the Grants Committee to distribute during the year 1921.

On the Jane M. Smith fund the following were appointed with power to act during 1921: L. O. Howard, W. J. Humphreys and B. E. Livingston.

Among the resolutions adopted by the Council are the following:

Be it resolved: That the American Association for the Advancement of Science would welcome the organization of Mexican men of science, and their affiliation with this Association.

Resolved: That a committee of seven be appointed to cooperate with such organization as Mexican men of science may form.

The following were appointed on this committee: L. O. Howard, *Chairman,* A. E. Douglas, E. L. Hewitt, D. S. Hill, W. J. Humphreys, D. T. MacDougal and W. Lindgren.

Whereas the American Association for the Advancement of Science includes sections on Physiology, Experimental Medicine and Zoology, and

Whereas advancement of knowledge in these sciences, which is dependent upon intensive study of living tissue, is inevitably followed not only by amelioration of human suffering, but also by a lessening of animal disease and by substantial economic gain and by conservation of the food supply, and

Whereas this association is convinced that the rights of animals are adequately safeguarded by existing laws, by the general character of the institutions which authorize animal experimentation and by the general character of the individuals engaged therein,

Therefore be it resolved, that this association agrees fully with the fundamental aim of those whose efforts are devoted to the safeguarding of the rights of animals but deprecates unwise attempts to limit or prevent the conduct of animal experimentation such as have recently been defeated in California and Oregon, for the reason that such efforts retard advance in methods of prevention, control and treatment of disease and injury of both man and animals and threaten serious economic loss, and be it further

Resolved, that a copy of these resolutions be included in the official records of this Association, and that copies be sent to the national congress, to the legislatures of each state in the union and to each member of the Association.

Whereas, clean culture of roadsides and the drainage of marshes in the United States is imperiling the existence of the wild-life of our country not now included in special preserves, and

Whereas, the preservation of this wild-life not in preserves is felt to be of great national importance not only to students and lovers of nature, but to human welfare in general, therefore,

Be it resolved, by the council of the American Association for the Advancement of Science, that it appreciates the importance of preserving this wild-life not in preserves, and that it lends its moral support to the effort to combine all interested organizations in a cooperative investigation and conservation program for the preservation of our unprotected wild-life.

Whereas, in recognition of the unique character and value of our National Parks and Monuments to present and future generations, twenty-four successive Congresses have wisely resisted attempts to commercialize them and have preserved them inviolate for nearly half a century,

Whereas, certain private interests are now seeking to secure special privileges in these areas, which if granted will seriously interfere with their true purpose and undoubtedly result in the entire commercialization of these unique national museums,

Therefore, be it resolved, that the American Association for the Advancement of Science request members of Congress first to amend the Water Power Act so that it shall not apply to National Parks and Monuments and that their full control be restored to Congress, and second, to reject all present and future measures which propose to surrender any part of these National Parks and Monuments to private control or to divert them in any way from their original and exclusive purpose, the preservation for all future generations of unique representations of natural conditions such as exist in no other part of the world.

SOME ECONOMIC PHASES OF BOTANY[1]

It is an old custom for the retiring vice-president of this section to deliver an address.

[1] Address of the vice-president and chairman of Section G, botany, American Association for the Advancement of Science, Chicago, 1920.

These addresses have taken various forms; in some cases a review of the achievements in some particular phase of botany; others have looked to the future. It has been my pleasure to have heard many of the addresses on these annual occasions for thirty years, and I feel sure that they have epitomized the botany for the time. As I look back I find there was much of inspiration in these addresses. We regret that some of the men who sounded the keynote at these gatherings are no longer with us. It is interesting to look back to see what was uppermost in the minds of the speakers on these different occasions: N. L. Britton, "Botanical Gardens"; J. C. Arthur, "Development of Vegetable Physiology"; L. M. Underwood, "The Evolution of the Hepaticæ"; T. H. Macbride, "The Alamagordo Desert"; D. H. Campbell, "The Origin of Terrestrial Plants"; H. C. Cowles, "Economic Trend of Botany"; B. T. Galloway, "Applied Botany Retrospective and Prospective"; William Trelease, "Some Twentieth Century Problems"; Charles R. Barnes, "The Progress and Problems of Plant Physiology"; W. G. Farlow, "The Conception of Species as Affected by Recent Investigations on Fungi"; Geo. F. Atkinson, "Experimental Morphology"; R. A. Harper, "Some Current Conceptions of the Germ Plasm"; F. C. Newcomb, "The Scope and Method of State Natural History Surveys"; Duncan S. Johnson, "The Evolution of a Botanical Problem"; Geo. P. Clinton, "Botany in Relation to American Agriculture"; H. M. Richards, "On the Nature of Response to Chemical Stimulation"; C. E. Bessey, "The Phyletic Idea in Taxonomy"; D. T. MacDougal, "Heredity and Environic Forces"; B. L. Robinson, "The Generic Concept in the Classification of Flowering Plants"; A. F. Blakeslee, "Sexuality in Mucors." Dr. Coulter in his address as president of the association spoke on "Botany as a National Asset."

