SCIENCE

FRIDAY, FEBRUARY 6, 1920

CONTENTS

MSS. intended for publication and books, etc., intended for review should be sent to The Editor of Science, Garrison-on-Hudson, N. Y.

BOTANICAL ACHIEVEMENT[1]

TWENTY-FIVE years ago The Botanical Society of America imposed on me the task of preparing a presidential address. To-day I meet a similar obligation laid on me by the somewhat more democratized society which continues to bear that name.

For my subject then, I took botanical opportunity—moved, you may say, by the hopefulness of youth which looks forward and plans optimistically. To-day I wish to speak of botanical achievement—moved, you may say, by the observed tendency of age to live in the past. Possibly, later, you may not be sure that in choosing complementary subjects I have not wanted to extract much the same hopeful anticipatory lesson from both.

As one looks back over the past, he sometimes finds it difficult to pick out the significance of individual components of the conglomeration that forms the present superstructure of our science, and its foundations are buried in obscurity. Perhaps the most significant observation that he makes is that a person who is minded to add to it has each year to climb to a greater height before his own work can be commenced—unless he turn his attention to repairing the weaknesses and filling the crevices and pointing-up what has been done by others.

Work of this kind really makes the structure stronger, really keeps it from crumbling at some weak point under the weight that has been added above, and gives it an appearance of finish that must be secured at some time and by some one's labor before it can meet with final approval under critical inspection. Undertaking it may bring to light, even, wholly faulty workmanship or the incorporation of materials that have already begun to

[1] Address of retiring president of the Botanical Society of America, given at the Botanists' dinner, St. Louis, December 31, 1919.

disintegrate, and in this way may lead to replacements at various points and to reenforcement of the very foundations.

In putting up a building, such work is found to delay completion of the enterprise to a surprising extent after it seems to the casual observer to be about finished. Those who do it usually derive their satisfaction as workmen from knowing that they are accomplishing something necessary but which ought always to have been left as they leave it; or their esthetic sense is gratified in the pleasing finish that they give to what they found strong and serviceable but raw; or they know that they are safeguarding the completed structure against the inroads of time: but they do not see it really grow under their hands.

If we understand science to be systematized and formulated knowledge, we may be pardoned for stopping to wonder whether sometimes we may not fail fully to grasp the meaning conveyed by these words. Knowledge in a particular field may appear to be systematized and formulated in itself while it lacks comparable incorporation into the knowledge of other things. It may appear ideally dissociated from useful application: but perhaps it never is so in reality. Segregation of the arts which apply science in the practical affairs of life, perhaps does not really remove the necessity of considering all of these applications in the classification and formulation of that knowledge which science claims as its peculiar field.

The edict of an emperor, the injunction of a priest, the counsel of father to son, in the far-off days when civilization was establishing itself on the Tigris and the Ganges or in China, fails to come within our definition of science. We call such instruction empirical rules. But in doing so we can not fail to recognize that before Aristotle philosophized on the phenomena of life and Theophrastus formulated what he knew of plants—which we call the beginning of the science of botany, men had acquired knowledge in our special field and had classified it obviously to the extent of rejection of what they could not use and of selection of what they made the basis of an agricultural practise which may have been crude and inefficient as measured by the standards of to-day, but which was adequate to their needs and appears very refined in comparison with the earlier dependence for food upon the chase— either on land or water, or gleanings of roots and fruits from the plain, the mountain-side, or the forest. One hesitates, even, to think of these still more primitive practises as carried on independently of a very large amount of knowledge gathered and sifted and winnowed through many preceding generations as men worked their way toward an empirical precursor of what we now agree to call science.

When Liebig, the chemist, disposed of the humus theory of nutrition of ordinary plants he is considered to have been making a contribution to the science of botany. When Gilbert and Lawes in the field, and Winogradsky in the laboratory, put the completing link into the chain of the circulation of nitrogen as an active element, they are considered to have been making the same kind of contribution to the same science. I am wondering if my late and lamented associate Cyril Hopkins, calling himself an agronomist, has been far from the same field of science in teaching farmers in the great corn region of the world how to maintain for their children and their children's children a soil fertility that the first generation of white settlers imperiled, and if the last service of his life—carrying his message to those who now farm the worn-out lands of the Hellespont —must be excluded from the recognition that we accord to the achievements of science. If in considering its achievements I chance now and then to wander too far from standardized or forming definitions of our particular science, I trust that the lapses may be excused as evidence of unclear vision rather than wilful disregard of established boundaries.

