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*APPLIED BOTANY AND ITS DEPENDENCE UPON SCIENTIFIC RESEARCH.**

UNFORTUNATELY for me, the time for this address before the Society for Plant Morphology and Physiology comes so far along in the twentieth century that there is opportunity for neither a retrospective nor a prospective view of botany, even were I competent to assume the rôle of an historian or a prophet. I had, therefore, thought of presenting a somewhat general discussion of some of the problems involved in soil bacteriology, but, fortunately for you, this has recently been done before another society by another investigator, so that there is no reason for digging over the same soil here. On the other hand, the discussion of some purely technical botanical subject connected with my particular field of work seems more properly to belong to that part of the program devoted to scientific papers. Consequently, by this process of elimination, the only question of general interest occurring to me seems to be that one which most of us have grown tired of answering and yet, because of the tendency of this age, is the one which we have to answer more often than any other, namely, Of what good is botany? Why do we teach it? and above all, Why have we as men and women allied ourselves with such a profession? Far be it from me to attempt to defend botany against all who are now engaged in its pursuit. These are matters for one's own conscience, but for those of us here, members of the Society

* Address of the president of the Society for Plant Morphology and Physiology, Philadelphia, December, 1904.

for Plant Morphology and Physiology and other societies in good and regular standing, I think, perhaps, it may be well to discuss for a short time the importance and significance of botany as a science and a profession, in order that those who are unfamiliar with the situation may realize that we have as distinct a part in the world's work as a banker, an engineer, or a bricklayer.

So hard pressed have scientific men sometimes been for an excuse for their existence, that I know of at least one instance where the reply of Cuvier to the practical jokers trying to frighten him by impersonating the devil, has been given as a legitimate reason for being acquainted with certain facts regarding the structure of animals. Perhaps you are not familiar with the story. It seems that Cuvier while a young man incurred the enmity of certain of his colleagues, who decided to give him a severe fright by dressing one of their number in the conventional garb of Satan and making a midnight call upon him. It is presumable that being aroused from a sound sleep, Cuvier was duly impressed with the figure before him and that some of the threats made were having the desired effect. But finally, in a last effort to overwhelm him, the devil threatened to eat the young scientist. This was a fatal mistake, for Cuvier, at once reassured, eyed the grotesquely-clad figure from head to toe and exclaimed, "What, horns and hoofs and carnivorous! Never!" He then rolled over and went to sleep.

Now, I can not maintain that the study of botany will enable one to detect the real devil from an impostor; neither do I consider that the botanist has any need for such knowledge. The particular use of the story, however, well illustrates, I think, how great has been the necessity at times for resorting to any means calculated to demonstrate the value of pure science to a certain class of people.

The test, of course, which nowayears is applied to any science or profession by a large part of the world is: What is it worth? How much money does it influence? What industries has it created? The money value of botany to those engaged in it, I will pass over in silence, it being impossible to say so little that a fair proportion would be maintained between the words and the compensation. But to those not teaching or studying it, those who have criticized botany and botanists for their lack of efficiency, and to the world in general, the value of our profession is so great that we may well feel proud to be among its numbers.

It may be regarded as an admission of weakness to even discuss the practical side of botany. But we who daily come in contact with the results obtained from our knowledge of plants are apt to forget that the large part of those engaged in other professions still look upon botany as it was considered fifty years ago, the whole function of which was so aptly described in the word to teachers by Mrs. Lincoln in 1845. She says: "In the first meeting of a botanical class, after some explanation as to the nature of the study they are about to commence, each member shall be presented with a flower for analysis." That this was the chief object of all subsequent meetings seems to have been taken for granted by many who have never had an opportunity of belonging to a class in botany. Perhaps it will be worth while to quote still further from this same book which served as an introduction to the subject for more than one of the sturdy pioneers whose names shall ever stand high on the roll of botanical achievement; for it is well to know how much foundation there is for certain opinions now held by the uninformed. In the introduction to