In reading these addresses one certainly feels that a wide range of thought and investigation is covered. When I began to reflect on a topic suitable for an occasion of this kind, and suitable for one who has been engaged in trying to interest students and help to solve some of the problems confronting those who have to deal with the economic phases of our subject, it occurred to me that "some phases of economic botany" would give me a chance to offer some suggestions that might be a stimulus to bring together the varying interests of botany.

HUMAN INTEREST OF BOTANY

Botany should, first of all, have an intensely human interest from the standpoint of our well being. If we recognize this fact then plants should be studied not only for what use they may be to man directly and indirectly, but we must recognize also the cultural value of botany in schools, colleges and universities. Those who have had something to do with the park movement in the United States appreciate, of course, that the general interest in plants is really greater now than ever before. The layman to-day takes intense delight in the great out of doors and he does so for the pleasure he gets out of contact with nature. To such men and women a knowledge of plants becomes an intensely fascinating subject. They are becoming as truly cultured as the men or women who studied Shakespeare or any other of the great writers. This is a new culture which I think means much to the human race and our profession. It develops the highest instincts and elicits highest emotions. Let us not forget that the much despised taxonomic botany has a real place in our life, especially for those who have come to look upon the out of doors as a means to enjoy life.

EARLY ECONOMIC BOTANISTS

Let us take a little retrospective view of the subject. Botany began as an economic subject. Dioscorides, Pliny, Aristotle and Theophrastus were observers who gave to the world what they observed in the plant kingdom, largely on economic plants. Moreover they related in good form what previous writers had observed, with comments on cultivation. Theophrastus and Pliny both made some ecological observations which were destined to play an important part in investigations of the future.

WHAT THESE MEN OBSERVED

Let us frankly recognize the service these men rendered to increase our knowledge of plants. The plant pathology of these earlier writers was primitive of course and the plant pathologist of to-day would hardly class this early work under that term. This knowledge of the ancients was buried for centuries, in which little attention was given to botany or related subjects, but we may feel sure that during the "Dark Ages" man was intensely interested in the economic phases of botany although we have little written evidence of such interest. Botanists of long ago paid some attention to medical botany. We need only recall that such treatises as Gerard's "Herbal" and later the painstaking work of Hayne, "Die Arzneigewähse," Rafinesque, "Medical Flora," and many others of the old writers up to the modern work of Millspaugh, "American Medical Plants," Kraemer, "Pharmacognosy," and Luerssen, "Handbuch der Systematischen Botanik," have kept us up with the times.

We know that the Crusaders brought from Asia and eastern Europe medicinal plants, cereals and fruits that made possible the highest type of civilization, for improved plants accompanied a revival of learning. We may be sure that during this epoch the economic phases of plants were studied because of the importance of increasing the food supply. The knowledge gleaned was passed on to the next generation to be of some use to man, and followed by the work of others who for the most part were observers, and our science, it must be said, began in observation. Men like Robert Morison, a close student of Cesalpino, Kasper Bauhin and others, added a little to the knowledge of previous botanists. John Ray and Francis Willoughby became interested in another phase of economic botany; they conducted experiments on the motion of sap in trees. Ray was generous to his predecessors like Grew, Jung and Malpighi. The old myth that wheat will degenerate in chess probably started with Ray, because he published a statement that *Triticum* could be changed into *Lolium*. Malpighi, the father of microscopical anatomy, gave a fair account of the structure of plants, including the ducts and the Malpighian cell. Economic plants always received special attention.

The English philosopher, Robert Hook, gave a fair account of cork, which he had studied with his improved compound microscope. He investigated the nature of food of plants.

Grew, in his "Anatomy of Plants," outlines in a masterly way the architecture of plants, interwoven however with the philosophical and theological prejudices of the time.

Bachman, who was a botanist, physiologist, pharmacologist and chemist, appreciated morphology and taxonomy. He introduced binomial nomenclature, and the reason given by him was that a prescription could be written easier. Think of it, that we as botanists are indebted to medicine for the naming of plants. Bachman refused to recognize cultivated varieties as species. Tournefort had only to go a step to recognize genera which he did in a splendid way. The last link in the chain of the botanists who were influenced by the older school was Linnæus, who borrowed from his predecessors like Cesalpino, Jung, Bachman and others, but always with fulsome praise of the work of his contemporaries and predecessors.

Sachs says:

> We are astonished to see the long known thoughts of these writers (Bauhin, Cesalpino, Jung), which in their own place look important and incomplete, fashioned by Linnæus into a living whole; thus he is at once and in the best sense receptive and productive.

