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BOTANICAL RESEARCH[1]

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THE advancement of human knowledge should be regarded as a worthwhile and praiseworthy effort. Those lines of learning which concern themselves with an understanding of the world in which we live have contributed directly to the welfare of the human race. In this field botany has occupied a worthy place along with the sciences of zoology and geology, and more generalized subjects, such as geography and climatology. To understand and control the environment man must have developed the sciences of physics and chemistry with the help of mathematics. But man has lived successfully with little or no knowledge of the latter sciences and possibly with only a very limited and practical knowledge of zoology and botany, a knowledge in this field comparable only to that possessed by any herbivorous or carnivorous animal. But even uncivilized man soon began to use plants as medicines and charms and to recognize or ascribe special properties to the various species. This very meager beginning was about as far as human knowledge had progressed in eons of time before modern science was born. As Ortega has so brilliantly pointed out, modern science in the sense of physico-chemical knowledge of processes is the newest thing in the universe. In time it extends back barely a hundred years. In space, likewise, science is one of the rarest things in the universe, for it touches only a small part of the earth's surface and a small part of the world population, and Ortega asks: Can a thing so rare and so new be also ephemeral; can it drop out as quickly as it came in?

Beginning with the herbalists, who sought cures for human diseases, the interest in plants grew and a beginning was made in classification and in making a

[1] Address of the retiring vice-president and chairman of Section B—Botanical Sciences, American Association for the Advancement of Science, Boston, December, 1933.

great inventory of the world's plant resources. This work was hardly well under way when it became evident that we must have a morphological basis for classification, and plant morphology quite naturally developed. Then began the study of the function of plants, and physiology also was given an early start. Morphology and anatomy had in the detailed phases to await the physical development of the microscope, while physiology could not proceed without physics and chemistry. Naturally enough, generalized subjects like plant ecology were begun before the other subjects had become recognized as such, and many of the earlier studies belong in this field.

Great progress has been made along all lines, but one is astonished to see and hear statements that our science has progressed too far and that in the interest of the race it could well be temporarily set aside. This is particularly true in the field of practical plant production. I do not wish to take this opinion too seriously, but to use it as a starting point.

It seems that the most rapid and really substantial advance in botanical knowledge and general interest came at the time our systematists were busiest searching out new plants. The beginning studies in botany brought to the student a desire to know the plants in the field and to note differences and similarities. With the great principle of evolution to vitalize or energize the comparisons, this meant to each student that every bush, every tree was a challenge to his or her meager knowledge, and that the plant, if unknown, was taken and treasured until it could be classified and named. Although few students were studying botany in those days, and although laboratories with equipment were almost wholly lacking, still almost every student had sufficient knowledge to make contact with plants in the field immensely interesting and a great mental stimulus. Saturdays and Sundays were spent in botanizing, and the vasculum brought in new flowering plants and ferns, and even mosses, lichens, fungi and algae, to be worked out in the laboratories, and classified and named. A few of the advantages which this type of botany has over the ordinary microscopic presentation are that it can easily be continued after the student has left the classroom; that it naturally leads to an interest in floriculture, horticulture, forestry and the other applied lines; and that it is not detrimental to the added interest in physiology, morphology and genetics.

But this tremendous interest has been largely killed. Beginning courses in botany must deal with more fundamental things than the names or classifications of plants, whatever one may mean by that most abused word—fundamental. The smaller and more difficult the demonstration is, the more "fundamental" the facts dealt with. We must study the protoplasm and above all develop microscopic technique, as well as study osmosis, turgor, respiration, photosynthesis and the alternation of generations. I do not wish to condemn these courses, but merely to point out that a student so introduced finds little in the out-of-doors to stimulate his interest. All leaves, as far as he knows or cares, have the same leaf structure and the same process of respiration, transpiration and photosynthesis. What thrill could one so trained obtain by comparing a buttercup and a poppy or a lily and a grass flower?

The high schools, like the colleges, have largely abandoned the older natural history approach, and the systematist is not allowed by the curriculum to come in contact with the mass of the student body. To the speaker this means that a large number of students live in a plant-world utterly oblivious to the variety of form and color, to the enticing satisfaction of knowing by name some of the more common and interesting plants of the region. The average European is interested in plants and knows the names of many of them. It's the exceptional American who is interested enough to know the name of a single plant, and trained botanists often boast of their complete ignorance of plant names and a knowledge of the system upon which the names are based. General interest in plants would be enormously increased by the proper presentation of work in systematic botany in either the high school or freshman university classes. Hundreds of boys and girls, with a little encouragement, would be collecting and sending in plants to be named if botanists had time or inclination to name the plants for them. And it is to this general interest that we must look for public support of research and, in the end, for private support as well.