The superstructure of botany, broadly defined, looks much the same to the casual observer as it did twenty-five years ago. It has been made more finished in parts, windows have been put in where there were blank walls, some parts have been pointed up or rebuilt, perhaps the gables have begun to take form

toward its final closing in; but a snapshot today from certain positions looks very like a snapshot taken a quarter-century ago except that what seemed then to be temporary lean-tos are beginning to look as if they belong where we see them or to give unmistakable signs of strengthening as well as amplifying the whole.

Perhaps this is the impression made on the superannuated workmen of a generation ago, and of some of those whose activities have continued from the earlier time up to the present. The idea of many who have come on to the job within the past two decades is very different. Under their own hands they have seen the shaping of the gables and the rising of the wings, and in their eyes these have given to the whole a very different appearance from what it presented when their work began. Indeed, under their guidance, and from viewpoints of their selection, it may scarcely look like the same edifice; and they may even point with pride to a well-finished and symmetrical annex in comparison with ragged parts of the main wall still defaced by temporary scaffolding.

The edifice of our science is less comparable with a modern warehouse like the great supply-base that the army constructed in nine months on the levee at New Orleans, than with a medieval chateau that has been changed from a feudal castle into a modernized home. The first is planned and constructed as a whole, and is consistent throughout. The other has existed through and developed with the centuries until most traces of its original plan—if there ever was one—have become obliterated.

Perhaps in this may be found explanation of an impatience that is manifested sometimes by botanists who do not like to see old symmetry changed, or by others who do not like to see labor wasted on walls that are no longer serviceable or to see these guarded from dismemberment so that their materials may be used for additions. Both kinds of criticism are likely to continue as long as construction continues. It may prove a misfortune for botany if either ceases, because the end of its usefulness will have come if it ever reach a stage in which it can no longer be changed with the changing times; but it will have become a ramshackle unserviceable monument if it ever reach a stage in which it has lost the unification of consistency in its details.

The achievements of botany have been like the achievements of nations in many respects, indeed like human achievements in the aggregate. It is impossible to trace its history without seeing some of the factors which have contributed to or retarded its advancement. Men and incentive have been necessary in the first place, opportunity in the second, and intelligent leadership in the third. Of these, perhaps, it may be said that "the first shall be last, and the last first," without too great deviation from the truth.

Men without leadership, even though they have opportunity and incentive, do not usually accomplish great things: and what unled men have achieved has resulted from their ability to plan for and lead themselves. They have been pioneers whose restless spirit has led them to spy out the land beyond the confines of the known. From the reports or echoes of their experiences has come knowledge that the limits of the knowable lay beyond the limits of the known as they found them; and their individual incursions have been followed ultimately by the invasion of numbers of men under the organization of leaders.

These are the true settlers: their leaders are the apostles of progress. Yet there rarely has been a time when an exodus or a hegira has been complete; and when it has, others less happily circumstanced have found in what was abandoned something to allure them from what they already possessed. Even good leadership, too, may have failed in adequate preliminary knowledge or planning, and more than once the new has proved inferior to the old or has been abandoned under wiser or better-informed guidance, or a generation and more of men have wandered in the wilderness before reaching the promised land; and lesser and transient migrations often have preceded or accompanied a large movement.

The founders of our science were pioneers rather than leaders: men with restless minds, no more satisfied with limitation of their field of action when they could see beyond its

arbitrary boundaries than some of us to-day are satisfied with an arbitrary zero-date for the scientific naming of plants when it is evident that scientific nomenclature began in part at a much earlier date.

Without the nature-philosophy of Aristotle there would have been no starting point for the systematization of Theophrastus. Yet without centuries of knowledge accumulated through human experience there would have been no background for either. They were the men who through systematization and coordination made the known understood, and thus opened knowable paths into what for them was the unknown.

It was a little incursion led, after a thousand and more years of mental vegetation, by a few nature-loving men of the Rhineland across the old boundaries. Though their day was that of revolt against theologically restricted thought, these resurrectors of a buried but not yet dead science were free-thinkers rather than protestants when they turned from canonized books to a real examination of nature. They were few in number and at first isolated in action; their excursions did not lead them far from home, but they were joined early by others, and their spirit found an instant echo in the sunny south. Instead of remaining explorers they became leaders of little bands whose small advances and retreats cleared the way for advance after advance of the usually better organized and at times better led army of searchers after the truth who in due time became known as botanists.