Mrs. Lincoln's 'Botany' you will find the following, 'The Study of botany seems peculiarly adapted to females,' and then, as if to justify this statement, she adds: "A peculiar interest is given to conversation by an acquaintance with any of the natural sciences, and when females shall have more generally obtained access to these delightful sources of pure enjoyment, we may hope that scandal, which oftener proceeds from a want of better subjects, than from malevolence of disposition, shall cease to be regarded as a characteristic of the sex. It is important to the cause of this science that it should become fashionable; and as one means of effecting this, the parlors of those ladies, who have advantages for intellectual improvements, should more frequently exhibit specimens of their own scientific taste. The fashionable *et cetras* of scrap books, engravings and albums do not reflect upon their possessors any great degree of credit. To paste pictures or pieces of prose or poetry into a book; or to collect in an album the wit and good sense of others are not proofs of one's own acquirements; and the possession of elegant and curious engravings, indicates a full purse rather than a well-stored mind; but *herbariums* and books of impressions of plants, drawings, etc., show the taste and knowledge of those who execute them."

We have here one result of the effect of botanical pursuits, which perhaps accounts for the well-known fact that botanists are freer from gossip and kindred vices than other scientists, and when we remember (if we may be allowed to quote once more) that this science is 'especially recommended to strengthen the understanding and improve the heart,' many things are made plain. But, seriously, the fact must be acknowledged that even at the present time there are altogether too many fair-minded people who have the idea that botany is a somewhat effeminate calling, and that while it does very well for ministers who have lost their voice, or for others who are unfortunately disabled, the taking up of the subject by an able-bodied man necessitates an explanation which is not always complimentary.

By hard work it has been possible within recent years to emphasize the pedagogical importance of botany, and the fact that accuracy, observation, discipline, etc., are inculcated by this subject has helped to raise it to something like the place it deserves in many curricula. But even here the struggle to differentiate botany from that all-containing, but often little-meaning term *biology* has usually resulted in most of the credit going to the animals instead of the plants. For while the improvement has been most encouraging in the last few years, it must be confessed that the proportion of botany to zoology in many biological courses is as that of copper sulphate to water in a reservoir treated for the extermination of algæ. But even after botany has received all credit due her from the purely educational standpoint, there is a vast majority who are still unconvinced of its worth and who think that the time of both student and instructor would much better be spent in some line that 'fits one for being of some account.' It is admitted by authorities that there are some subjects now taught whose only real claim for being maintained in schools and colleges is their pedagogical value. Botany is fortunate in having additional causes for its importance, and for this reason, if for no other, it should not rest its entire claim for existence upon purely educational grounds.

That botany has a definite practical field aside from distinguishing deadly from edible mushrooms, or being able to tell poison ivy when you see it, is usually something entirely new to that most impractical of persons, the so-called practical man, and the assertion that years spent in looking

through the microscope or in the scientific investigation of problems concerning plants could ever add to the world's wealth or be classed as a productive pursuit, is often quite beyond his comprehension. Because botanists generally want the interest of this class of men, would like their advice occasionally, and under all circumstances need their money, it is well perhaps that now and then the utilitarian side of the study of plants be emphasized, even though it may shock a few of those who seem to have associated themselves with the profession because they consider it so absolutely incapable of being turned to account. For it must be confessed that there still persists a small class of botanists who look upon anything practical connected with the subject in much the same way that a physician regards advertising. Just why it should be a disgrace to undertake a problem which has a definite industrial application is a little difficult to understand, but there can be no question that some investigators need no further inducement to drop a piece of work than to have it intimated that possibly it may result in some good. It is to such members of the profession that we owe, in part, at least, the comparatively low place botany takes to-day as one of the applied sciences.

It is also true that the indifference of many of the earlier botanists to those problems, the solution of which promised to be of actual service to mankind, has made it necessary for other more enterprising scientists to undertake work not strictly within their province and has resulted in the credit accruing to their particular field rather than to botany, where it belonged. It is a fact to be regretted, but which can not be denied, that systematic botany so occupied the attention of the early students of plants that it was necessary for physicians and chemists to make nearly all the investigations carried on in plant physiology and similar branches of the subject. This naturally led many to consider that there was nothing to botany except the analyzing of flowers and recording their names, and although this branch of the subject contributed its share to the establishment of applied botany, it was not sufficient of itself to bring the profession to the high position it deserves as an industrial science. Even now the old order of things is so strong upon some of us that there still exists a kind of feeling that any investigation carried on with plants, other than their systematic determination, is not pure botany and should be relegated to the chemist or physicist. While this is unfortunate, it is not of so much consequence as at one time. Such a condition, however, tends to prevent a proper estimate of the value of our science in comparison with others, and makes it possible for such statements as the following, recently made in a public address, to go unchallenged: "Practically all forms of productive activity from the cultivation of the soil for the growth of cotton to the finished tinted fabric, from the digging of the ore to the engines which distribute our commerce in its most varied ramifications, rest upon chemical phenomena." I think it is about time for the botanist to begin to assert himself, at least to demonstrate by his work and the results obtained that botany has fully as large a place in productive activity as any of the other sciences, and that much more credit is due to the student of plants than is ordinarily supposed.