Some of our older botanists were masters in stimulating interest, and the beginner who collected the most common weed was made to feel that it was very worth while to know the plant, where it came from and something of its ecological history.

The fields of systematic botany and directly dependent fields, such as plant geography and plant ecology, as well as plant introduction, forestry and range investigation, are by no means exhausted. They probably never will be. But to find states with the flora still not covered by a manual, to find many groups of plants here in our own country for which no even approximately accurate names can be secured seems almost inexcusable; unless we remember that we as botanists have probably been directly responsible by assuming the greater importance of other lines of study. That would not be so bad, but in many cases botanists have done all they could to actually discourage work in taxonomy. The geneticist, the morphologist, the cytologist and the chemist may contribute greatly to a thorough understanding of the relation-

ship of plants, but they can not replace the systematist in painting a picture which can be seen and interpreted. It is impossible to complicate the work of the systematist with all the details of these contributing lines, and the Linnean species is a general concept which must be used if we are to establish a reasonably understandable inventory of the world's plant resources.

We are now faced with a public demand to control erosion and increase the range for the production of domesticated animals, also to improve cover and food for wild life and develop our forests and recreational areas. This brings us squarely to a consideration of the available species of plants for use in such purposes and also to the realization that we have probably only touched the world's resources along these lines.

Probably not half of the world's resources in useful plants have been studied, and at this time our practical work must be delayed and held back by inadequate knowledge of the plants best adapted to this particular use. Suddenly, and with huge appropriations, we will nationally undertake to accomplish in a day this task or other and similar tasks, forgetting that time and brains are more essential to this work than large appropriations. An American big business man once remarked to his European friend, "Well, as yet we in America have not given much attention to culture and art, but when we do we'll make it hum!" Art and culture can not be developed in this way, and neither can constructive accumulation of information as to the world's resources of useful plants be met by a sudden demand for results, no matter how large the financial backing. To-day, of all days, we should have a knowledge of the world flora, a knowledge of the distribution of species, a knowledge of the areas characterized by the major plant communities and an interpretation in terms of human need of the value of each as forest land, grazing land and as agricultural land.

In science there seems to have been a tendency for the lines of investigation to regard the related fields in a competitive rather than a cooperative sense. Mathematics with its exactness looked down a little on physics and chemistry until they established themselves mathematically, and the latter in turn looked down on botany until it became mathematical or physical or chemical. Naturally the more physical, chemical and mathematical a botany course could be made, the more scientific the instructor felt he had become. It so happened that most of the criticism aimed at the taxonomist comes from botanists themselves, and especially the physiologists and geneticists. It was natural, perhaps, when the geneticist discovered that the species was a great aggregation of strains, to conclude that it had little or no real significance. Yet it is easily conceivable that had there been geneticists before there were taxonomists they would have been so hopelessly lost that they would have had to do the work in taxonomy before they could begin work in genetics. It is interesting to see well-trained physiologists change rapidly to taxonomists when transferred to a region where the flora is as yet unknown.

The falling off in the work of taxonomy with the job only partly done is deplorable from many points of view. It is due in no small part to the lack of interest and actual belittling of its importance by botanists themselves. It has resulted in the lessening of knowledge and interest in plants by the mass population, and this lack of general interest seriously threatens at this time public support of all lines of botany, pure and applied.

Morphology and anatomy have also suffered somewhat by the feeling that they had not the practical demand which has been so great a factor in developing pathology and genetics. Looked at from a broad point of view, this field must be developed. If one is to understand the problems which daily confront the ecologist, horticulturist, agronomist and forester, he must know, not the generalized text-book presentation of plant anatomy, but the actual structure of the particular plant in question. Generalized knowledge will no longer serve, and any attempt to apply to a plant under a definite set of conditions the results of a study under a different set is likewise a dangerous procedure.