Linnæus thought it important to know all species of plants. His "Philosophica Botanica" was a splendid text-book of botany. There was nothing else like it for more than a generation, at least there was nothing that equalled it in clearness and completeness. He was not an experimenter and cared little for it. In Germany, under his influence taxonomy degenerated into mere plant collections, collectors calling themselves taxonomists.

POST-LINNÆAN BOTANY

A new era opened with such men as Jussieu, Gaertner, DeCandolle, Robert Brown, Adanson, Endlicher who knew how to observe and interpret the things they saw. Experimental work with plants became more important; botanists began to ask the why about plants; and so E. Mariette, one of the first experimental physicists, studied the salts of plants and the active forces of attraction and nutrition.

Martin Lister directed attention to the movement of water in plants. Christian Wolff, too, experimented on the nutrition of plants. Stephen Hales in his "Statistical Essays" sought to trace back the phenomena of vegetation to mechanico-physical laws, as then understood, and studied the water taken in by plants and its exit by the leaves and the formation of solid substances.

The discovery of oxygen by Priestley was important in plant physiology, but he missed the important discovery that light is a vital factor in making plant food. This was left to Jean Ingenhousz, whose experiments showed that purifying of air goes on in light only. This led him to study the food of plants and the improvement of soils. He discovered that plants use CO_2 and under the influence of light make plant food. Jean Senebier was the first to give a clear statement of the process of photosynthesis. We are indebted to the chemist, DeSaussure, for his discoveries, which laid the foundation in an experimental way of the process of food-making in plants. It is a long way from the researches of these pioneers to the work of Boussingault's quantitative methods of studying the food requirements of plants, especially with reference to nitrogen, and the work of Sprengel on ash constituents and Liebig's work, "Chemistry in its Relation to Agriculture and Physiology." These greatly helped to advance plant physiology, as did also the work of Lawes and Gilbert on the mineral constituents of plants and later the pot culture method of Knop, Sachs, and the work of Lachmann, who in 1858, spoke of the "Vibrionenartige" organisms found in leguminous nodules. Later the work of Schloesing and Muntz, Warrington, Beijerinck, Winogradsky, Hellriegel and Wilfarth and many others made secure for ever a better agricultural practise. Added to the knowledge of the importance of the legume bacteria the important discoveries of Wollny and Berthelot show that bacteria in the soil are the makers of plant food.

Plant physiological work in Europe made rapid strides through the labors of Detmer, Pfeffer, Sachs, Jost, Palladin, Haberlandt and many others. The question of photosynthesis long remained obscure because of insufficient chemical study of the plant pigments. The environmental factors were partially determined by F. B. Blackman and then Willstatter and his coworkers determined the chemistry of chlorophyll, which enabled plant physiologists to better understand the problems of carbon assimilation. Jorgensen and Walter Stiles in their résumé say:

> No prophetic vision is needed to foretell development in plant physiology as great as those which were produced by physics and chemistry in engineering and other technical sciences.

It is refreshing to observe that a soil physicist like Edward Russell in his paper "Soil Conditions and Plant Growth," should put stress on plant physiological problems as fundamental to a study of soils and plant nutrition.

Jung did not entertain any definite idea of the sexuality of plants nor did Grew have a clear conception. Rudolph Camerarius, however, settled the problem by making experiments with maize and mulberry, two economic plants.

We can only marvel at the economic trend of the work of Leewenhoek in the study of linen, who made the discovery of minute organisms, and thus repudiated the theory of abiogenesis. People became curious to study the hitherto unseen world. The use of the microscope in the hands of the curious was not for scientific or practical purposes, but gave source to wild speculations in disease and the origin of life. However, its useful day came many years later, when its discoveries were made use of in many practical problems, connected with disease of plants and animals and the physiological problems in connection with crop production.

PLANT PATHOLOGY

Meyer, an extraordinary man who died at the age of thirty-six, published a work on phytopathology, a paper on corn smut and one on actinomyces. He was a physiologist and looked at the problem of disease from the standpoint of physiology, really the only way the subject should be treated. Camerarius seems to have antedated the work of Meyer by over one hundred years in the publication of his paper "De Ustilagine Frumenti." Julius Kuehn was primarily an agriculturist and as director of the Agricultural Institute at Halle started a series of experiments on plants that have become classic. While thus engaged in the work he became interested in a study of the diseases of plants. To him we owe the first comprehensive treatise on plant pathology. He had breadth of vision to study and interpret what he saw with the microscope and thus there came into being "Die Krankheiten der Kulturgewächse," which stands as a monument to his labors. It is the only botanical paper by him listed by Pritzel in his Thesaurus. M. J. Berkley's work, "Introduction to Cryptogamic Botany," gave to English-speaking people the first real treatise on plant diseases, which laid a sure foundation for a study of plants, along economic lines.