Small wonder if this growing army saw its legitimate opportunity less comprehensively and less clearly than we see it nearly five hundred years after the movement started! Without such pioneers, the science of botany might have remained to this day within the bounds that Theophrastus found to encompass it over two thousand years ago. Without other, later, even more venturesome pioneers, what they saw in it might remain to us as its present content.

Back of their activities was the incentive that underlay these, the unquenchable human thirst for knowledge. Through the following centuries this has operated side by side with the equally ineradicable human instinct for leaving well enough alone; and men have progressed dominated and restrained by the massive inertia of conservatism, but breaking free every now and then for a trial of the individual inertia of motion, much as a molecule of evaporating water passes off into freedom—ultimately to be lost in space, to enter into a new cycle, or to return to the bondage from which it made its escape, with far-reaching derangement in any case of the stability of what it left behind or joined.

Effort, when really effective, is purposeful. When the microscope provided means of seeing clearly what living beings consist of, it was not Hooke, who first published its revelations, but Malpighi and Grew, who shortly afterward examined the structure of living things with a view to understanding their vital processes, who laid the foundation for a broader science than their predecessors had conceived. They and their followers, in planning and building on the lines that we now recognize from long habit as being those that characterize botany, did not go far from the procedure that has distinguished successful human effort in general, in which a search after the true and the effective has shaped itself usually into a quest for proof or disproof of some theory of what is true or effective.

Without the guiding line of philosophy, the search might or might not have reached its goal. But with it, the result has depended upon adaptation of the means to the end—an adaptation which in our own day and in the last quarter-century has grown with surprising rapidity and extension of the experimental questioning of nature to which science turns with confidence for the solution of those problems that really lie within its field. Beyond that field still lies the realm of metaphysical speculation, which Lewes, half a century ago, protested against calling philosophy because in this sense he felt constrained to call the restless motion of philosophic speculation rotary in contrast with the linear (perhaps one would rather say dendritic) progress of science. The lure of the pioneer lies in the prospect of novel as well as great return. A few years ago some botanists were discussing

present-day opportunity in botany, and the opinion was voiced that it lies in the line of large and special equipment opening fields beyond the reach of the ordinary man. This may really be so. Certainly the first men to use the microscope were privileged beyond their fellows: but as we look back on their work they do not shine with a brilliancy corresponding to the greatness of this privilege. Rather, they profited by it to the extent of their knowledge and talent; made much or little progress according to their possession of these personal gifts; and have been surpassed by men who much after their day were impelled and instructed to look deeper and see further with the same instrument.

The optimism which led me twenty-five years ago to see hopeful opportunity for every man inspired by an all-compelling curious interest in nature and natural phenomena leads me still to see hopeful opportunity ahead of every such man—proportioned to his talent and under everyday environment rather than dependent on the special and novel provision which may fall to the lot of a fortunate individual here and there.

Botany, as a science, grew out of the gradually accumulated knowledge of plants acquired through using and cultivating them. The art of applying this knowledge really underlay the science into which it has been organized and formulated, though to-day it rests upon this, which constitutes a firm foundation in agriculture, medicine and the varied fermentation industries. That its scope should broaden, was as inevitable as that the natural horizon should amplify for a man climbing to a hilltop. That the mere selection of suitable subjects for microscopic study should result in closer observation of all that was looked at was equally natural. That Van Helmont's demonstration that plants are not built up out of earth should have preceded a separate analysis of all possible sources of their substance is self-evident. But discovery of the large part that the atmosphere plays in this organic synthesis, of the marvelous organism that a vegetable cell proves to be, and of the part played in heredity by some of the parts of this unit organism of organisms, is seen to have resulted more from the intelligent ingenious use of means at hand than from restricted privilege.