Physiology has not progressed rapidly enough to supply the demands of genetics, agronomy, ecology, pathology and related subjects. Only a beginning has been made in comparing physiological processes of different plants, and also the effect of different environments on the same plant. To conclude that the findings of any investigation in any one of the physiological processes will be applicable to another set of conditions is not a safe practise. Yet most of our basic studies of physiological processes are made with plants under conditions so artificial that the plant could not possibly survive. All our scientific experience has proved it erroneous to conclude that the results of a physiological experiment of any kind have universal application. Tried out under varying conditions, we find that each observation merely indicates a point on a curve and that usually hundreds of observations must be made before general conclusions can be reached. Possibly the more exact the measurement, the less likely the investigator feels himself called upon to duplicate or multiply the observations. In many cases in physiology, as well as other related sciences, the investigator has placed entirely too much reliance on a single observation.

The value of morphology, or of morphological ad-

justment, in measuring environmental conditions has not been adequately developed, and the subject of physiological adjustment or the use of a physiological measurement to correlate plant behavior with environmental conditions is still a relatively undeveloped field. There should be a plant measurement, a measurement of physiological and morphological adjustment, to take the place of habitat studies, which are too often not at all correlated with plant behavior. Probably no single study would so materially aid the development of plant ecology, and such applied lines as forestry, plant introduction, agronomy and horticulture, as would a plant measurement of the morphological and physiological adjustments to the environment. A beginning has been made, but the whole field is open and is one which should advance the field of pure science and yield practical results of great importance.

In genetics we have dealt with too limited a field in the problem of crop improvement. Here the recent Russian work has been far more farsighted. If we are to improve any crop for any country, we should have available the world supply of genes as a basis, for no one can tell in advance what the potentialities are, and the world supply will give the greatest promise of results. Imagine the work which plant breeders have expended on a single species of potato and how they could have widened this field by bringing in related species. The possibilities now before the Russian plant breeder are myriad as compared with those available to our men in this field at the time our different strains were developed.

Science has profited immensely by the work of the technical man, but it has also suffered at his hands. One often hears the technical man decry the science on which he depends. It is like a man denying the God who made him. To borrow again from Ortega, the technical man who does not recognize his debt to science is like the barbarian who has stepped through the wings onto the stage of modern civilization. Just as an African native who in a few short weeks will master the technique of driving an automobile, merely filling it with gas and oil and attending to the tires, but having no conception of the laws of the diffusion of gases, induction currents and the construction of steels, drives the machine until it fails, so technical knowledge which does not recognize and keep alive the science on which it rests can also be driven until it fails; it has no guarantee of continuation.

The provincial attitude has damaged the subject very greatly. Physiologists are satisfied to work in one environment, and that often one under which a plant can not possibly maintain itself. The conclusion that results obtained in one place or set of environmental conditions will apply in all, is unsound. Many of the controversies in physiology, cytology and anatomy are due to a failure on the part of the investigators to recognize the fact that a change in geographic location, accompanied by a change in environmental complex, will alter the results of an investigation, and that their results can not therefore be regarded as basic and as a standard in judging the results of other workers.

With distance so thoroughly annihilated in our industrial world, we should annihilate it in the botanical as well. With the present ease of travel and the wide distribution of men and women interested in botany, it would seem possible to compare the species from all parts of the world. What justification can there now be for monographing the species found in a state, a nation or a continent? Why should not the whole world collection, as nearly as it can be obtained, be brought together for comparison and study?

The botanists have open to them a great field in the use of vegetation to measure environmental conditions, to evaluate land and climate for plant production, and as a basis of any sane land use program. At present there is a tremendous demand for information about land potentiality. The soils men have pushed the work and are the chief source of such information. Still, their basis of classification is difficult to apply. The soil has to be examined, and this is a slow process. As a matter of fact, soil classifiers use the plants to indicate the soil types and use plant growth as the final test of the chemical and physical fitness of a soil for crop production. The plant cover can be rapidly and accurately graphed, and if properly interpreted, will serve as the best basis for estimating potential agricultural value, for any program of erosion or flood control, for water-shed protection or for land-use planning.

The intensive specialization necessary to progress has to some extent stifled the older and less specialized branches of our science, to the end that we are now badly in need of a synthesis of the specialized lines and a unified interpretation in terms of significance to human welfare and interests.