Another reason why botany has not taken first rank among the applied sciences is that when investigation has shown the study of certain plants to be of vast economic value, the results have been of such importance that that particular line of work has soon assumed the proportions of an independent science, and consequently the parent has often been lost sight of in

the admiration for the child. I imagine the members of the Society of American Bacteriologists would be somewhat surprised if they were asked or expected to merge with other botanical societies and form a section in any large botanical organization. And yet this is the only logical place for them, and in the time of Cohn and DeBary there would have been no question about it had the bacteria been considered of sufficient importance to warrant a separate section. It will not be long, if indeed the time has not already arrived, when forestry will cease to give any credit to botany for the practical results being obtained by this rapidly developing profession, and other examples might be given to illustrate the general tendency to magnify the industrial branch of a science at the expense of the main body from which it originally, at least, obtained its strength.

Part of this diversification in botany is due to the fact, of course, that as a science it does not involve certain methods as in the case of chemistry or physics. It is usually a simple matter for the average person to recognize the benefits derived from either of the two last-named sciences, because they are definitely associated with test tubes and balances, reagents and dynamos, and other well-known objects.

This recognition of the method is carried to such an extent as to result, in university catalogues at least, in such hybrids as 'chemical-engineering,' 'chemical-mineralogy,' 'mathematical-geology,' 'mathematical-biology,' etc. An investigation into what is usually taught under such heads shows that it would be fully as legitimate to establish courses in botanical-architecture because of the knowledge of woods required, or zoological-engineering since the power is reckoned in horses. As well try to assign all work involving retorts and reagents to chemistry, to call everything botany or zoology which requires the use of a microscope, or claim for physics the exclusive privilege of developing all industry involving light or heat or motion, as to maintain that because a method originated in one science it can not be applied in another without uniting the two, or even losing the problem involved in the contemplation of the tools to be used in solving it. There are certain definite lines of research which appear to all fair-minded investigators as belonging to certain fields. The question to be answered is either chemical, zoological, botanical or whatever the case may be. A dozen sciences may contribute to its solution, but the fact should always stand out preeminently as to its real origin. This has not always been the case in botanical problems, and it may be a matter of some time before workers in general recognize this principle. Nevertheless, I think it extremely necessary that botanists do not fail to call attention to such cases and that in the future no opportunity be lost to obtain all proper and legitimate credit for our science and profession. The time for modestly sitting in the background and seeing our best fields for work appropriated by other sciences should have passed.

It may seem as though I were a long time coming to the second part of my subject, but the ignorance regarding the industrial importance of botany, as compared with the other applied sciences, seems to call for some explanation, and I have sought to point out, very imperfectly I will admit, a few of the reasons which have occurred to me as accounting for this peculiar situation.

To attempt to give even an outline of the many botanical achievements which have been of economic importance is manifestly impossible in the time at my disposal. Neither is it necessary to submit a catalogue of the work accomplished by those most eminent in our profession.

I do think, however, that any evidence calculated to enhance the importance of pure investigation (that most necessary source of practical results in botany) should be referred to frequently, because there is no use in attempting to conceal the fact that the average man of the world looks with contempt upon the general subject of scientific research as undertaken in botany and similar fields. That certain so-called scientific investigations carried on in the name of research are far from being in any way a contribution to science must be admitted; but so much good work is being done that it is time that we make a little more of an effort to have it receive proper recognition. Perhaps the day will come when research work will appeal to the world upon its merit. Certainly the last ten or fifteen years have seen a great advance in this line, but at present there is no question but that the best and quickest way to obtain the recognition and reward due to pure botanical research is to show how practical results are obtained by this means, which years of blind groping along applied lines have failed to produce.