All of the work on plant diseases and the anatomy of plants was better established later through the classic work of DeBary. DeBary, of course, did not have, except in some cases, the practical problems in mind, though the science of botany and plant pathology in particular have been greatly benefited through his profound researches in connection with the development of life history of fungi. DeBary brought to the science of mycology a breadth of knowledge along many lines of botany and one marvels at the enormous amount of research work he did. Nor should we omit to mention the great work of Tulasne (who had the merit of first breaking the ground in a study of rust, smuts and ergot), on the discovery of the germination of the spores of rusts, smuts and the sexual organs of Peronospora. While these researches did much for mycology, indirectly they have been of great practical importance to pathology. Robert Hartig, perhaps the foremost student in the world during his lifetime of the diseases of forest trees and the decomposition of wood, exerted a great influence on the practise of forestry, followed later by the splendid work of Marshall Ward, a student of Hartig. We may mention in this connection the work of Fischer de Waldheim, Wolff, Sorauer, Appel, Millardet, Prillieux, Jones, Halsted, Arthur, Bolley, Atkinson, Stewart, Whetzel, Freeman, Clinton, Thaxter, Duggar, Stakman, Cook, Stevens and Melhus. These as well as a host of others, added to this economic phase of botany, making secure the science of plant pathology. I need only add here that the stimulus given by these men to this economic phase of botany has been communicated to all parts of the world; and so we may mention especially the pioneer work by Dr. Farlow on Gymnosporangium, grape vine mildew, onion smut, Dr. Burrill on apple blight and sorghum blight, the epoch-making researches along the line of bacterial diseases of plants by Dr. Erwin F. Smith. Surely America may well be proud of its achievements. The present age has hundreds of new problems in plant pathology. The superficial only was touched on by the early workers. We may mention especially the root disease of cereals and other crops. The plant pathological studies on these parasites has changed our methods of agriculture completely. We need more careful and profound work on many of the problems worked upon by the pioneers. The pioneers who blazed the way may be excused for errors, but the modern investigator should not be. He has the equipment and money and should do good work.

POLLINATION OF FLOWERS

Another phase of the subject of economic botany is that of pollination. Progress was slow. Geoffroy, who as early as 1711 made some observations on the nature of the style, is said to have conducted some experiments with maize; however that may be he did make use of the work of Camerarius. Geoffroy concluded from various sources that fertilization was a kind of fermentation, but he was inclined to accept a second view of Morland that the pollen grains contain the embryo which find their way to the seed. We may also recall the work of John Logan, at one time governor of the colony of Pennsylvania, who conducted experiments on the fertilization of maize, in which he noted that cobs covered with muslin did not produce seed, but seed was formed on cobs where pollen came in contact with the stigmas. Logan suggested that the wind carried the pollen. Gleditsch in a study of one of the palms (*Chamærops humulis*) strewed loose dried pollen on the stigmas of a female plant which produced seed which later was planted and germinated; a simple experiment but a convincing one to the botanists of the time, who had never seen pollination demonstrated before. Philip Miller in 1751 calls attention for the first time to the importance of insects in the pollination of tulips. The first scientific experiments on hybrids were made by Koelreuter, who discovered the use of nectar and the importance of insects in the pollination of flowers. Koelreuter clearly set forth the facts that the mingling of two substances produced a seed. These general statements as set forth by him still hold true. He was a skillful experimenter in the hybridizing of plants. The work of Sprengel on the pollination of flowers is well known to the older botanists. His sharp discriminating observations on the relation of insects to flowers were little understood at the time. The full import of these problems were recognized by Charles Darwin, who in his masterly way showed the application of this in practical problems. Earlier Sir Andrew Knight had demonstrated "that no plant fertilizes itself through an unlimited number of generations." Dr. Gray put this in a much more terse way. A score of investigators like Hermann Mueller, Fritz Mueller, Delpino, Ludwig Axell, Hilderbrandt and in our country men like Gray, Trelease, Riley, Foerste, Beal and Robertson demonstrated the use of insects in pollination and the application of this fact to important agricultural crops. These fundamental facts are fully recognized to-day in the growing of apples, alfalfa, sweet clover, melons, squash and cucumbers. The orchardist recognizes the importance of bees in connection with the growing of apples, pears and plums. The farmer recognizes the importance of bees in the alfalfa and sweet clover fields, just as Charles Darwin recognizes that the bumble bee is important in the red clover pollination. In this connection, as an economic problem, I may call attention to the honey flow in flowers. It is true beekeeping is only one of our minor agricultural problems dependent entirely on the relative abundance of honey plants in a given region. There are a great many interesting physiological problems in connection with nectar secretion, as Kenoyer has shown. One wonders why alsike clover scarcely yields any nectar for bees in Iowa and yet in some regions of the country it is one of the best of nectar plants. There is seldom any nectar in buckwheat flowers after 10:00 A.M. in Iowa, and yet in sections of the United States the period of nectar flow is much longer. Is soil alone a factor or is moisture an important factor, or are the two factors combined? We have enormous expanses of waste land along our highways in the United States, why not combine the esthetic with the economic if we can find plants that are suited for such places that will yield good returns for the beekeeper.