We are concerned here not only with the value of various lines of botanical investigation, but with the attitude of people toward these lines of work. Is it possible that recognition of our advance is measured by the amount of approval we receive from the basic sciences on which our investigations rest? Is it possible that we can advance our cause by evaluating our own work? Can man do just as he pleases and continue to receive from society at large his food, clothing and shelter? Is it possible that in order to further our subject we must take time to bring to the man of the street an appreciation of the subject to which we have devoted our lives? Was our greatest appeal to the outdoor man and even the city man thrown aside when we ceased to be interested in the names of plants? Is this phase of botany, which came first to the race, still the first and most natural

interest of the individuals and the one which leads most naturally to the other phases with least loss of time or effort? In attempting to interest our English or Spanish or law majors in the more abstract phases of physiology and morphology before they have by actual experience or contact become interested in plants, are we giving them something which can contribute little to their enjoyment of the out-of-doors and their appreciation of the wonder and value of the plant world?

The changes that are now taking place may mean that public support for botanical work will be increasingly difficult to obtain. Long years of patient study necessary to master the technique and to obtain the breadth of view that enable one to monograph one of our larger groups will be increasingly difficult to finance. If private fortunes, which have been the basis of the establishment of many of our foundations, are made more difficult to amass, as now seems probable, we can look less and less to this type of support to carry on the work. Whatever the outcome may be, the best assurance of the continuance of workers and opportunity in the field of botanical research rests on a wide knowledge and interest in plants and a fuller appreciation of the importance of the subject from a cultural as well as a practical viewpoint on the part of the mass population.

It may seem a far cry to one who occupies a protected chair of botany in an old established public or endowed institution to call attention to the necessity of making our subject one of real interest to our high-school and college students, but public support may easily be withdrawn and future endowments dwindle without the broad general interest. Administrators realize the difficulty of defending any line of work during periods of stress such as that of the last year or two. They realize, too, that there must be tangible evidence that each man on the payroll is yielding the proper contribution to cultural or applied science.

The world is dependent on plants, present and geological, for all but a small percentage of its raw material. An organism so stupendously important should be the object of the most thorough and searching scientific investigation. In terms of the industrial civilization we are accustomed to, it is essential to human welfare that pure science and applied science move forward hand in hand. In order that this may be, in a democracy at least, we must bring to the masses an interest in the general subject. We must make them see, if only vaguely, their dependence on these phases of human development which have made possible our high stage of civilization. To again use Ortega, a liberal democracy and technicism are characteristic features of modern culture, and the vital center of technicism is pure science—the very spirit of progress. Without science the whole superstructure of modern industrialism will fall. It behooves us to support those things which we believe most essential to the human race, and our science stands second to none in its possibilities.

This is a period, as many believe, when we are passing through changes even greater than those which have recently affected many other nations, greater because we are seeking to avoid the revolutionary method of destroying those who oppose change, by attempting to reform the ideas of a large part of our population, and by remaking some of our most cherished principles because they have so signally failed. It involves a sort of spiritual rebirth of a new American ideal. A man can not stand on his reputation but must now justify his very existence by his ability to do. Any activity publicly supported or privately conducted is examined and re-examined by a new standard, that of service to humanity as a whole. There seems little hope in the days to come for the man, be he botanist or business man, who wishes to live in his protected environment and do as he pleases. Endowed institutions are not at all sure of their future support. Public support is very uncertain and may demand production and be unwilling to await the slow and patient progress characteristic of the protected scientific man of the last century. But one who has touched the subject of science can not doubt that it is the greatest single development in the long rise of the human race. A continuance of scientific knowledge, if accompanied by equal social and economic advances, will insure the greatest good to the generations to come. The love of pure science or unbiased search after truth is the very soul and spirit by which can be developed an industrial world with a high standard of living for all, with time and opportunity for mental culture and with poverty and hunger reduced to a minimum. If we wish to aid in developing such a world, it is our responsibility to botanical research in the years to come to bring to the masses of the American people an interest in plants and a realization of the importance of our subject in their future welfare.

SCIENTIFIC EVENTS

ACQUISITIONS TO THE COLLECTIONS OF THE BRITISH MUSEUM (NATURAL HISTORY)

THE London *Times* reports that portions of the egg-shell of a dinosaur and some meteoric iron are among the January acquisitions of the British Museum (Natural History).

The department of zoology has received as a donation from Mrs. Charles Buckley and Mr. Godfrey R. Buckley the mounted head of a cow of the Chartley