If I may be allowed to take an example or two from my own experience, I will refer to the investigations leading up to the solution of the problem involving the prevention of bad odors and tastes in drinking water. This disagreeable effect, due to the growth of algæ, has been one which has baffled the efforts of engineers, chemists and bacteriologists for years. And well it might, for why should a question of this kind, involving the life history of a certain small group of cryptogamic plants, be referred to any other profession than botany for its answer?

There is not a state in the union which has not reported difficulty from these algal growths, and in some communities the odor and taste during certain months of the year have rendered the water absolutely unfit for use. In a few cases the strong odor has even necessitated the giving up of the use of the water for sprinkling the streets and lawns. One water commission in New England considered the trouble due to algæ of so much importance that they were willing to expend about four million dollars upon devices, by no means certainly effective, in order to try and prevent such difficulties. A city in the far west spent over one million dollars securing new sources of supply so that the algal-polluted reservoirs might be abandoned. In the south we have a case where the algæ led the local authorities to take steps to cause the franchise of the water company to be forfeited, on the ground that they were not furnishing a potable water. The company had spent thousands of dollars in mechanical filters and other devices, without results, and there was no alternative but to install a new supply at a cost of double the one already in use. There is no necessity for multiplying examples. Those of you who are familiar with the question of furnishing pure water in this country know how many millions of dollars have been lost owing to the presence of algæ in water, to say nothing of the great inconvenience caused by the odor and taste and for which there did not exist an adequate remedy. It is needless to say that a question of so much financial importance has been investigated exhaustively from the so-called practical side, and various recommendations made, all of little or no effect. Finally, the difficulty was relegated to the botanists, who took hold of the problem from the purely scientific standpoint and showed how certain plants were the specific cause of the trouble. It was then a comparatively simple matter, by applying the knowledge gained years ago by Naegeli and others in botanical research, to find a remedy for the difficulty. The only wonder is that it was not thought of before. Within the last six months the

method of destroying or preventing the growth of algæ in water supplies, as devised by the Department of Agriculture, has been used with marked success in over fifty water supplies throughout the country, on a scale running into the hundreds of millions of gallons, and causing a saving in money difficult to estimate. In fact, there is now on file a list of testimonials from hard-headed, practical, business men which should make systematic algology and plant physiology hold up their heads with pride. The whole matter has created a demand for trained botanists able to tell the difference between *Volvox* and *Uroglena*, which can not be supplied, and there is no doubt but that within the next few years the leading water companies will consider an algologist as important a member of their staff as the bacteriologist, and under certain conditions, of much more practical necessity than a chemist. It is difficult to prophesy what will be the future of this method which applies our knowledge of plant physiology in such a simple manner. Physicians and health officers are making use, in a number of different ways, of this piece of botanical investigation, and the employment of copper in one form or another, as an efficient means of fighting typhoid, cholera and similar diseases is undoubtedly destined to become of the utmost importance. I have referred somewhat in detail to this example because it seems to me to offer a very strong argument in favor of the ability of scientific research to furnish the solution for some problems which ordinarily might not be considered as falling under its influence. Here we have a long history of failure, due to the lack of scientific information. I am sure no one can realize how complete and absolute that failure has been until he has had an opportunity of examining the reports made by the practical men who have been attempting to solve the difficulty. It is no wonder that it was not until the investigation was transferred from the reservoir to the laboratory that the remedy was found.

Perhaps no branch of botanical research seems farther removed from the practical side of life than that usually referred to as cytology. The killing and fixing, staining and cutting of plant and animal tissue, seem to be an operation calculated to result in but small good to mankind, however much it may add to its store of information. But it is not beyond the range of possibility that these very cytological investigations of Farmer and other botanists may be destined to throw much light upon what may be termed the most important unsolved problem in medicine. Most of the diseases in the world are the result of filth, or imprudence, or some condition which could be prevented if we would. Tuberculosis, diphtheria, typhoid fever and similar contagious forms can generally be prevented and are most certainly curable, if we but use the knowledge that scientific research has given us. But cancer remains as the one dread disease, about which authorities are in dispute even as to its origin. Ask any up-to-date physician, thoroughly familiar with the results of research in laboratories at home and abroad, what is the most baffling, the most hopeless disease, the one thing he oftenest meets for which he has no remedy, and there will be no hesitation in his reply of cancer. That the cytological investigations of Farmer and others, concerning the abnormal growths occurring on ferns, may lead to the ultimate solution of the cause and cure for cancer, we can only hope; but certainly they have been able to throw a flood of new light upon the nature of malignant growths in man which can not but be of practical value.

