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# ACADEMIES OF SCIENCE AND THE COOPERATIVE SPIRIT IN SCIENTIFIC RESEARCH[1]

By Dr. C. A. BROWNE

U. S. BUREAU OF CHEMISTRY AND SOILS

IN coming to you on this occasion as a representative of the United States Department of Agriculture and as a delegate of the American Association for the Advancement of Science I wish to convey the best wishes of both of these great scientific organizations for the success of the project which you are now inaugurating—the establishment of the Florida Academy of Sciences.

An academy of sciences has been defined as a society or corporate body which has for its object the cultivation and promotion of the whole general field of science, with no other motive than that of the pure love for scientific pursuits. The earliest prototype of such an organization was the celebrated Museum of Alexandria founded by the first of the Ptolemies in the third century, B.C., in which the most learned astronomers, geometers, mathematicians, geographers, mechanicians and devotees of the various natural sciences in the ancient Greek world gathered for consultation, study and instruction. The great benefit derived from the Museum of Alexandria is evident from the important discoveries which were made by the Greek scientists of this institution during the many centuries of its existence.

The various European academies of science which sprang into existence in the seventeenth century had a purpose very similar to that of the Alexandrian museum. Like their ancient prototype, these modern scientific academies brought together eminent specialists from different fields and thus fostered a cooperative spirit in their search for new knowledge.

It is a truism to affirm that the cooperation of scien-

[1] Inaugural address before the Florida Academy of Sciences, Gainesville, Florida, May 8, 1936.

tific men, who labor in different fields, is highly desirable, yet there has always existed a resentment on the part of certain investigators against the invasion of their domains by scientists from other realms. Sixty years ago, when Pasteur, a chemist, began to occupy himself with a study of the cause of anthrax, he was bitterly condemned as an intruder by some members of the medical profession, yet no physician to-day would deny the immense benefit which the science of medicine has derived as a result of this intrusion. In the same way Senebier, the Swiss chemist, felt it necessary in 1783 to write an apology for chemistry because certain plant physiologists objected to his using the methods of this new science to explain the behavior of green vegetation in sunlight; but now times have so far changed that no one can qualify to-day as a plant physiologist who has not been trained to employ the processes of chemistry as an aid in the solution of his problems. In fact, chemistry and its sister sciences, which were hardly on speaking terms in the time of Liebig, have to-day become so far reconciled that chemical papers are accepted as a matter of course upon the programs of physical, geological, medical, horticultural and other scientific associations.

The advantages of cooperative research are well summarized in the Greek sentence of Aristotle that has been inscribed as a motto upon the marble front of the home of the National Academy of Sciences in Washington, which states that "the search for truth is both difficult and easy, for it is evident that in its pursuit no one can either be completely successful or go wholly astray; if, however, each one makes a small contribution to natural science, the sum total of all the knowledge thus gathered together will be something considerable."

The great advantage of the cooperative as compared with the individualistic method of scientific inquiry is that the errors of the individual worker are more or less eliminated by his collaborators, each of whom approaches the problem from a different angle and that the conclusions of each individual, when viewed from all points of approach, are seen in a better scientific perspective. When properly conducted this cooperative plan of research is the most productive of all methods of scientific investigation. It was first described by one of the greatest philosophic writers of history, Sir Francis Bacon, three centuries ago, in his utopian sketch entitled "New Atlantis," where a staff of selected experts, called Solomon's House, a preconception of our modern academies of science, cooperated for the purpose of discovering new scientific truths. As the earliest detailed outline of the cooperative method of scientific inquiry, Bacon's imaginary description of the employment and offices of the fellows of his "Solomon's House" is worth quoting:

> We have twelve that sail into foreign countries . . . , who bring us the books and abstracts and patterns of experiments of all other parts; . . .
>
> We have three that collect the experiments which are in all books, . . .
>
> We have three that collect the experiments of all Mechanical Arts; and also of Liberal Sciences; and also of practices which are not brought into arts. . . .
>
> We have three that try new experiments, such as themselves think good, . . .
>
> We have three that draw the experiments of the former four into titles and tables, to give the better light for the drawing of observations and axioms out of them. . . .
>
> We have three that bend themselves, looking into the experiments of their fellows, and cast about how to draw out of them things of use and practice for man's life and knowledge, as well for works as for plain demonstration of causes, means of naturall divinations and the easy and clear discovery of the virtues and parts of bodies. . . .
>
> Then after diverse meetings and consults of our whole number to consider of the former labors and collections, we have three that take care out of them to direct new experiments, of a higher light, more penetrating into nature than the former. . . .
>
> We have three others that do execute the experiments, so directed, and report them. . . .
>
> Lastly we have three that raise the former discoveries by experiments into greater observations, axioms, and aphorisms. . . .
>
> We have also, as you must thinke, novices and apprentices, that the succession of the former employed men do not fail; besides a great number of servants and attendants, men and women. And this we do also: We have consultations, which of the inventions and experiences, which we have discovered, shall be published and which not; . . .

