nebulæ and suns, is a perennial joy and consolation. We should all be happier if we were less completely obsessed by problems and somewhat more accessible to the esthetic and emotional appeal of our materials, and it is doubtful whether, in the end, the growth of biological science would be appreciably retarded. It quite saddens me to think that when I cross the Styx, I may find myself among so many professional biologists, condemned to keep on trying to solve problems, and that Pluto, or whoever is in charge down there now, may condemn me to sit forever trying to identify specimens from my own specific and generic diagnoses, while the amateur entomologists, who have not been damned professors, are permitted to roam at will among the fragrant asphodels of the Elysian meadows, netting gorgeous, ghostly butterflies until the end of time.

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TENDENCIES IN AGRICULTURAL RESEARCH[1]

LAND rather than soil problems engaged the attention of our pioneer farmers. To them the passing of the public domain into private ownership meant much. It meant the conquest of the wilderness, the leveling of dense forest growth, the turning of prairie sods. It was the era of agricultural exploitation without the thought of climbing yields and of better races of plants and animals. The rugged faith and courage of the pioneer were pitted against a not over-friendly environment in the persistent building of an agricultural empire. But, while in the retrospect of the present day the outcome was predestined, the path of progress was beset with many difficulties and uncertainties. Despite these, an unending procession of home-seekers braved the perils and solitude of forest and plain, the human stream flowing on to the west to build, to sow and to harvest.

Scarcely more than one hundred million acres of our land surface had been transformed into improved land by the middle of the last century. In the following decade each year brought an addition of five million acres of improved land, a rate of progress temporarily halted by the tragedy of the Civil War. But the beckoning furrows lengthened and multiplied, and it was a poor year between 1870 and 1890 when the addition to our improved land area was less than ten million acres. In the thirty years following 1890 this area grew from about 360 to more than 500 million acres. The conquest is still to be completed, but the era of land exploitation as such has been well passed. Coincident with the development of our land resources the acreage of our staple crops grew by leaps and bounds. The area under hay and forage crops increased from about thirty millions in 1879 to about ninety-six millions in 1919. There was a corresponding increase from about sixty-two million to eighty-seven million acres in the case of corn, from thirty-five to seventy-three millions in the case of wheat, from sixteen to about thirty-eight millions in the case of oats and from fourteen to nearly thirty-four millions of acres in the case of cotton. The relative increase in the acreage of rye, potatoes, tobacco and rice was even greater. Increasing numbers of farm animals followed the expansion in the acreage of improved land. They brought, as did the expanding acreage, a great array of problems that insistently called for solution.

The pioneer farmer was chiefly interested in methods that promised the most effective utilization of the vast resources of our soils and forests. He reached out for more efficient tools as well as for more efficient plants and animals. The invention of agricultural machinery was stimulated by the apparently unlimited acreage and ready accessibility of agricultural land. Implements of tillage, as well as harvesting machinery, multiplied the labor resources of our farms. Improved transportation came with the reaching out of our railroad systems. Mechanical power was later added to our agricultural labor resources and land utilization soon assumed vast proportions. In response to the demand for more efficient plants and animals better varieties of plants were made available by importation and se-

[1] Address of the vice-president and chairman of Section O—Agriculture, American Association for the Advancement of Science, Boston, December, 1922.