The application of facts obtained from pure research in that most practical line of botany—plant breeding—is well known to all of you. Of the utmost theoretical importance, this branch of botanical in-

vestigation makes it possible to increase the yield of wheat and corn a definite measurable number of bushels which the farmer can appreciate at once. It is useless to enumerate the fruits, grains, fibers, etc., that have been improved by this means. It has been said that in the breeding of plants we have a practise unconsciously carried on for centuries, and that the ordinary selection of the farmer results in as great improvement as can be obtained from the application of scientific knowledge as to the strains best adapted for crossing and selecting. If this be true, why is it that all these centuries have not given rise to the results, easily obtained in one generation by the scientific way? No one would for a moment wish to dispute the great good that has resulted from the use of the knowledge gained from experience in the raising of plants for commercial purposes, but when one has witnessed the immediate benefit of the application of science to the traditional practises of the farmer and horticulturist, he can no longer deny that the combination is more practical and more efficient, and results in returns vastly in excess of those obtained when the methods are separated by prejudice or ignorance.

It is always easier to estimate the value of any piece of work when it is possible to base it upon what has been actually gained, rather than upon any loss which it prevents. Consequently, the vast saving to this country because of the investigations made upon plant diseases is usually overlooked. No line of botanical research has resulted in a greater practical benefit to the farmer and those engaged in the growing of plants for profit, and yet it is seldom that the tedious and necessary investigations carried on by the mycologist, upon which all intelligent remedial work is based, receive due credit.

If we turn to the realm of beneficial bacteriology and mycology, there are, of course, innumerable instances of the direct results obtained from botanical research, not only in those processes having to do with the growing of crops for man and beast, but also in increasing the value and importance of numerous industries. See how necessary the trained mycologist has become to the brewer! No industry is more scientific in its methods, and it required but the investigations of Hansen and Jörgensen to place the business upon a plane of absolute security, scarcely enjoyed by a manufacturer depending upon the most mechanical and routine processes. By the pure yeast cultures the brewer has everything under his control, for the mash is sterilized by boiling and the addition of the hops prevents the growth of deleterious bacteria which might be added subsequently. Thus, there is no reason why the beer made a year hence should not be precisely the same as that made to-day.

The maker of wine has not been so quick to take advantage of the information furnished by botanical research, and in many cases the results of his labors are lost, or at most, the product is often far from what it might have been had the proper plant furnishing the proper enzyme been specifically added, instead of its being left to chance. While it is true that there may be difficulties attending the sterilization of the grape must, which, of course, is laden with wild yeasts and moulds, to say nothing of the bacteria, it seems more than probable that by proper attention to the acidity of the must and by adding the pure yeast in considerable quantity so as to overcome the objectionable forms, most beneficial results may be obtained. Certainly, the only way in which the making of wine is to be placed upon the same precise and satisfactory basis as that of malt liquors, is by investigations concerning the purely scientific processes involved and not

by a continuation of the old hit-or-miss, inaccurate methods developed centuries ago before there existed any botanical research.

It is not necessary to refer here at length to the wide influence research has had upon the dairy industry. Slow as we are to abandon long-established custom, the introduction of the pure 'starter' for the production of a standard type of butter is coming more and more into use, and the certainty with which it is now possible to obtain an agreeable and pleasant aroma in butter, with no danger of spoiling the product, is what has made possible the vast creameries of the present day.

While it is probable that the part played by bacteria is not so important in the ripening of cheese as formerly supposed, the necessity for the lactic bacteria in acidifying the milk for the production of a good curd is well recognized. We also know that in some kinds of cheese moulds are essential to produce the characteristic flavor so much relished by some. In addition, the supplying of certain bacteria, known as 'langvey' in Holland, plays a most important part in preventing the deterioration of the cheese, owing probably to these organisms keeping down the growth of objectionable forms by exhausting certain necessary food products. This latest discovery is likely to open up a new field in the dairy industry, as, in a sense, it does away with the necessity of keeping out all deleterious organisms, and permits a good product under conditions which otherwise would make it impossible to manufacture cheese at all.