As a scheme for the proper conduct of scientific investigation, Bacon's plan is still commendable in many of its details, as for example in the preliminary survey of existing knowledge, the collation of all pertinent information, the making of trial tests before the actual crucial experiments, the application of the new discoveries to the enlargement of science and to the arts, the training of assistants and the selection of material for final publication. The most remarkable thing about this scheme is that Bacon without anything previous to guide him should have elaborated the plan so completely as he did and that he first suggested by his Solomon's House the idea of organized cooperative research which led to the establishment of the Royal Society and the numerous scientific academies which were founded within the half century following Bacon's death. It is interesting to note how some of these organizations seem to have imitated Bacon's plan even in matters of detail. Bacon's establishment, for example, of several scientific committees of three members each finds a later counterpart in the constitution of the reorganized French Académie

des Sciences of 1699 whose fifteen pensionaires, or working members, consisted of three geometricians, three astronomers, three mechanicians, three anatomists and three chemists. Time is lacking to trace other parallels of a similar kind.

In every extensive scientific research, whether individual or cooperative, there should be, to employ the archaic expression of Bacon, an occasional "drawing of observations" in order to determine if the drift or tendency of the results can be formulated so as to indicate certain tentative hypotheses or generalizations. New experiments under many changing conditions will then serve gradually to eliminate the suppositions which are found to be incorrect, until after a most rigid and impartial series of examinations some single one of the tentative hypotheses is accepted as the most satisfactory. This method of examination and reexamination requires, however, the utmost candor and frankness of mind, for the investigator must approach each one of the hypotheses which his scientific imagination has framed with the strictest impartiality. Nothing can be done without the imaginative faculty in scientific research, but it must not be allowed to interfere with the just performance of experimentation. The dictum of the great French physiologist, Claude Bernard, is worth remembering in this connection: "Divest yourself of your imagination, as you do of your overcoat, when you enter the laboratory; but do not forget to invest yourself with your imagination again, as you do with your overcoat, when you leave the laboratory."

Some of the world's greatest scientific investigators have failed at times to scrutinize sufficiently some tenaciously held hypothesis. Priestley, celebrated for his discovery of oxygen and other gases, long wandered in error because of his obstinate adherence to the erroneous doctrine of phlogiston. Few chemists have been so fortunate as Liebig in the making of important discoveries, yet his over-hasty desire to defend some preconceived hypothesis caused him, time after time, to go astray. One great value of the cooperative method of research is the prevention of the individual from making over-hasty generalizations and conclusions. As long as Liebig collaborated with Wöhler, he was safe, his impetuosity and haste being held in check by the calmer and more cautious temperament of his friend. No more beautiful illustration of the collaborative spirit in scientific research can be found than in the joint chemical investigations of Liebig and Wöhler. The mutual advantages of this cooperation have been described by each. Liebig in contrasting the differences of his own and Wöhler's nature expressed himself in the following words:

> While in me the predominating inclination was to seek out the points of resemblance in the behaviour of bodies or their compounds, he possessed an unparalleled faculty of perceiving their differences. Acuteness of observation was combined in him with an artistic dexterity, and an ingeniousness in discovering new means and methods of research or analysis, such as few men possess.
>
> The achievement of our joint work upon uric acid and oil of bitter almonds has frequently been praised; it was his work. I can not sufficiently highly estimate the advantage which the association with Wöhler brought to me in the attainment of my own as well as of our mutual aims, for by that association were united the peculiarities of two schools—the good that was in each became effective by cooperation. Without envy and without jealousy, hand-in-hand, we plodded our way; when the one needed help, the other was ready. Some idea of this relationship will be obtained if I mention that many of our smaller pieces of work which bear our joint names were done by one alone; they were charming little gifts which one presented to the other.