If one were to lapse into momentary pessimism in an optimistic review, the slip would come from recognition of the instinctive conservatism that inclines most of us to see only a form of some well known plant in a specimen that the inspired discoverer knows and even describes as hitherto unknown; or that leads us to ignore as "dirt" or artefacts the seemingly uncharacteristic parts of our preparations—as Löhnis believes that the most eminent bacteriologists have done; or that leads to a wish that experiments on living things were not so apt to turn out differently from the predicted result. We may destroy puzzling intermediates, throw away disappointing preparations, or exclude unsuccessful experiments from our calculations: but we do not explain them in doing this—we merely evade the truth that they mutely offer for our apprehension. It is the exceptional man who, even if he lay them aside for the time, as Haeckel, in his youth, did the "bad" species of his herbarium, can not rest until he understands them.

This is the true pioneer type, not content with what is believed to be the known nor satisfied with little excursions beyond its border, but boldly, in season and out of season, pushing out into the unknown. Such incursions, guided by the compass of correct methods and starting from the direction of acquired knowledge, have been, are and seem likely to continue to be, the epoch-making first moves in scientific progress.

Men who lead in such progress sometimes set off with general approval and good wishes. They follow the bent of their less enterprising fellows. Even rumors of their achievements are received at par and passed on at a premium. Fortunate, then, for science, if the log of their journey come back for verification, for our average human tendency is to believe what we want to believe, and those of us who do not travel to the pole care for little more than to be told that it has been reached by an enterprising explorer when we confidently expected such an explorer to get there.

Quite as often, the pioneers set off in a direction that is uninteresting to the rest of us. They go and come, and we hear with passing attention if at all what they have been doing.

Sometimes they do a good deal of talking about the inadequacy of what is accepted currently; they are regarded as heretics or at best as destructive critics. We complacently await the calamity that we believe them to court, and are incredulous if not really disappointed when they do not disappear for good but return and ask for an impartial examination of what they claim to have brought back.

Each of these types has been represented over and again in our science, which has profited by the good of each; and in the long run it can not suffer through the bad, because time inexorably eliminates this. But there have been quite enough instances of mistakes and delays and discouragements on the one hand, and of spurts of stimulated effort on the other, following the activities of men blessed with the gift of originality and at the same time favored or hampered by its human concomitant of radicalism or conservatism, of sanguine credulity or of phlegmatic incredulity.

Starting from isolated springs of impulse, progress has settled into a continuous flow of constantly increasing volume and rather fixed direction, over and over again, until a new touch of genius or a new revolt against the established order has opened new channels that have broadened and deepened with the years without causing the main course to run dry.

Sometimes change has come through the talent of coordination, as when Linnæus brought chaos into order in the arrangement of flowering plants, or Saccardo in laboriously assembling the fungi. Sometimes it has come from an attempt to dam the main channel as a means of diverting a part of the flow in a new direction, as when Schleiden fought the systematists. Sometimes broad epitomization has caused the change, as when Sachs revivified the science by giving it coherence as a whole. Sometimes an epoch-making improvement in technique is to be seen, as when Strasburger showed how the most transient inner processes of the dividing cell may be preserved for comparative study extending over months or years. Sometimes a device accurately recording for later study every phase of a passing physiological process has shown what was unseen before. Sometimes, and perhaps more often, the result has been achieved through the purposeful untiring straightforward work of a man possessed at once of the plodding industry of the laborer, the genius of the designer, and the perspicacity of the philosopher: such men were von Mohl, Hofmeister and De Bary.

Whatever its type, work that has left its mark indelibly on the science has been done by men endowed with an infectious enthusiasm. These men may have lived to see their own discoveries set aside as incomplete or even faulty, like Schleiden; or they may have discarded their own forceful convictions, like Sachs; or they may have known that in doing a serviceable work effectively, they were as effectively placing a barrier before the greater work that they foresaw ahead, as did Linnæus when he substituted an artificial key for the real taxonomy that he could not develop. But, however far it may have been from perfection, what these men did appealed to the understanding; what they said obtained a hearing; and, above all, their consuming interest was communicated to others and yet others. They proved leaders as well as workers.

The personnel of botany forms a roster of men sometimes working alone, unstimulated and without following, sometimes founding schools, sometimes following in the footprints of masters. The suggestive thought is that these masters for a considerable part have been self made: that their followers who have become masters have broken for themselves new paths; and that one and all they have been workers fitting their work on to that of others, systematizing all, and enlisting eager hands to do the work that they saw ahead waiting to be done. They may not always have had what we call a proper veneration for

the antique, or a good sense of perspective, but they have left their mark on the edifice.