PLANT BREEDING

I heard a practical fruit grower in Iowa say the other day when a new chance seedling apple was shown me that nearly all of the new good things in the fruit line are chances; that is to say the new productions by Burbank, Hansen, Patten, Beach, Hedrick, Webber and many other plant breeders are not equal to those found in nature. I need only recall the many fine things the modern plant breeder has produced. Of course, new types will always appear, as they have in the past. The work accomplished, it seems to me, will justify larger expenditure of money.

In the matter of fundamental study of these problems practical agriculture, horticulture and floriculture are indebted to the classic fundamental work of Hoffmeister and Strasburger. This work led up to and explains the physical basis of Mendelism discovered by Gregor Mendel, a work that is most important in the breeding of new types. We have had a host of botanical investigators who have enhanced our knowledge of plant breeding, linking it with practical work like Nilsson, Johannsen, Bateson, Correns, Shull, White, Webber and Emerson. Agriculture and horticulture are indebted to the epoch-making work of DeVries on mutation. His work has set a score of botanists to work on the pedigree culture work. I may mention Nilsson, Johannsen and Gates especially. Possibly the outstanding problem of the pomologist in states like Iowa and Minnesota is that of hardiness. In breeding experiments at the present time it is necessary to set the trees out and test them for a term of years, to see whether or not this climate is too severe. Bakke in some recent experiments has found that by ascertaining the depression of the freezing and the moisture content at a time when all the tissues are in an active state of growth, it is possible to obtain an idea of the comparative hardiness of different apple trees. These tests have been made upon trees in the nursery as well as upon trees in an orchard, 10 years old, with practically the same results.

SEED STUDIES

After a consideration of pollination the matter of seed is of importance. The first great work published is that of Gartner, "De fructibus Seminibus plantarum." Gartner was free from the bias of those who preceded him. We have a truly modern work by one whom we may regard as a modern man of science. He made a comparative study, correctly determined the relation of the endosperm to the cotyledon and named the embryo. We have had a long line of investigators on the subject of seeds.

The practical application found expression in the work of Nobbe, Harz and others. We may recall the work of Nobbe in the testing of seeds at the small experiment station at Tharand, which was the beginning of the experiment stations such as we know them today. Nobbe did not merely do the mechanical part in connection with the testing of seed, but inquired into real scientific problems in connection with specific gravity, and the vitality of seeds under different conditions of storing. The germination of many seeds is of special concern to the agriculturist, because it is important to know under what conditions a seed will germinate best to bring the largest returns. It is a matter also of some concern for the farmer to know whether weeds' seeds have a varying period of vitality when buried in the soil, whether for instance the seeds of *Hibiscus Trionum* and *Abutilon Theophrasti* will come up in his fields after a quarter or half a century when he practises rotation of crops. The vitality and structure of seeds has of course received much attention. I need only recall the classic work of DeCandolle who more than a century ago studied the prolonged vitality of seeds. The data secured by DeCandolle is frequently quoted in text-books of plant physiology. Also much later work of Becquerel, Beal, Ewart and Hanlein on delayed germination, as well as the work of Crocker and his students like Shull, on the delayed germination of seeds, like wild oats and other seeds of economic importance. To Crocker we are indebted for an explanation of the delayed germination of such seeds as the cocklebur. Knowing that there is a delay in some seed the farmer is better able to follow a rational practise in the treatment of seeds. I am sure that most of you are familiar with the work of Schleiden and Vogel, Chalon, Malpighi, Haberlandt, Sempolwski, Beck, Moeller and Oesterle, Mattirolo and Buscalioni, Hanausek, Harz, Junowicz and many others who were interested in a study of seeds of Leguminosæ, particularly with reference to the light line. The writer more than a quarter of a century ago brought the literature on this subject together in his paper on the "Comparative Anatomy of Seeds of Leguminosæ." Comparatively little has been done since. Intensive studies on the seeds of such families as the Leguminosæ. Convolvulaceæ, Cucurbitaceæ, Malvaceæ, Tiliaceæ should be made because in most of these families where the light line occurs the seeds have a prolonged vitality. The subject has more or less of a practical bearing. The problem as to the nature of the light line in these seeds has not been solved. A number of present-day botanists, like Martin, Harrington and others are taking up the problem. Present-day investigations with seeds are bringing many valuable practical results in commercial seed production, as in clovers. The seed control work by the establishing standards of purity is a practical problem. The work in determining the conditions of germination, experiments with light, electricity, heat, moisture and drying and studies of seed coat are also important. The important problem of rate of maturing of seed in storage is being worked out. Seed-testing laboratories, while they are obliged to answer the immediate pressing problems on the impurities of seeds and their germination are engaged in a study of the more fundamental problems of the viability of seeds. It has been the custom for the American Seed Analysts Association to send to its co-workers seeds to test for purity and vitality. With careful treatment, there is still the greatest variation in the results. Presumably, in part at least, the methods used by seed testers is not the same and, therefore, the result can not be uniform. We should bear in mind that the viability is a matter of climate and condition of storage of the seed. The fundamental problems of every one of the great staple agricultural crops, so far as vitality of seeds is concerned, has not been entirely solved and awaits solution by the investigator.