Wöhler, on the other hand, wrote as follows:

> We two, Liebig and I, have dissimilar kinds of talent; each, when in concert, strengthens the other. No one recognizes this more fully than Liebig himself, and no one does me greater justice for my share of our common work than he.

The performance of cooperative research on the part of two scientists of equal eminence, such as Liebig and Wöhler, depends for its success upon mutual good will, an absence of all envy, jealousy or suspicion and a complete renunciation of all motives of personal profit. This requirement places a severe tax upon some inherent traits of human nature, and some attempts at cooperative research have been shattered because of a suspicion on the part of one of the participants that his collaborator was reaping an undue share of the honor or gain. Yet there are many outstanding examples of brilliant pieces of cooperative research, such as those of Liebig and Wöhler just mentioned, upon oil of bitter almonds and uric acid, that of Bunsen and Kirchoff upon spectrum analysis, that of Michelson and Morley upon the velocity of light, that of Rayleigh and Ramsay upon the isolation of argon, and those of Lawes and Gilbert upon the fertilizer requirements of crops.

Administrative burdens and irritations have proved in many cases very harmful to the successful performance of cooperative research. On the other hand, where the administrative faculty is coupled with investigational ability in the person of an inspiring teacher or director great results have been accomplished. This was splendidly illustrated in the school of chemistry which Liebig established at Giessen over a century ago. The method of Liebig is one which can always be followed with profit. It was described by one of his American pupils, the late Professor S. W. Johnson, in the following words:

It was in that spirit that Baron Liebig instructed the students who gathered in his laboratory from all quarters of the globe to learn the art of making discoveries in science. They were set to testing the truth of some idea, or the connection of some fact; or else to make new observations and discover new facts to lead to new ideas. It was not the novelty or the glory of discovery, but the genuineness of discovery that was regarded as of first importance. He listened patiently to their accounts of each day's progress, considered their plan of investigation, saw the apparatus or arrangements they devised, witnessed the observations they were led to, and heard the theories they imagined. He encouraged, but he criticized. He asked questions, suggested doubts, raised objections. His students were required not only to collect facts, or supposed facts, and to connect and complement them by comparison, analogies, and theories but they were made to attack their theories in every weak point and to verify or disprove the supposed facts by scrutiny from every side.

The fruits of Liebig's teaching are a sufficient proof of the value of this method of instruction.

A more modern illustration of the same type was the school of research conducted by the late Emil Fischer at Berlin. Here was a wonderfully gifted man with a clearly defined vision of the problem to be solved and of the means for its solution and who by assigning to each one of his coworkers a specific phase of the problem was enabled by such cooperation to make contributions to organic chemistry of stupendous magnitude and importance. Other examples of what can be accomplished by cooperative research under capable sympathetic administration can be cited in the case of many modern industrial organizations, engaged in the manufacture of electrical supplies, photographic goods, optical instruments, dye-stuffs, medicines and numerous other commodities. In this instance the collaborating investigators are actuated not only by a love of science but in many cases by the financial inducements of greater income. The poet Schiller once remarked in a famous couplet that

Science to one is the mother revered by the gods; to another
Only a cow whence to squeeze profits in butter and cheese.

Some investigators, adopting the heavenly goddess view-point, regard the practical application of science to industry or commerce as degrading and mercenary; other investigators, adopting the milchcow attitude, regard research that is purely scientific as speculative and unprofitable; a third and much more sensible group takes the intermediary view that science should be cultivated with the double purpose of adding to theoretical knowledge and of contributing to human welfare. This was the attitude, I remember, of Professor Nernst in the school of physical chemistry which he established at Göttingen. He applied his theoretical investigations upon the electrical conductivity of the oxides of rare earths to the invention of a new electric lamp, and his conduct in doing this at a university devoted to pure learning was the occasion of criticism by some of his academic colleagues. Without disdaining at all the value of purely theoretical studies, we can truthfully say that only those scientists have earned the name of benefactors who have made a practical utilization of their discoveries either by increasing the means of human welfare and comfort or by removing the causes of disease and suffering. Yet it must be remarked that many inventions of the greatest utility were the indirect result of a discovery in pure science, the practical bearings of which were unforeseen or disregarded at the time.