Two somewhat paradoxical if not antithetic achievements in botany stand out conspicuously in the last quarter-century or so: increasing assimilation of the science itself with cognate sciences into the broader science of life—biology; and an increasing tendency for its own members, differentiating into organs, to segregate into offsets and strike root for themselves.

To-day we rarely hear any one talk of the food of plants being inorganic, and that of animals, organic; we hear, rather, of green plants as the food makers of the world. Even the word assimilation has fallen into disuse or become hyphenated as applied to this process. Digestion, metabolism, nutrition, have become subjects of parallel investigation in the two branches into which the tree of life has evolved.

The incipient stage of cell division, with qualitative bipartition in its somatic stages and qualitative segregation in the formation of gametes in all but the very lowermost of protista, has become so largely known as to make it hard to think of any bit of existing protoplasm as other than a fragment of one primordial protoplast, or to think of a protoplast of today as not genetically related to every other protoplast past or present.

The chemico-physical activities of plant and animal no longer claim attention as separate problems; absorption, selection and rejection of material, ionization, diffusion, osmosis—all have become biological rather than zoological or botanical questions, as they pertain to living things; but botanists are doing their full share toward answering them.

That botanical investigation should have demonstrated Mendel's law two generations ago or exhumed it two decades ago, places this discovery among the achievements of botany; but on it has been founded the biological superstructure of genetics—as valued an adjunct of the stockbreeder as of the breeder of plants. That a botanist differentiated between fluctuations and mutations and so simplified the understanding of natural selection has not prevented that differentiation penetrating into every branch of evolutionary investigation.

That toxins became known when the activities of bacteria were studied, has not prevented the student of animal physiology from carrying the same study of excreta into the relations of animal parasites and their hosts, or from developing from it the theory of autointoxication. Enzymes, hormones and vitamines—whatever either may be, now lie in the common field of biology, but some of the best work on them is done by botanists.

Out of the harmonies and disharmonies of plants with the manifold kinds of environment that the world offers, has developed a line of ecological observation, experimentation, and speculation that not only has brought the microscopic algæ of the world-plankton into recognition as the first fruits and the foundation of all aquatic life, past and present, but points as unmistakably to the individual birth, adolescence, mature life and senescence of a flora as the experience of agronomy does for a plant or recorded history does for a community of men: it has passed forever from the kodak-census stage.

Incursions into the no-man's-land confronting science are increasingly paralleling the phenomena that ecology deals with. The rapid invasion of an army of men, or a swarm of locusts such as I have seen blackening the sky in Central America, carries its own suggestion of impending conquest or devastation. The trickling of a thin thread of water through the dike, the exploration of a few pioneers or the settling of a few families beyond the front, may escape notice as significant; and the army may be driven back or the grasshoppers stopped by attention to their breeding places. The most-heralded advances sometimes prove the least important, and the humblest, the most significant, in retrospect.

Who but a croaking pessimist would have dreamed that an unknown fungus spore dropped on the Emerald Isle would lead to famine and starvation affecting a large population of men; that a rather uninteresting imperfect fungus added to the local flora of New York would cause the magnificent chest-

nut forest to disappear from our seaboard; that the cultivation of a water plant would choke the streams of England or render those of Florida unnavigable? The like is going on all of the time without such results, and even the man who knows speaks often to an unhearing audience when he ventures to proclaim that an immigrant can do what the leopard moth has done to the elms of New England or the boll-weevil to the sea-island cotton: but the lesson is being learned, bit by bit, and applied with quite as much zeal as wisdom.

In much this way, science has reached its achievements: sometimes annexing large fields that have proved less profitable than they were advertised to be; sometimes finding itself in possession of most fruitful territory that it did not know it was invading. That the mountains of conquest sometimes prove barren and the drained plains of slow sedimentation sometimes prove of inestimable productivity may well lead us to embark in future on the most lauded enterprise with reasonable caution, and to foster in every wise way the experimental prosecution of even the least obviously promising of minor undertakings.

Among newer lines of botanical activity none stand out with more significant distinctness than those directed toward getting conclusive demonstration of the active causes of organic variation and of organic function through a direct questioning of nature. To such experimentation, the shifting theory and complicated phenomena of physical chemistry are fundamental; to it, the deftest and best controlled manipulation is essential; to it, recognition and successive elimination of the many interwoven conditioning factors are indispensable. From it, the subtle change that converts living into dead matter is not capable of separation.