The debt owed by the tiller of the soil to the vast number of purely botanical investigations of so much money value to the farmer, is but seldom recognized or acknowledged. To admit oneself a scientific farmer is to at once invite a deluge of almanac and comic weekly jokes that have been accumulating against this class since Adam began to work for his living. And yet, barring conditions beyond the control of man, the only way in which the most profit can ever be obtained from a farm is by adhering rigidly to the information based on pure science, much of which has been discovered in the botanical laboratory. It is quite true that certain wild speculations, masquerading as scientific research, have resulted in unjustly causing many practical men to look upon botanical investigation as being the last thing to prove beneficial to those who grow plants for profit. But the farmer is beginning to distinguish between the real and the false, and it will not be long until it is recognized that the only man who fails to make a success out of his land is the unscientific one, who either can not or will not take advantage of the practical facts put at his command by the investigator in the laboratory, who may not know the difference between a double shovel and a disc harrow.

It is also interesting to note that our science can no longer be disregarded by the judge and the lawyer as being without their sphere, for it has been possible for the botanist to invade the field of expert testimony in a most practical fashion, and the number of cases demanding the knowledge which can only be properly furnished by a student of plants are constantly multiplying. In one instance, an increase from $9,000 to $25,000 in the damages asked, was due directly to the evidence submitted, depending entirely upon plant histology and physiology. And the basis upon which a verdict of $20,000 and costs was finally rendered was the possibility of demonstrating damage by the discussion of such strictly botanical subjects as cross-sections of rose leaves, cambium, photosynthesis, root pressure, etc. That the result would have been different had the attorney for the defendant possessed a little botanical knowledge is perhaps a question, but there

is no doubt but that his examination and cross-examination were sadly confused for the want of a few correct ideas about plants.

After all, it is not so important to dwell upon what scientific research has done in the past for practical botany and related subjects, as to emphasize what it may do in the future. Fortunately, botany is not yet at the place where she desires to stop and contemplate her achievements in a spirit of self-satisfaction or contentment. The unsolved or uncompleted problems of the industrial world waiting for help from the botanists are many, even more, perhaps, than the botanist himself realizes. No one man could enumerate them and any attempt to more than suggest the opportunities in a few lines with which I am most familiar would be presumptuous. Therefore, I hope it will be understood that my idea in mentioning the possibilities of scientific investigation in one or two specific cases is not intended as an indication of what I myself may hope to accomplish in this way, or as suggestions to others who are engaged in more important work. I merely wish to indicate to those not familiar with botanical research how we realize that much remains for us to do.

To begin with a very homely example, the investigation of the bread yeasts offers a fertile field for some botanist desiring to be of service to his fellow-man by improving one of the most necessary and important manufacturing processes carried on in domestic life. An examination of many of the yeast cakes upon the market will show that they usually are as rich in bacteria as in yeast cells, no particular care having been taken to maintain the purity of the yeast. While we have had some investigations pointing out the bad effect of certain of these bacteria upon the bread sponge, it is more than likely that other bacteria may be of great importance in converting the starch to sugar; at any rate, definite scientific knowledge is necessary before we can hope to get the best practical result. The possibility of improving the bread yeast itself is also a piece of work which I am not aware has yet been undertaken. When it is remembered that the source of most bread yeast is a beer yeast and the function of the two is not by any means the same, it would appear that some careful cultural work would be calculated to greatly improve the ease and certainty with which good bread might be made. Another possible point of improvement lies in the fact that the bread yeasts on the market are generally selected because of their rapidity of multiplication. Since it is now known that this function generally varies inversely as the gas forming power, it would seem more than likely that by no means the most efficient type of yeast was now being used for bread-making purposes.

Tanning, flax and hemp retting, and other similar industries dependent upon fermentations set up by various micro-organisms, all offer most inviting possibilities for the utilization of the results of pure botanical research. Because certain operations, worked out by experience and many failures, have been carried on for centuries with a fair measure of success, is no argument against the scientific investigation of the fundamental processes underlying the results obtained. It is more than probable that by the discovery of the precise organism involved, and the elimination of the undesirable, if not harmful, forms introduced accidentally, certain industries in this country can be revived and put upon a paying basis undreamed of by the practical man. At any rate, if improvement is to come, it must be as the result of information acquired by means of the scientist working in his laboratory, rather than through the efforts of the business man and manufacturer in the shop.