lection. Improved types of animals were likewise brought in from foreign countries and an effort was made to adjust both plants and animals to their new environment. Variety tests among the more important crops, exhibits at local and state fairs, the organization of breed associations and feeding trials constituted the means of hastening the introduction and use of the more productive types of plants and animals. But the era of exploitation had to reckon with the very serious losses caused by insect enemies, plant and animal diseases, animal parasites and predatory and destructive animals. To the problem of large scale production there was added the problem of adequate protection against these enemies. The Hessian fly, the chinch bug, grasshopper, weevils of stored grain, the codling moth, plant lice and wire worms are but a few of the outstanding insect pests that menaced the prosperity of the pioneer farmer. Farm animals were similarly threatened by ticks, flies, lice, mites and intestinal parasites. Fungi and bacteria levied a heavy toll on both crops and animals. Rusts, blights, mildews and other diseases became quite destructive even though the extent of the losses caused by them were not always fully appreciated. Cattle fevers and plagues, the spread of bovine tuberculosis, the ravages of hog cholera and the far-reaching damage done by blood parasites constituted a tax that early farmers seemed unable to escape. Quarantine, crop rotations and preventive treatment brought at best only partial relief. They helped to bring out in bolder relief the need for the accurate study of the mysterious forces that cast their evil shadow on the farmer's industry and thrift. To the progressive farmer there came the growing conviction that the solution of many of his problems lay outside of himself. He came to feel in time that the organization of schools of agriculture would react favorably on the interests of American farming and would point the way to better methods of production. The organization of experiment stations was a logical outgrowth of our agricultural colleges. The Land Grant Act, signed in the dark days of the Civil War, created the state agricultural colleges, which prepared the way and trained the men who later formed the vanguard of our agricultural research.

Land utilization and the introduction of improved types of plants and animals were the outstanding features of American farming during the second half of the nineteenth century. During that time distinct progress was made in answering the more insistent questions of our agricultural industry. Feeding trials, variety tests, the analytical study of the soils and crops, rotation experiments and the study of the response obtained from applications of manure, fertilizer and lime became more and more common. The more exhaustive and discriminating study of the underlying principles had scarcely made itself felt. Through the general progress of science, the increased number of trained men and the more intelligent and generous public support, the opportunity became ripe for the more systematic organization of agricultural research. The new century thus brought with it the men and the resources for the comprehensive inquiry into other important phases of plant and animal production. Not content with the testing of empirical remedies, the entomologist attempted to gain an intimate understanding of the life history of insects, their response to changes in their environmental conditions, the nature and occurrence of insect parasites. The entomologist sought the aid of the chemist, the bacteriologist, the mycologist and the physicist. We learned to know about contact and stomach poisons and the reaction of insects to light, heat, humidity and the nature and supply of their food. The body of knowledge concerning insects assumed large proportions and was gradually organized to form the foundation on which systematic methods of eradication and control could be developed. Thus, sprays, dusts and fumigants, as well as parasitic insects and fungi, have helped to erect a more or less effective barrier against a menace that is never absent. In their efforts to minimize the damage done by microorganisms the bacteriologist, the botanist and the chemist found cooperation desirable and satisfactory. The development of resistant species of plants through selection and breeding offers more than a partial solution of a difficult problem. Similarly, resistance and

immunity against pathogenic organisms has been the outcome of the isolation and study of microorganisms, their food requirements, the changes produced by them in the culture medium and the relation to their host. Sera, vaccines, antitoxins and bacterins were added to the weapons of defense against the invisible destroyers. In a word, then, the pioneer stage in the development of American agriculture had sufficiently tested the resources of agricultural research to prove its effectiveness and its promise. The mining of plant food was still carried on extravagantly and on a vast scale, the herds and flocks still grew in numbers, land utilization and crop and animal production had found at least partial insurance against catastrophic losses.