The scientific research work of the Department of Agriculture, being in the interest of the oldest and most important of human arts, must, in its ultimate analysis, be of a most practical utilitarian character. A strict observance of immediate practicality would, however, be unfortunate in the selection of research projects, for had such a rule been universally applied some of the most important investigations in agricultural science would never have been undertaken. This is particularly true of plot experiments with soils and fertilizers such as were initiated at Rothamsted in England over eighty years ago and which are still productive of results of the greatest practical value. It is in the case of agricultural researches, which must extend over long periods of time, that a cooperative campaign is especially desirable.

We are beginning to realize more and more that the demarcations between some of our sciences are largely conventions. The boundaries of one science continually encroach upon the territory of others and it is in that fertile borderland where chemistry, physics, biology and other fields of knowledge overlap that the greatest discoveries are now being made. The biologist who, in his quest for truth, strays over the grounds of his neighbor, be he chemist, physicist or geologist, is no longer stigmatized as an intruder but is greeted instead as a welcome visitor. It is in the cultivation and encouragement of this friendly cooperative spirit between men working in different fields of research that academies of science, such as the one which you are now establishing, can serve a most useful and deserving purpose.

Numerous examples can be cited of the great benefits which have resulted from the encouragement of cooperative research by academies of science. I will select only one typical illustration in my own special field of agricultural science.

In 1834 Dr. Pallas, head physician of the military hospital of Saint Omer and the owner of a maize plantation in French Africa, presented to the French Academy of Sciences an interesting observation upon the apparent changes in sugar content of corn-stalks

during their period of growth. The question was referred by the academy to a joint committee of chemists and physicists who after consultation recommended that Pallas be encouraged to continue the investigation which gave promise of leading to conclusions of scientific and industrial importance. In a later report Pallas stated that by removing the ears of corn at the beginning of their development the sugar content of the stalks seemed subsequently to undergo a considerable increase. This important observation was referred by the academy to another committee of distinguished scientists, consisting of the agricultural chemist Boussingault, the physical chemist Regnault, the industrial chemist Payen and the physicist Biot, who reported that the conclusions were of such importance to plant physiology and industry that the problem would be taken over by Professor Biot for accurate analytical verification. Biot's brilliant solution of this problem, contained in the *Comptes Rendus* of the academy for 1842, not only verified Pallas' statement as to the increase in sugar content of cornstalks as a result of removing the ears, but it marked the establishment of a new polariscopic method, using the principle of inversion, for determining cane sugar in mixtures of other sugars—a now universally employed method which has been of inestimable value not only to pure science but to agriculture and industry in all parts of the world.

In this instance it is seen how the French Academy served not only as an agency for recording the date of an interesting scientific observation (a service of importance in settling disputes about priority) but also as a clearing house for securing the needful cooperation without which the statements of Pallas would have remained mere matters of conjecture.

For its best results cooperative research between different scientists requires frequent and open discussion. It is the opinion of many that an investigator should be uncommunicative about his ideas and results until his material is ready for publication. This is a safe rule for the solitary conservative worker who dislikes to receive criticisms or suggestions, who wishes to avoid the annoyances of premature publicity and who desires to prevent a misappropriation of his ideas by others. Cooperation in research requires, however, a loyalty and mutual confidence on the part of all members of the group who should naturally respect the wishes of each collaborator as to a policy of silence or publicity. A friendly discussion and criticism of each other's work within a group of collaborators will not only prevent the performance of useless work, but it serves to develop latent ideas which otherwise might never have been conceived. Some very brilliant scientific conceptions have been evoked by the random remark of a friend or coworker.

One of the great advantages of cooperative research, especially in a field that has so many factors and variables as agriculture, is the benefit to be derived in the interpretation of results. Probably no two scientists will draw exactly the same conclusions from a complex table of data and it is very desirable that results which are affected by numerous variables be interpreted from every possible angle. Great improvements have been made in recent years in statistical methods of analyzing numerical data, and these have been applied very successfully in agricultural research, not only to present investigations but to the results of old experiments. No less an authority than Sir John Russell, the present director of the Rothamsted Experiment Station, has declared that "a massed attack by a competent band of statisticians on the whole of the data of the best Experiment Stations, dealing with yields of crops under different conditions of nutrient supply, temperature, rainfall and other factors that go to make the aggregate called season, would yield information of extraordinary value."