Biometry, laborious to the last degree, is the scale by which some of its results are to be made evident and coordinated. Biochemistry has taken assured place as one of its most necessary tools. Even the physical intricacies of behavior in colloids that never figure in vital phenomena are being pressed into daily use as furnishing analogies for if not demonstrations of the workings of that substance, protoplasm, which alone lives, alone responds to stimulus in the sense of the physiologist, and alone increases its substance through nutrition.

This entire line of advance is very new: some of its progress is startling: but its final results do not appear to promise to be those of metamorphosis but rather of cumulative mutations, perhaps mostly small. In it, above all other lines of progress, caution, conservatism and avoidance of too free generalization and haste in announcing and applying results appear to be desirable.

It is natural that a science concerning itself with the prime makers of human food—and for that matter of all food, and of the healing agents and poisons of the world, should have gleaned its very first results from the usefulness or noxiousness of the materials of its study, and that its achievements should have acquired great economic importance. Too much stress can not be laid on the fact that this is so, and within reason too much can not be expected from its future activities.

This science works within the bounds of what we still regard as natural law, and will continue to be so limited however these boundaries may be defined and extended. Nevertheless because of its discoveries the unpalatable has been made palatable and the unwholesome made wholesome in food; two blades of grass and two grains of wheat really have been made to grow where but one grew before; it has unraveled the mystery of the epidemic scourges of farm and barnyard, has pointed the way to prophylaxis and breeding of hardier races, and at the worst, has shown where therapy is futile. It certainly will make known and understood the critical periods in crop growth, and enable the agronomist to foster and protect his crops with profit at these periods; and it is not unlikely to enable the man who knows to judge and score the growing crop as the growing herd is judged and scored. It has founded a practise of self-sustaining fertility of the soil, and it points a way to restoration of impoverished soils.

These achievements have not come by leaps and bounds of either discovery or application:

they represent gradual accomplishment in both directions. Nevertheless such practical results have been reached within the memory of men now living—many of them indeed through men now with us. The methods of our science are analytical, its application is educational: both require time, and the applications of its teachings tend to pass its results from the questioning realm of science into the formulated empiricism of an art.

The world stress that we are passing through has caused attention to be turned, as never before, toward science; and science and its methods have received a utilitarian recognition never before accorded them. If botany and its dependent arts have met practical expectation as chemistry and physics and their dependent arts have, its hopeful activities are assured quantitatively and qualitatively for generations to come: if it has shown an inherent lack of the liability of these sciences, in which application is almost synchronous with discovery, an understanding of its slower but none-the-less certain methods will secure for it opportunity for equally honorable and useful future advance; and if we think it has been slow in response we must recognize that like the plants with which it deals it requires a period of tilth and growth between seeding and harvest.

Useful though it may be, until it shall have become a finished work, fit companion for those arts and achievements now kept from oblivion through the kind offices of the museum, it will be a sorry day for this or any other science when its prosecution proves to be dependent upon the evident and immediate usefulness of its discoveries.

When the inspiration of the greatest of modern botanists, Sachs, gave to botany something of the meaning that it now has, its place in the educational world changed. Though biological science from its more complex nature fails to give the promise of unmistakable and predictable answer to experiment that the physical sciences pledge and furnish, it took place quickly and without question as one of the foundation stones of the educational idea which recognizes experimentation and observation as of fundamental value in training the human mind.

Perhaps it was put to this use in the best possible way and for the best possible reasons. Its achievements for two generations show that large results have come because of or despite its incorporation into the curriculum of even the secondary schools: the methods of using it, at any rate, have been largely those believed best calculated to make investigators of the pupils who studied it.

To some people, it has seemed from the first that all who study a science can scarcely be expected to become specialists in it. There is no reason for surprise in the patent fact that few of the myriads of students of botany during the last half-century have become professional botanists: investigators are born rather than manufactured. There may be just ground even for a growing feeling that in its application to education, botany should appear in a different guise and with different accents from the same science as the investigator knows it.

If we are wise and alert who wish to see botany or even biology at large continue—as we all must believe that it should—an element of popular instruction, we must see that in the school it regains that simple understandable everyday relation with everyday life that its vastly simpler precursor possessed; that in the college its more complex present-day relations with life are made part of the equipment of all of those who are to teach it in the schools and to follow it into the university; and that in the university its study is characterized by a breadth of understanding and a scope of vision commensurate with that refined specialization which marks the successful delver after facts.