The more constructive phase of our farming belongs distinctly to the present century. Soil exploitation is finding its counterpart in soil building. The continuous growing of a single crop has largely been abandoned through force of necessity. Wheat, corn, cotton, flax, tobacco and other crops refused to yield a profit when grown on the same land year after year. Diversification and crop rotations established themselves through the farmer's efforts to escape the ravages of economic insects and fungus diseases. They found justification, also, in that they permitted the more economic use of labor and equipment resources of the farmer. But the theory of crop rotations, the significance of plant associations, the relation of individual crops to the soil micro flora and the plant physiological reactions of individual crops were to be made the subject of study at a later date. To the earlier farmers the use of lime was well known. The nature of the changes produced by lime, its relation to soil texture and structure, its effect on soil microorganisms and its direct and indirect influence on the plants themselves were to offer an attractive problem to the soil investigator. The practice of green manuring had become well established in the second half of the nineteenth century. The significance of the biological fixation of atmospheric nitrogen and likewise the biological formation of ammonia and nitrates was pointed out in the last quarter of that century. There were, nevertheless, many questions related to the underlying principles and their application that were still to be answered. Thus, the occurrence and distribution of symbiotic and nonsymbiotic nitrogen-fixing bacteria, the effect of soil reaction, the influence of the soil solution and of other factors on their activities were still to be determined. The more effective and the more profitable use of green manures was made possible by the more exact information on the response of the green manure plants to their environment. The botanist, bacteriologist and chemist have all had a share in creating this more exact information. In the building of soil fertility artificial fertilizers have played an outstanding rôle. Agricultural research has been obliged to deal with almost innumerable questions that have arisen in the manufacture and use of such fertilizers. The influence of fertilizers on the nature and concentration of the soil solution, the absorption and adsorption of soluble salts in different soils, the exchange of bases, the losses of soluble salts, the influence of the soil solution on germination and plant growth, the relation of fertilizer treatment to the activities of soil microorganisms and many other problems have received the attention of the investigator. Soil research is thus engaged in a thoroughgoing examination of the constructive phases of soil utilization. This is distinctive of the present trend of agricultural research. In so far as it may be consistent with economic practice, the tendency will become more manifest toward the liberal use of commercial fertilizers, the accumulation of reserves of available plant food in the soil and the effective utilization of the circulating plant food capital in increasing the average yield per acre. The soil investigator is very far from content with the results already achieved. He is reaching out toward a better understanding of the functions of manganese, fluorine, iodine and silica (formerly regarded as purely accidental constituents of plants). He is trying to find out to what extent protozoa are a limiting factor in the transformation of plant food by bacteria. Soil fungi and nematodes are, likewise, being made the subject of study in an endeavor to interpret more clearly the outstanding facts of soil biology. All this must hasten the progress toward higher levels of production just as selection, breeding and protection among plants and animals must assure us of the more

effective utilization of our plant food resources. But there are other problems now coming to the fore in American agriculture that are offering themselves as a subject of fruitful research. We have come to agree that we must make better use of our food resources. Physiological research has pointed out to us that the blending of proteins and their derivatives, of carbohydrates, fats, minerals and accessory substances in the feeding of animals holds the promise of greater net profits to the livestock producer. The application rests on a body of knowledge slowly created and as yet not fully interpreted. We know something at least about the cleavage products of protein and of the analytical and synthetic processes occurring in the animal body. We have made more than a mere beginning in the study of internal secretions and their rôle in animal metabolism. The study of vitamines may have assumed unseemly proportions, but has none the less given us a rich fund of information. Animal nutrition has thus entered a new stage that points the way to the conservation of our food resources and their more effective use. Our knowledge of feeding stuffs appearing as industrial by-products has also become more exact. The protein and carbohydrate feeds represented by cottonseed, linseed and soybean meals, or peanut and copra cake, have certain limitations when their composition is considered. Other by-products, like bran, gluten feeds, dried beet pulp and molasses, are not always utilized to the best advantage. Research problems relating to both conservation and use are making a strong appeal to the investigator. The same may be said of the conservation and best use of hay, straw, cornstalks, sunflowers and other crop materials. The study of ensilage and the conditions under which it is produced has already yielded profitable returns. The investigator is now looking ahead to the more systematic study of our forage plants in order that a basis may be created for the more effective utilization of our pastures, ranges and forests.