It is important also during the course of a research that the accumulating data be frequently collated and studied by every collaborator in the investigation. The director of the research should go over the discussion of the data with all his coworkers, who will thus be kept in close acquaintance with the plan and progress of the work. Many valuable and expensive investigations have suffered from the death or resignation of the one scientist who was familiar with all the ramifications of the work and who alone was able to interpret the results. This could have been prevented by a more thorough plan of collaboration. One of the best illustrations of constant cooperation in agricultural research is the one employed at Rothamsted, which has already been referred to. The field plots there, according to Director Russell, "are under continual observation by a group of three workers, a physiologist, an ecologist, and an agriculturist, who study such factors as rate or habit of growth, earliness of starting or maturing, degree of resistance to insect or fungus attack; their observations are fully recorded and brought before the chemical, physical and botanical departments at regular and frequent intervals. Certain of the experiments are repeated at other centers on closely similar lines for purposes of comparison. In consequence the old field plots which have been studied for the past eighty years by Lawes, Gilbert, Warington and Hall, and might have been supposed to have no further tales to tell, are found to be still yielding results of great interest in agricultural science and practice."

It may seem contradictory to state that the most successful specialist is the one who does not always specialize. The truth of this apparent paradox can be made evident by referring again to research work in

agriculture where chemists, entomologists, plant physiologists, pharmacologists and other specialists must frequently cooperate in the solution of a common problem. It is because of this growing need of close collaboration that a scientist, in addition to attending meetings which are devoted exclusively to his own specialty, should participate also in scientific gatherings of a more general character, such as those of the American Association for the Advancement of Science or of some state or local academy of sciences, where botanists, chemists, geologists, physicists and other investigators meet for the discussion of their common problems. The great benefit of such general meetings and discussions can hardly be overstressed.

It is interesting to follow the developments of the various academies of science in different countries and to note the varying directions which the activities of each have taken. One academy will be found to lay more stress upon the rôle of science in education, another upon applied science, another upon experimentation, another upon the publication of books of outstanding scientific merit and another upon the advancement of the national culture.

The earliest association in the United States to bear the name of academy was the American Academy of Arts and Sciences, chartered at Boston in 1780. Its establishment was a part of a general movement, typified by the American Revolution, to become independent of European tutelage in all matters of national development, not only in political affiliations, but also in literature, science, art and industry. This patriotic motive was also strong in other scientific academies and lyceums which were established in the decades following the Revolution and the War of 1812. These institutions have had a varied history. Some of them, after a brief period of activity, languished and became extinct. Others that were more fortunate in location and in membership have been able to survive. The American Academy of Arts and Sciences, just referred to, is still most active and awarded grants from its permanent science fund last April of $4,670.00 to research workers in different states.

The oldest of our state scientific academies is the Maryland Academy of Sciences whose interrupted existence and several reorganizations are typical of similar developments in other American scientific societies. The Maryland organization dates back to The Academic Society, founded in 1797 by the artist Charles Wilson Peale and reorganized in 1819 by Dr. L. H. Girardin as the Maryland Academy of Science and Literature. After successive periods of prosperity and decline it was again reorganized in 1866 under the present name. The Maryland Academy of Sciences owns its own buildings in Baltimore, where it maintains a library, museum, observatory, lecture hall and laboratories. Its main objects "are to maintain a museum of science and natural history with adequate services for the public; to provide its members with opportunities for study, research and self-improvement; to provide suitable lectures, instructive discussions and conferences, and to aid in making known the resources and advantages of the State of Maryland."

Another example of suspended activity is the case of the Western Academy of Science, which was founded in Saint Louis in 1837 and was perhaps the first scientific society for cooperative research established west of the Alleghanies. After a brief period of progress, the society began to languish and finally ceased to exist. In 1856 the society was recreated under the present name of the Academy of Science of Saint Louis, which inherited the library, collections and apparatus of the older organization.

There are now 29 state and local academies of science in the United States which are affiliated with the American Association for the Advancement of Science. One great advantage of this affiliation is the incentive which it gives to the cultivation of the cooperative spirit in scientific research. It is hoped that your newly established Florida Academy of Sciences will also belong to this group of affiliated societies, who are all actuated with the common purpose of promoting scientific research and diffusing scientific knowledge. In addition to these two chief motives may be mentioned also certain other aims which are expressed in the constitutions of some of these affiliated societies, such as unifying the scientific interests of the state, promoting an interest in various departments of science, providing means for the prompt publication of papers or abstracts (a valuable service to those who wish to announce a discovery), providing opportunities for increased cooperation and fellowship, rendering public service in scientific matters and cooperating with other scientific bodies having similar aims.