The possibility of large practical results from botanical investigations along agricultural lines seems to be particularly promising at the present time, probably because so many botanists are directing their attention in this direction. What the future has in store for the farmer of this country, because of the researches now being carried on in plant pathology, plant physiology, soil bacteriology and other branches of botany, can only be conjectured, but that much of real value will be forthcoming there can be little doubt. In no other field are the opportunities so great; in no other way are the practical returns of botanical investigation so sure.

When the farmer is made to realize that the soil upon which he is so dependent is not dead and inert, but a living, changing thing, the laboratory in which some of nature's most wonderful miracles are performed, he will be more ready to accept help and advice from a man who may not know how to plant and reap, but who understands the nature of the growing and the fruiting and the factors controlling them, as only one who has given himself to searching for botanical truths can know them. And when such knowledge applied by the farmer means all the difference between success and failure, an increase of one hundred to one thousand per cent. in his crops, the growing of new plants in new ways, the successful combating of ruinous diseases, the conservation of the real worth in the manure pile instead of allowing all its fertilizing power to be wasted into the air—these and many other practical results will at no distant day establish botanical research as one of the most necessary and beneficial aids to the most important industry in the world.

Before I conclude, it may be well, perhaps, to inquire into the nature of the research now being carried on in botany under the name of scientific investigation. Is it always scientific, or, indeed, even botanical? Does it in every case result, not necessarily in creating value where waste and worthlessness existed, but in that real addition to knowledge and the clarification of the subject which is supposed to be its function? I am sure you will agree with me that nothing so tends to prevent the advance of any science as for it to be loaded down with a vast weight of undigested facts, which are published and republished by man after man in the fond belief that they are 'contributions to knowledge.' Such a practise can not always be prevented, but it behooves botanists to realize their responsibility and to do all in their power to elevate their science and the character of the work being done under their direction. It does not necessarily follow that because a man has just taken his bachelor's degree that he is qualified to carry on the investigation of some real problem in botany, even though his instructor does give him the subject. Far be it from me to advocate in any sense of the word a commercial test for botanical investigation. There are many problems in botany which all of us want answered, but which probably will never be capable of an industrial application, and no one wants them to be. Furthermore, it is not given to us to determine the outcome of any particular line of work, and those fields which have seemed furthest removed from utility have often yielded results the most beneficial. I do wish, however, that the test always applied to scientific work which has a practical application might also be used, at times, at least, in judging all botanical investigation. There can be little doubt about the wide difference in the scrutiny given a paper prepared on some technical subject, upon which the writer is no doubt able to speak with authority, but which will at most provoke a controversy between some half dozen others in the world who are

likewise authorities, or think they are, upon the same subject; and in promulgating a theory or a method of economic value which will be tried by thousands with no regard for your feelings, if it fails to accomplish all you have claimed for it.

If this proving of our botanical work, by the rules and regulations of a practical world, accomplished nothing else, it would certainly tend to make the general character of scientific investigation a little more exact and definite than it has always been in the past. A clock striking the half hours near midnight does not always give the information you wish. It may be half-past twelve, or one, or half-past one, and in spite of the number of times it makes itself heard it is of no more value and not nearly so satisfactory as a clock not striking so often, but telling the time when it does strike. We make many claims for the high ground upon which scientific research stands, but I am inclined to think that the motive behind part, at least, of the botanical investigation of this country is no further removed from criticism than if it were undertaken for the mere dollars and cents involved in a commercial proposition. It is a fine point in ethics to determine whether the reward of a degree, a fellowship, or a teaching position for a piece of scientific research, places the work and the worker upon a higher plane than when similar investigations are undertaken for the purpose of solving a problem of definite money value which, unfortunately, for this reason alone are apt to be more accurate and more complete.

And here I think it may not be out of place to felicitate those who have been so instrumental in building up the *true* botanical research of this country (and those who have had the good fortune of being under their instruction are also to be congratulated), upon the very high place Americans have come to occupy among the botanists of the world.