Agricultural research is now concerning itself with the problems involved in the manufacture of what we might well term secondary agricultural products. These would include milk and its products, fruits, vegetables and their derivatives, meat products, starches, sugars, etc. We have traveled far along the road in our study of dairy products. We know much about bacteria and fungi more or less prominent in the manufacture of butter, cheese and fermented milk beverages. We have done almost as much in the study of fruit derivatives, such as marmalades, sugared fruits, dried fruits, etc., but many attractive problems are still before the investigator. This will apply also to vegetables and the other commodities already mentioned. The agricultural colleges and experiment stations, so generously supported by the tax-paying public, will be expected to lay more stress on the investigations of such manufacturing methods as would substantially reduce the terrific waste of food materials now constantly occurring in our fields, orchards and storehouses. For example, many millions of bushels of potatoes, sweet potatoes, apples, pears and peaches are allowed to decay because of the lack of facilities for their conservation. Much sugar and starch in inferior potatoes, fruit and berries should not be sent to glutted markets to compete with these ingredients in vegetables and fruits of better quality. As time goes on greater stress will be laid on the utilization of the sun energy stored in the cellulose of our corn stalks, straws and other now relatively worthless materials. Whether or not alcohol is the most promising successor to petroleum and its derivatives as a fuel for our motor-driven machinery, it is almost obvious that agricultural research will have to deal earnestly with the transformation of the now less valuable agricultural commodities into products possessing food, fuel or other value.

Agricultural research will reckon to an increasing extent with problems of storage and handling. Refrigeration has undoubtedly stretched our food resources, but there is need for research not only as to types and methods of refrigeration, but also on the effect of refrigeration on the market and food value of fruits, vegetables, meats and other commodities. Transportation offers certain research problems, for much of the food shipped by rail or truck is more or less extensively infected with bacteria and spores of fungi. Very extensive losses occur in transportation because of faulty cooling or handling. Our agricultural colleges and experiment stations will

be expected to turn their attention to these problems. The quality and quantity of food as affected by storage, handling, transportation and distribution will then be less adversely influenced. Another tendency quite manifest in agricultural research is that relating to the economic side of agriculture.

The producer of agricultural commodities is just beginning to recognize the intimate relation that exists between his farm operations and the trend and interplay of economic forces. It is dawning upon him that production costs, taxation, land tenure, imports and exports, transportation, cooperation and marketing are vital factors in the agricultural industry. As he thinks of these a host of questions arise before him and fill his mind with doubt and suspicion. It is but natural for him under such circumstances to turn to his agricultural college and experiment station and to ask for light and guidance. He is readily given the information that is available, but he is made to realize, at the same time, that our knowledge of agricultural economics is, at best, quite limited. It is a field for exploration and ready to yield some of its secrets to the student and investigator. Because of his close contact with his agricultural institutions, he feels that he has a right to ask for research that would remove his perplexities, free him from the burden of uncertainty and allow him and his fellow farmers to build hopefully on the solid foundation of exact knowledge. Obviously, then, research on agricultural economics is to occupy the attention of our agricultural colleges and experiment stations. Research projects in this field will multiply. A demand will be made on the agricultural colleges to train men for the carrying on of research in this field.

The higher standards of living adopted by the progressive element in our agricultural population are creating a demand for research in the fields of sanitation and hygiene. The water supply in rural districts, its chemical and microbiological qualities, its possible significance as a carrier of pathogenic organisms, and its treatment and purification may be made the subjects of experimental study. The construction of septic tanks and of filter beds in connection with the disposal of household wastes, the mineralization of organic matter in sewage and the biology of sewage disposal on the farm present certain research problems. Flies and mosquitoes are not only a source of discomfort, but are potentially dangerous as carriers of disease organisms. Their control and possible elimination offers an opportunity for experiment and at times for the fundamental study of the relation of organisms to their environment.

The present day organization of the American farm creates well-defined problems in engineering. Farm power, the relative cost and effectiveness of animal and mechanical power, the relation of tillage machinery to soil texture and structure, the illumination and heating of dwellings and outbuildings, ventilation drainage, land clearing and road construction demand inquiry that may range all the way from simple tests to carefully planned research. The requests for these and other inquiries are becoming more and more insistent, and while our rural constituency is often more than generous in its support of agricultural research it is now and then impatient of results. When a new insect enemy or plant disease brings widespread destruction and loss the discouragement among the producers reacts unfavorably on the agricultural colleges and experiment stations, as well as on the Federal Department of Agriculture. The farmer facing ruin, like the cotton grower in the boll weevil infested territory, must have immediate relief and he expects nothing short of the impossible. But on the whole the farmers are loyal to the research institutions. Time is bringing to them a keener discrimination and the understanding that knowledge can be gained only slowly and painfully by following devious and thorny paths, by discarding much and keeping little. They are more appreciative of the time element in the conduct of important investigations and are willing to tax themselves and to contribute directly from their slender purses toward the time-consuming and rigid culling of facts and principles. There is much encouragement for the student of agricultural science in the broadening outlook of the nation, in its concern for the conservation and upbuilding of our land and crop resources. Well beyond the pioneering stage of exploitation and of empirical practice, we are moving forward to rising levels of production, and

