workers, it is gratifying to know that year by year there has been marked improvement in both, and that now many of the directors are men of such scientific training that they wisely use the means at their disposal for investigations of permanent scientific value. And if I read aright the tendencies in these stations, it will not be long until their scientific output will be wholly reliable, as indeed it is now in some cases. This condition will be fully realized when these stations are wholly under the direction of men of broad scientific training.

And here again we have a duty to perform. We must recognize the agricultural

experiment stations as permanent parts of the botanical equipment of the country. They will be with us in the future, and their results will continue to be added to botanical knowledge. We must accept them as a part of our scientific equipment, and help to make them more efficient. It will not do for us to stand aloof, and decri their results as not accurate, and as agricultural instead of botanical. When we fully realize that we have in these experiment stations so many institutions of endowed research, we shall not hesitate to welcome them to the ranks of science. The fact that these researches in regard to plants so often have an economic purpose does not lessen the value of the results to the botanist of broad training and sympathies. Here again we must remember that as botanists we should not undervalue those contributions to knowledge in which we happen not to have an immediate interest. My scriptural quotation of a few minutes ago might well be repeated here: "the eye can not say to the hand 'I have no need of thee,' or again the head to the feet 'I have no need of you.' " When they receive the hearty cooperation of the botanists of the country the agricultural experiment stations will develop into centers of investigation of the greatest importance to science.

Already we have stations for the study of plants under particular environments, as our seaside stations, our mountain stations and a single desert station. I take it that these are suggestive of what are to come in the future. Instead of trying to make seaside conditions away from the sea, we go to the sea and there set up our laboratories. So when we want to know how plants behave in the desert we go to the desert. And this is no doubt to be the direction of botanical investigation. We are going to study plants under their natural environ-

ment, and to the seaside laboratories we shall add (as indeed we have already to a limited extent) lakeside laboratories, riverside laboratories, swamp laboratories, forest laboratories, field laboratories. Already the tropical laboratories, in Java, Ceylon and Jamaica have justified themselves, and no doubt to these we shall soon add arctic and tundra laboratories. All this signifies that more and more we are going to see what the plant is doing in its natural environment, and then we can undertake intelligently to watch it under a changed environment. So the future is to witness a great increase in the number of these laboratories, and how far it will go can only be conjectured. It now appears probable that eventually every botanical department will have one or more of these environmental laboratories in which work may be done by advanced students. They will take the students out of doors, as the old-time systematic botany took them out, but these students will go equipped with thermometers, psychrometers, anemometers and balances, instead of vascula and plant presses. Thus we shall again go afield, but on what a different quest! The old-time botanist in the field was mainly concerned with the question of the specific identity of each plant he found; the botanist afield in the future will ask what the plants are doing under this or that environment. He will not neglect the earlier question, in fact he must have that answered, but that answered he has still his main question before him. The work in the field laboratories must necessarily be of the kind now called ecological, and so as I see it the botany of the future will have much more of ecology than is common to-day.

Yet when we think of these botanical stations whose laboratories are taken afield, as it were, we must not suppose for a moment that the old-time laboratories on the uni-

versity campus are to be abandoned. Far from it. As the work in the field laboratories is enlarged there will be still greater need of the far more exact work that can be done only in laboratories where every factor can be perfectly controlled. There will still be need, greater need I might say, for perfectly constructed plant-houses in which we may observe plants under controlled conditions, and where we may increase or decrease this or that factor at will. I emphasize this point because there are some who prophesy the eventual abandonment of the precision laboratory in botany, when in fact everything points to the opposite conclusion.

Another kind of station, of which we have now only the beginnings, is one which will carry the results of plant breeding into the domain of phylogeny. Of this we have now some faint suggestions, which must grow into far reaching results under the direction of men who know more of the subject than we do now. It may be that such stations will then, as now, have a strong economic bias, but this will not so narrow them as to exclude the phylogenetic aspects of the work they are doing. In such laboratories we shall be able to see how evolution has contributed to the present wonderful diversity of form and size and color and habit among related plants. Such laboratories will enable us to answer the demand formerly so often made, but less often heard now, for a demonstration of cases of actual evolution. Although such cases are well known to botanists, their occurrence has hitherto not been such as to admit of easy citation for purposes of popular demonstration. So I regard the breeding laboratories of the future as welcome additions to the means of demonstration which science will possess.