It must be admitted that some of the older academies of science, in Europe as well as in the United States, have declined in later years with the rapid growth of individual scientific societies to which allegiance has been transferred. This decline can be attributed in most cases to the neglect of the cooperative spirit. Interest was kept alive in the days of the old academies by the fact that the biologist or the chemist or the geologist could comprehend what scientists in other fields were saying. As soon as the language of each science became so highly technical that it was no longer intelligible to specialists in other branches, then the members of the general science bodies, like the workers at the Tower of Babel who could no longer

"understand one another's speech," began to disband and go their several ways. It is no wonder then that the annals of some of our local academies of science have become disappointing records of dwindling membership and declining interest.

There is, however, a greater need of such academies of science as the one which you are now inaugurating than at any other period in our country's history. Such organizations may be assured of a lasting success provided they serve not only the wants of its members but also the cultural needs of the civic communities in which they are placed. Science has its cultural side as much as literature and art, but it must first be humanized, and the humanization of science consists simply in making it intelligible and interesting to every man, woman and child.

Just one hundred years ago our great American philosopher, Ralph Waldo Emerson, gave a lecture upon the "Humanity of Science," and one of the means which he recommended for giving the sciences more of a vital human interest was a study of the history of the sciences. The story of the struggles, disappointments, trials and successes of each great man of science carries with it lessons and inspirations which appeal to every child. The public should be informed not only about the history of science in general, but its interest should be aroused in the past contributions to science by the citizens of its own community and state. In the stimulation of such interest the academies of science in our different states can perform a most useful service.

The interest of the younger generation in scientific matters must also be aroused. A half century ago many of our schools had natural history clubs known as Agassiz Associations which by excursions and meetings were very useful in awakening a love for science among its youthful members. Our various state academies of science might well foster the establishment of similar clubs in our schools to-day. In fact, the establishment of junior academies of science and of high school science clubs has been actively sponsored in recent years by several of the more progressive state academies of science. Awards of diplomas of merit to young students for deserving essays upon scientific subjects would lend great encouragement to this movement. Such efforts are not wholly disinterested, for the academies later on can count upon these clubs as recruiting grounds for increasing their own memberships.

The program, ladies and gentlemen, of this first meeting of the Florida Academy of Sciences augurs well for the future of your organization. Its success will be measured not only by the immense satisfaction that you will derive from the mutual exercise of the cooperative spirit, but it will be determined to a vastly greater degree by the services which you can render to the cultural needs of the community, the state and the nation.

# OBITUARY

## JULIUS ARTHUR NIEUWLAND

JULIUS ARTHUR NIEUWLAND was born at Hansbeke, near Ghent, Belgium, on February 14, 1878. He died unexpectedly of an acute heart attack in the chemical laboratory of Catholic University, Washington, D. C., on June 11, 1936. A few days previously, at the annual commencement of the University of Notre Dame, he appeared in the best of health and spirits.

His parents moved to South Bend, Ind., when Nieuwland was about three years of age. He grew up in the city much as any other boy. He collected stamps and birds' eggs; but, unlike so many other naturalists, subsequently never took any interest in birds. He attended a local German parochial school; was graduated from the University of Notre Dame in 1899; was ordained priest in the Congregation of Holy Cross in 1903. He studied botany under Professor E. L. Greene and chemistry under Professor John J. Griffin at Catholic University, Washington, D. C., from which he received a Ph.D. degree in 1904.

From that time until 1918 Father Nieuwland was professor of botany at the University of Notre Dame. From 1918 until his death he was professor of organic chemistry, serving as dean of the College of Science during the years 1918 to 1922. He served as curator of the University Herbarium, of the Greene Herbarium and of the Greene Botanical Library. While he was professor of botany he used to make sets of histologic preparations and sell them, the proceeds being used in buying books for his library, which contains many old and rare volumes.

His interest in botany, while broad, was mainly devoted to the taxonomic study of the flowering plants and ferns. He never lost his interest in these groups. He often used to point out places in South Bend that once were swamps and good botanical collecting grounds, which are now well-paved city streets. His herbarium numbers about 20,000 specimens, mostly collected by his own hands, and from various parts of North America. Wherever he went he usually found time to send back at least a few plants. He was a conservationist in the broad sense; and, if there were but a single plant in an unusual locality, he was always careful to take just enough of the plant for identification and leave the rest for propagation. He deprecated the promiscuous draining of swamps and