with the help of the trained man we are trying to look beneath the surface. We are reaching out into new fields of research endeavor, we are gathering facts and deductions from the outlying regions of science, we are multiplying and sharpening the tools of research workers, and are constantly widening the perspective of agriculture. Much is being given to agricultural research and much is expected from it. Will the Department of Agriculture and our colleges and experiment stations measure up to the task? The answer must be an affirmative one if we are to gauge future achievement by the more ample facilities for study at our colleges and universities and the zeal, the integrity and the humility of our research workers.

J. G. LIPMAN

RUTGERS COLLEGE

FRITZ WILHELM WOLL

DR. FRITZ WILHELM WOLL, professor of animal nutrition in the University of California, well known as a writer on animal feeding and dairy subjects, died at Berkeley on December 6.

Dr. Woll received his early education in Christiania, Norway, obtaining the degree of Ph.B. from the Royal Fredericks University, Christiania, 1883. Later, degrees of M.S. and Ph.D. were conferred by the University of Wisconsin in 1886 and 1904, respectively. After graduation as Master of Science at Wisconsin Dr. Woll was appointed second assistant chemist, Wisconsin Agricultural Experiment Station, 1887, and rose to the position of chemist for the station in 1897. He became professor of agricultural chemistry, University of Wisconsin, in 1906, which position he held until 1913, when he was called to the University of California as professor of animal nutrition, holding that chair until his death.

He was the author of many works, each of which has been reissued in a number of editions; among these may be mentioned:

"A Book on Silage," revised edition, 1900.

"A Translation of Modern Dairy Practice" (from Swedish of G. Grotenfelt), 1894, third edition 1905.

"A Handbook for Farmers and Dairymen," 1897, sixth edition, 1914.

"Testing Milk and Its Products" (with Professor E. H. Farrington), 1897, twenty-fourth edition, 1918.

"Productive Feeding of Farm Animals," 1915, second edition, 1916, third edition, 1921.

"Feed Manual and Note Book," 1917.

Dr. Woll accomplished a large amount of scientific work while at the universities of California and Wisconsin, as is well shown by the series of important and timely bulletins of the respective agricultural experiment stations. He was also an extensive contributor to technical publications and agricultural and dairy papers. His articles were always replete with valuable aid to dairymen and feeders in general.

It is primarily due to the untiring efforts of Dr. Woll that the cow-testing associations of so much value and importance to the dairy industry of California have been developed and placed on a business-like and permanent basis.

He was a member of many agricultural and scientific societies, including: Wisconsin Academy of Sciences, Arts and Letters; Society for the Promotion of Agricultural Science; American Society for Animal Production; Association of Official Agricultural Chemists, (president, 1909-11); American Dairy Science Association; Sigma Xi; Member International Jury Panama Pacific International Exposition, 1915.

The passing of Dr. Woll is a great loss to the University of California and to the animal industry of the whole country.

SCIENTIFIC EVENTS

INTERNATIONAL TELEPHONY

THE inaugural address delivered by Mr. Frank Gill, as president of the British Institution of Electrical Engineers, as reported in the London *Times*, discussed the problem of establishing efficient international telephonic communication among the different countries of Europe, including Great Britain.

He expressed the opinion that, given adequate facilities, there is traffic waiting to be handled between the cities of Europe, and urged that there are weighty reasons for providing those facilities, such as the present necessity for improving the relations between nations, in addition to the normal commercial advantages. So far as distance is concerned,