Not long ago, while visiting the laboratory of a noted German botanist, I asked if he had any American students. "No," he said, "I do not expect to have any more. There is no need for you Americans to come to Germany any longer. You have the men and the laboratories. One needs only to come to Europe for the language or to look at specimens." Is it not time that the botanists of this country began to let it be known that even the Germans are recognizing our worth and our facilities, and that when a student goes abroad it is no longer because no one in this country is capable of teaching him, but for the language, the experience, the travel? Indeed, if it did not sound too vain-glorious, I would have no hesitation in saying that, in certain lines, at least, we have so far exceeded the foreign teachers and laboratories that it can not be long until the tide turns in the other direction and the most anti-American botanist will be forced to come to us for information.

The day is easily within the memory of some men now teaching chemistry, when this science had no more standing as an economic subject than botany has now. I believe, if botanists but realize the necessity of calling the attention of the world to the practical results already accomplished, and will maintain the standard of true scientific research at its highest point, that botany will very soon take the foremost place among the applied sciences. Further, I am of the opinion that the uniting of *all* those professionally engaged in the study of plants into *one* efficient, active organization could not but hasten this day, and that it would not be long until chairs of applied or industrial botany would be as necessary in a thoroughly equipped university as they are now considered for certain other sciences. We have scarcely more

than begun the scientific investigation of a field which offers the widest opportunities for results. Not only does it seem probable that practically new lines of business are to be created by botany, but the improvement in old methods which have been maintained for centuries simply because 'our fathers' did that way, has already demonstrated to the most conservative that the scientific botanist, true to type, is a man of immense practical value to the farmer, the manufacturer, the engineer and the world at large.

May we none of us, by our work or our words, retard the rapid advance now being made, along both pure and practical scientific lines, of our chosen science—botany.

GEORGE T. MOORE.

BUREAU OF PLANT INDUSTRY.

AMERICAN ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE.
SECTION B, PHYSICS.

THE annual meeting of Section B, Physics, of the American Association for the Advancement of Science, in affiliation with the American Physical Society, was held in Philadelphia on December 28, 29 and 30, 1904. The attendance was representative in an unusual degree of the physicists of the entire country, including not only those from many important institutions of the east, but also from the south, the west, and from California. The average attendance was nearly one hundred.

The retiring vice-president, Edwin H. Hall, introduced the presiding officer, Professor W. F. Magie, of Princeton University, the vice-president of Section B. The other officers of the section who were in attendance were Dayton C. Miller, secretary; Henry Crew, councillor; A. W. Goodspeed, member of the general committee; and the following members of the sectional committee, W. F. Magie, E. H. Hall, D. C. Miller, E. L. Nichols, F. E. Nipher, G. F. Hull, A. G. Webster, D. B. Brace.

For the next meeting, to be held in New Orleans, beginning December 29, 1905, the presiding vice-president is Professor Henry Crew, of Northwestern University. The other officers for the New Orleans meeting, so far as now determined, are:

Retiring Vice-President—W. F. Magie.

Members of the Sectional Committee—Henry Crew, W. F. Magie, D. C. Miller, E. L. Nichols, F. E. Nipher, G. F. Hull and A. G. Webster.

Secretary—Dayton C. Miller, Case School of Applied Science, Cleveland, Ohio.

On Thursday the retiring vice-president, Professor E. H. Hall, of Harvard University, gave an address on 'A Tentative Theory of Thermoelectric Action.' This important paper, which is printed in full otherwhere in this journal, was listened to by an unusually large audience.

Twenty-two papers were read before Section B, all of which were of such importance that it was generally expressed that this meeting was one of the most valuable that Section B has ever enjoyed. The subjects may be classified as follows: on light, nine papers; on electricity, five; on meteorology, two; and on general subjects, six papers. Papers on related subjects were grouped together more than had been usual before, and ample time was allowed for discussion. This arrangement added to the value, as well as to the enjoyment, of the sessions.

Beginning on Friday, December 30, the sessions were in charge of the American Physical Society; a large number of valuable papers were read, an account of which is given in the report of the Physical Society.

The abstracts of the papers read before Section B are given below.

Note on the Mirror-Telescope-Scale Method: GEORGE F. STRADLING, Manual Training School, Philadelphia.