The writer and Miss King, during the past few years, have continued investigations on germination of seeds of forest trees and shrubs. The results exhibit surprising irregularity and uncertainty in the germination of these seeds. Boerker, of Nebraska, has followed the same line of research. The work of Sir John Lubbock on Seeds and Seedlings and various papers of Tubeuf on seeds of forest trees, although purely morphological are always valuable for reference and bear in general upon forestry problems, of economic botany.

GRASSES

Botanists have long recognized the importance of grasses in our welfare. The prosperity of the United States outside of the rich natural resources of forestry, mines and water power is concerned with the economic production of cereals, cotton and livestock. Turning to some of the older works I recall the work of Sowerby and Parnell on grasses, Metzgar, "Die Gereidarten," Stebler and Schroeter, "Körnicke, Die Gebreidearten," and Hackel, "True Grasses." In our own country early works were Flint's "Grasses of Massachusetts," Klippart, "Grasses of Tennessee," Lapham, "Grasses of Wisconsin," Vasey, "Grasses of the United States," Lamson-Scribner, various papers published by the U. S. Department of Agriculture, Beal, "Grasses of North America," Hitchcock and Chase papers. These and other authors touching the economic problems of cereals, like Hunt, Carleton, Shear, Warburton and Ball have stimulated prduction but it would seem as though we have only scratched the surface so far as a study of the real problem of cereal production is concerned. It vitally concerns us as a nation to stimulate the production of cereals and forage crops because the ever-increasing population demands increased production. How can the botanists contribute more to the welfare of mankind than to study such problems as the physiology of the nutrition of the growing of wheat, maize, oats, barley and rice, or to make a study of pollination under different climatic conditions, or the breeding of varieties of cereals resistant to diseases? We might well consider the stupendous losses from parasitic fungi of cereals. There never was a time when research on cereals and other agricultural crops was as important as it is to-day. We have, on a large scale, undertaken the removal of the barberry in the wheat-growing section of the country, because the plant pathologists are convinced that the common barberry is an important factor in rust production. And yet, I was confronted with the frequent statement by practical men in western Minnesota that there is no barberry in this particular section. I certainly saw none in the immediate area to speak of, although there was some barberry thirty miles to the south. I could not make the questioner see the importance of the barberry in connection with grain rust. Some seasons no doubt there are actually viable uredo spores on grasses. The point, I think, we should determine to convince the wheat grower on is this: are the uredo spores viable in weedy grasses, and how far can the uredo spores be carried? The farmer who loses $3,000 on a quarter section of land in a single year of wheat-growing wants some solution of the problem. It is the duty of the government and the botanist to solve the problem for the country. Unless this is done by exterminating the barberry, the breeding of resistant varieties and the elimination of weedy grasses, the growing of spring hard wheats will be a thing of the past, and the farmer will be forced to turn his attention to the growing of other cereals, not subject to rust. The government and the states directly interested, can well afford to spend a half million dollars annually until the problem is solved.

WEEDS

The subject of weeds is related to that of plant disease. It greatly interests the farmer and gardener. The farmers of the United States, at least in some sections, have endeavored to remove by legislation some of the injurious weeds, expecting, of course, that the law would be obeyed and the weeds would soon be eliminated, but instead they are constantly increasing. As illustrations of weed legislation I need only remind you that some twenty-five years ago nearly all the northwestern states made it illegal to permit Russian thistle to grow. During these twenty-five years it has spread from the Atlantic to the Pacific. In Washington and Colorado where the conditions are suitable it covers the ground on little travelled roads and on the plains. In Iowa we made an effort by legislation to reduce the infested areas of quack grass, but it has so increased that the farm values in some cases are reduced because of its presence. During the past two seasons I have received a large number of specimens of knapweed (*Centaurea solstitialis*) from many points in Iowa and northern Missouri, distributed largely through alfalfa seed. Buckhorn (*Plantago lanceolata*) is rapidly interfering with clover culture in Iowa.

We have described weeds and how to eradicate them, because this is the kind of information the farmer wants, but we have not solved a single one of the important problems in connection with weeds. Weeds have an important bearing on the crops produced. The small ragweed no doubt reduces the efficiency of the Iowa pasture during the autumn months fully one half, the weeds of corn fields frequently cut the yield one third. How these yields are reduced has not been determined. How much do we know about the mechanical interference of weed roots and the agricultural crop? So far as I know, there is absolutely no data on the subject. Water is an important factor in crop production; therefore, a study of transpiration is of importance in connection with a study of weeds. It has been pointed out by Livingston that transpiration is practically a simple function of the leaf surface and that the total transpiration is a measure of the growth of a plant, whether it is one growing in a waste place or of economic importance.