This is a suggestive gathering. It is a session of The Botanical Society of America, but there are present many members of the Phytopathological Society, of the American Society of Naturalists, of organizations of ecologists and geneticists, of fern students and of moss students. Such organizations are meeting in affiliation with the American Association for the Advancement of Science, and members of

the botanical and agricultural sections of that great Association are of our number. Pomologists and men devoting themselves broadly to horticultural science are with us. I should not be surprised if there were present also men who call themselves bacteriologists, foresters, or pharmacognosists, though the immediate affiliation of their special national societies has been shaped otherwise. We are here at the present moment as botanists, viewing botany from the various sides of its many specializations and applications. To-morrow we shall be pressing its subdivisions and segregations intensively in specialized sessions. Let us not forget when we do this that in union lies strength and that in division of labor lies efficiency; nor that efficiency usually reaches its maximum in the connected correlated organs of an organism, each taking and giving for the common good.

I would not urge the tyro among us to become less a cytologist, less a bryologist, less a physiologist, less a bio-chemist, than his greatest inspiration prompts: but I would urge him earnestly to be more a botanist, more a naturalist, more a disciple of a broad science which in strength and effectiveness and symmetry combines all that is good of its many and diversified component parts.

Horticulturists talk of graftage. They know that their art can produce more effective creatures than nature has evolved; but stock as well as scion is selected for its inherent worth, and both are essential to the whole that is built up from them.

The great world upheaval has severed many a scientific union that seemed destined to last interminably. Some of the disjointed parts may never reunite: some unquestionably require careful handling. It appears to be our plain and paramount duty now to see that, if worth it, the parts of the old tree be given a chance to establish themselves anew, either on their own roots or on a better footing—not thinking for a moment that the tree of science is limited in time or space or components, but remembering always the old maxim that the whole is equal to the sum of all its parts and greater than any of its parts.

Out of the world dismemberment has come opportunity for cooperative world reorganization and reconstruction which can be made more effective in science than anything that has preceded it. The opportunity is ours. If we make the most of it, we shall attain the greatest of the achievements of science. Even if we fail, we need not miss the lesson that accomplishment in our field is of necessity never final but proves always to be the opening of new fields, fresher and larger, to those who understand the real nature of achievement—out of which opportunity continually develops.

SOME SUGGESTIVE ADDRESSES, ETC.

Allen, W. E. The naturalist's place in his community. Science, n. s. 50: 448–451, Nov. 14, 1919.

Arthur, J. C. Research as a university function. Science, n. s. 49: 387–391, Apr. 25, 1919.

Bailey, L. H. The modern systematist. Science, n. s. 46: 623–629, Dec. 28, 1917.

Bailey, L. H. Some present needs in systematic botany. *Proc. Amer. Philosoph. Soc.*, 54: 58–65, Apr., 1915.

Bailey, L. H. What is horticulture? *Proc. Soc. Prom. Agric. Sci.*, 26: 31–40, 1905.

Bessey, C. E. Some of the next steps in botanical science. Science, n. s. 37: 1–13, Jan. 3, 1913.

Botanical teaching. A conference at the Minneapolis meeting. Science, n. s. 33: 633–649, Apr. 28, 1911.

Campbell, D. H. The present and future of botany in America. Science, n. s. 41: 185–191, Feb. 5, 1915.

Clinton, G. P. Botany in relation to agriculture. Science, n. s. 43: 1–13, Jan. 7, 1916.

Copeland, E. B. Botany in the agricultural college. Science, n. s. 40: 401–405, Sept. 18, 1914.

Coulter, J. M. Botany as a national asset. Science, n. s. 45: 225–231, Mar. 9, 1917.

Coulter, J. M. The evolution of botanical research. Science, n. s. 51: 1–8, Jan. 2, 1920.

Crozier, W. L. The position and prospects of botany. Science, n. s. 48: 193–194, Aug. 23, 1918.

Davis, B. M. Botany after the war. Science, n. s. 48: 514–515, Nov. 22, 1918.

Farlow, W. G. The change from the old to the new botany in the United States. Science, n. s. 37: 79–86, Jan. 17, 1915.