Unity of Action.—Allow me to look once more into that future which holds so much

of promise for botany. I am assured as I consider the trend of scientific thought that there will be greater unity of action among the botanists of the country. At present we are still in the guerrilla stage of botany, in which every man acts independently and for himself. And it must be admitted that much effective work is done by guerrillas in war and in science, but in both there is far too much waste of energy. Let me pause a moment to explain more fully what I mean by this guerrilla condition in botany. Although we profess to be botanists acting for the best interests of science, we have actually no uniform standard by which we may measure our actions. In one particular we have tried to set up a standard, in certain international rules pertaining to nomenclature: and yet after several congresses of botanists we have the humiliating spectacle of a set of laws that nearly everybody disobeys! In other matters also, every man does as he pleases; and the worst of it is that he vehemently defends this free, untrammelled mode of action. We have been guerrillas so long that we resent the suggestion of conformity to any regulation.

Brethren of the ancient order of botanists, this is scientifically quite unseemly. We must cease this personally independent, but disorderly life, and enroll ourselves in the regular army as good soldiers who will obey orders, and who will act in unison for the common good. And this is no illusory vision. It is one of the things that the future will bring us, yes, I may say, is bringing us. For already we find the beginnings of a reduction of some of the disorder in certain fields of work. In the management of the work of the agricultural experiment stations there are hopeful signs of a healthy progress. Certain officers in Washington, having general supervision over the stations, seeing that there is much useless

duplication, have begun suggesting more harmonious planning, one station to emphasize this line of investigation, and another that line, instead of working quite independently of one another. This beginning is suggestive of what might and should be done elsewhere.

And we shall not confine unification and coordination to investigation alone, but will carry it into the teaching departments. As a matter of course the more general aspects of the science must find place in every college department of botany, requiring to this extent the quite legitimate duplication of the best laboratory and other facilities that can be provided. But beyond this the duplication should cease, especially of facilities that are costly in installation and maintenance. When we fully reach a condition of scientific sanity we shall agree upon such a program as will assign particular fields of work to those institutions that are best able to care for them, and it follows that students will be sent to these for such specialties. In the case of the state institutions there is already the beginning of the attempt to reduce needless duplication—in some instances crudely and awkwardly, it is true—but the significant thing is that there is already an attempt to reduce duplication. Which suggests that “the children of this world are in their generation wiser than the children of light.”

This is not the place for the discussion of the details of the educational cooperation which is coming—a cooperation which will result in a conservation of educational energy. As the details are needed they will be worked out, but I may be permitted to suggest that in the near future we shall reach a solution something like the following:

(a) That the small colleges shall provide a standard course in general botany, with adequate facilities as to material and apparatus.

(b) That the larger colleges and universities shall provide an identical standard course for those of its students who have not pursued this subject in the small colleges, and to this they will add certain advanced, also standardized, courses, requiring facilities beyond the reach of the small colleges.

(c) Then will come, especially in the state-supported schools, such advanced courses as are required by the nature of the institutions, and the needs of each particular state; as the study of useful plants, noxious plants, local systematic botany, dendrology, pathology, etc.

(d) Last will come a division of labor with regard to the more profound lines of research and teaching. Certain favored institutions will place especial emphasis upon minute anatomy (cytology and histology), or special morphology, or physiology, or plant breeding, or ecology, or phytogeography, or special taxonomy, or general and experimental evolution, or botanical history, etc.

These suggestions are not chimerical. They are indicated by the recent trend of scientific thought, which recognizes more and more the value of the conservation of human effort. And as I look into the future a vision rises before me of the scientific army, working harmoniously like well-drilled soldiers, and not wasting their strength by turning their guns on one another. In this army of science I see a company of thoroughly disciplined botanists who in orderly fashion plan their campaign. And, from the many doing severe garrison duty in the small colleges, to the heavy artillerymen in the big university fortifications, and the few isolated scouts along the frontier of special investigation, all are actuated by a common spirit of scientific patriotism and loyalty.

This, my botanical brothers, is what the

future is bringing us—a united, harmonious body of trained men, whose endeavor is to carry forward the banner of science, not for personal advantage, but for the glory of the science to which we have dedicated our lives.

CHARLES E. BESSEY