Kesselback makes it clear that weeds such as sunflower use more than three times as much water per plant as corn. while water used per unit of dry matter was slightly more than double that of corn. In other words, a sunflower plant will consume as much water as a hill of corn. Brenchly in a recent publication states that weeds like mustards did better when they were associated with other plants, than when they were subjected to competition with their own species. Wheat is not so well able to overpower the *Brassica* and reduce its growth as is the case with some other weeds. Mustard would then, according to Brenchly, even in moderate amounts do considerable damage.

Possibly in the majority of places, even in the agricultural areas of the middle west, there are times in which there is not enough water to supply the needs of the plant. Water is used by a plant in large quantities and practically all of it passes off in the transpiration stream. Water being an important item, its conservation is a question which we must be concerned with. From the few citations given above we conclude that weeds do considerable damage to growing crops by consuming the moisture. Knowing that transpiration or the giving off of water by the aerial portions of a plant goes hand in hand with the leaf area, a study in which the leaf area and transpiration are measured from time to time at specific intervals should give us much information concerning the effect of weeds upon the crop in which they are associated, both in the greenhouse and in the field.

Some preliminary work done in plant physiological laboratory at Ames by Bakke shows that the matter of transpiration by weeds is an important item in crop production. In these experiments wheat, oats and mustard were grown together and, with one exception, it was found that the total transpiration for the mixed cultures is greater than for the pure wheat and oats cultures. The present study shows that wheat transpires during the growing season more than oats.

ECOLOGICAL PROBLEMS

Another phase of economic botany has interested me very much, namely the relation of plants to soil. This requires the best kind of taxonomic work if the ecological investigations are to be correctly interpreted. The national government in cooperation with various states is spending large sums of money to study soils. It is a good kind of investigation. The soils are carefully mapped on a scale as never before. The plant is an index of what the soil will produce and the aim of this work is to help the farmer. I am sure it does; and why should the botanists not cooperate with the geologist, and the soil expert make just as detailed a study of the plant life as the geologist does of the soil. In no place in the world can this problem be studied better than in the prairie states. There is scarcely anything left of the great prairie domain, except as we find it along the right-of-way of railroads. Should not a group of botanists in these prairie states study the ecological and taxonomic phases of the richest, virgin, agricultural soil in the world, as Shimek is now doing for the prairie plants of Iowa. What we need is a crop ecologist, who after a study of the problem, can tell the farmer just what crops can be grown together or what crops are best suited for his soil. Let us as botanists seek a closer cooperation with the soil expert.

I am reminded that Dr. Cowles in an address before this section called attention to the use of an ecologist to settle a legal question involving a large amount of money in regard to a meandered lake in Arkansas where a study of the problem by the ecologist disclosed the truth that the so-called lakes had been covered with trees much antedating the survey made by the government. I am told that in some surveys along the Mississippi the government instructions are to include all land to the limit of apparent line of vegetation. Who should determine the apparent line of vegetation; the surveyor, who generally knows nothing about succession, or the ecologist? It would seem to me, the ecologist.

EROSION

In a prairie state like Iowa every available area has been brought under cultivation, or the wooded areas have been turned into pastures. Millions of dollars worth of the very best soil in this great agricultural region are annually carried down the Mississippi, finally helping to increase the area of Louisiana, or to fill up the channel of the Mississippi River. The government to prevent disastrous floods builds levees. The water, under our present system of intensive agriculture, is rushed off as rapidly as possible, the little lakes are filled up with silt from the neighboring drainage area or they are drained. Drainage no doubt does help crop production but the water table has dropped twelve feet, according to McGee, in fifty years in Iowa. Now if the water table will show a further drop it is a question of vital concern to the agriculture of Iowa. Have we any plant physiological data to show how this has influenced crop production or the growth of trees? The botanist can do a real service by making a study of the movement of water in the soil and its relation to plant growth. We know that the climatic and edaphic relations of forests are important. Zon has given us a comparative study of the problem in his paper on "Forests and Water in the Light of Scientific Investigation." Then we may also recall the work of Pearson on the "A Meteorological Study of Parks and Timbered Areas in the Western Yellow Pine Forests of Arizona and New Mexico." and the work of Hall and Maxwell, Bray and Schwartz on forests and streams flow.

In order to determine the problem of water conservation and forest conservation, I. T. Bode made an investigation in one of our park areas in Iowa. The results are interesting, as showing the close relationship between forest cover and soil moisture. The results show unmistakably, even in a small area, that the forest cover keeps greater quantities of water in the upper soil layers, that these forest areas maintain a higher water level in the soil.