Gager, C. S. A basis for reconstructing botanical

education. SCIENCE, n. s. 50: 263–269, Sept. 19, 1919.

Gager, C. S. Horticulture as a profession. SCIENCE, n. s. 49: 293–300, Mar. 28, 1919.

Gager, C. S. The near future of botany in America. SCIENCE, n. s. 47: 101–115, Feb. 1, 1918.

Galloway, B. T. The twentieth century botany. SCIENCE, n. s. 19: 11–18, Jan. 1, 1904.

Ganong, W. F. Some reflections upon botanical education in America. SCIENCE, n. s. 31: 321–334, Mar. 4, 1910.

Hitchcock, A. S. The scope and relations of taxonomic botany. SCIENCE, n. s. 43: 331–342, Mar. 10, 1916.

Jones, L. R. The relations of plant pathology to the other branches of botanical science. *Phytopath.* 1: 39–44, 1911.

Lefevre, G. The introductory course in zoology. SCIENCE, n. s. 50: 429–431, Nov. 7, 1919.

Livingston, B. E. Some responsibilities of botanical science. SCIENCE, n. s. 49: 199–207, Feb. 28, 1919.

Lyman, G. R. The need for organization of American botanists for more effective prosecution of war work. SCIENCE, n. s. 47: 279–285, Mar. 22, 1918.

Nichols, G. E. The general biology course and the teaching of elementary botany and zoology in American colleges and universities. SCIENCE, n. s. 50: 509–517, Dec. 5, 1919.

Orton, W. A. The biological basis of international phytopathology. *Phytopath.* 4: 11–19, 1914.

Osborn, H. Zoological aims and opportunities. SCIENCE, n. s. 49: 101–112, Jan. 31, 1919.

Peirce, G. J. What kinds of botany does the world need now? SCIENCE, n. s. 49: 81–84, Jan. 24, 1919.

The reconstruction of elementary botanical teaching. *New Phytologist,* Dec., 1917. A series of papers.

Ritter, W. E. A business man's appraisement of biology. SCIENCE, n. s. 44: 820–822, Dec. 8, 1916.

Roberts, H. F. Agricultural botany in secondary education. SCIENCE, n. s. 50: 549–559, Dec. 19, 1919.

Shear, C. L. First decade of the American Phytopathological Society. *Phytopath.* 9: 165–170, 1919.

Shull, A. F. Biological principles in the zoology course. SCIENCE, n. s. 48: 648–649, Dec. 27, 1918.

Stevens, N. B. American botany and the great war. SCIENCE, n. s. 48: 177–179, Aug. 23, 1918.

Stockberger, W. W. The social obligations of the botanist. SCIENCE, n. s. 39: 733–743, May 22, 1914.

Trelease, W. Botanical opportunity. *Bot. Gaz.,* 22: 193–217, Sept., 1896; Smithsonian Report 1898: 519–536.

Zeleny, C. The personal relation of the investigator to his problem. SCIENCE, n. s. 50: 175–179, Aug. 22, 1919.

WILLIAM TRELEASE
THE UNIVERSITY OF ILLINOIS

THE BIOCHEMIST ON THE HOSPITAL STAFF

DURING the past few years there has been gradually evolving in the general mind, and particularly the medical mind, the idea that the chemist is actually something more than a druggist or a detector of arsenic. The present records of the efforts directed towards an elucidation of the reactions of the human organism in health and disease, along the lines of chemical investigation, are an achievement that by their very import, if not their voluminousness, have forcibly directed the attention of the medical profession to the possibility that here is a line of attack worthy of notice. The rapid progress being made is adding so much to the fundamental knowledge of how the organism carries on its activities, that the solution of the many problems being brought to light is most turbid in the minds of the chemical physician and he is turning to the biochemist for clarification. Scientific medicine to-day acknowledges the fundamental value of chemistry in the fight for the prevention and cure of disease; it recognizes now, as never before, the need of ascertaining the basic facts concerned in body reactions and that the satisfying of that need rests in the intensive application of biochemical methods to the study of the human organism. Outside of diabetes there is a general lack of definite information concerning the intricate processes going on, giving rise to, or accompanying pathological conditions, and there is opening up a larger opportunity for acquisition of this information through the open-hearted cooperation between physician and scientist that is now becoming evident.