The conclusion to be drawn from the work and some done by others of the Forest Service is that all hills subject to erosion should be covered with timber.

AQUATIC FARMING

I have been more or less interested in the preservation of our lakes, not only because the community and state will receive the benefit of recreation, but our lakes and streams should furnish an important source of food, and also a source of income from the fur-bearing animals. The botanist should make more study of the food for fish and game. It is said that the little muskrat in Iowa has become so depleted that it will be necessary to have a closed season. Much of this depletion is no doubt due to trapping, but may not the food supply have some bearing on the problem? Take for instance the water-lily, which has become a somewhat rare plant in Iowa. How far does this plant and the lotus minister to the food of this little rodent? Sportsmen are agreed that wild rice and wild celery are very important food plants for the wild duck. Schofield has given us a practical method of germinating wild rice, yet we know almost nothing about the maximum yield of this plant and how it might be increased. There are millions of acres of land suitable for the growing of wild rice in the United States, especially in the northern Mississippi valley. It should be used more extensively for human food than it is to-day. We know little about the uses of aquatic plants by animals. May we not breed a variety of wild rice which will cling somewhat more tenaciously to the rachis? Some plant breeder should undertake the selection of plants with this in mind.

COOPERATIVE WORK

We have never in the history of the world had as much productive research work as now, although there may be a slight curtailment since the war. Our various journals, like the *Botanical Gazette, American Journal of Botany, Bulletin Torrey Botanical Club, Journal of Agricultural Research* and various publications from experiment stations, national government and academies of science are publishing an enormous amount of good material. All state, national and private agencies are working to increase the amount of research. Cooperation seems to be the slogan to-day and the National Research Council, created as a war measure, is functioning to stimulate research in all of these institutions of the country in a cooperative way. Botany certainly has not been neglected as evidenced by the fundamental physiological work on fertilizers and the growing of wheat, and the fundamental work in connection with the treatment of plant diseases which will be taken up by the Research Council through the Crop Protection Institute in a cooperative way. Cooperation in every line is desirable, but is it not a fact that all great discoveries are made by individuals? These individuals should have plenty of equipment and help, and each should have a free hand to work out his or her problem.

In conclusion the plea I desire to make is that the botanist should enter more vigorously into the exploitation of fields of agronomic work, ecology and taxonomic work, as it is related to horticulture and agriculture. We have allowed some splendid fields of work to slip away from us, largely because we were indifferent to the problems of agriculture. This is not true of plant pathology which has made itself felt along economic lines. It is true that some phases of plant breeding, physiology and soil relations of plants are masquerading under various forms of agriculture and horticulture. It is not my aim to belittle much that has been accomplished by horticulturists and agriculturists, but this work, when botanical, should finds its place under the head of botany. Let us look for a new era in botanical work. Then the various phases of the work will find their rightful place, not only in our teaching, but in our research as well.

L. H. PAMMEL

IOWA STATE COLLEGE

SCIENTIFIC EVENTS

THE BOWDOIN MEDICAL SCHOOL

THE Bowdoin Medical School, established a century ago by Maine's first legislature, will be closed as a department of Bowdoin College at the end of the current year next June, unless by that time it receives financial support.

The following announcement has been made by President Kenneth C. M. Sills by authority of the boards of trustees and overseers.

By action of the board of trustees and overseers the Bowdoin Medical School will be finally closed as a department of Bowdoin College at the end of the current year, June, 1921, unless by that time some way shall be found to meet the requirements necessary to keep the school in Class A of American medical colleges. It has been conservatively estimated that for this purpose there must be an addition to the resources of the school of $25,000 for immediate equipment of laboratories and of at least $50,000 yearly income for more teachers and for up-keep. Unfortunately at the present time the college sees no way of procuring such funds; the need of such an endowment has often been placed before the people of Maine, but the appeals have never received an adequate response.

The college will not apply for state aid for the school. But if the citizens of Maine and the friends of medical education who believe that the maintenance of a medical school is properly a state function, desire to have the medical school reestablished as a state institution under state control and adequately supported by the state, Bowdoin College will be glad to give all assistance possible to that end, and would doubtless offer for such a purpose for temporary use, if desired, such part of the buildings and apparatus of the college as might be available.

The trustees and overseers of the college believe that there is a place for a medical school in Maine and are hopeful that the people of the state, despite the great demands on the incoming legislature, will establish such a school as a state institution, around which all the medical and public health work of the state would be centered.

THE DIRECTORSHIP OF THE BUREAU OF MINES

DR. F. G. COTTRELL, director of the United States Bureau of Mines, on December 31, handed his resignation to the President, through Secretary of the Interior Payne. He leaves the bureau to take up his duties as chairman of the Division of Chemistry and Chemical Technology of the National Research Council. Dr. Cottrell recommends as his successor H. Foster Bain, of California, whose