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AGRICULTURAL RESEARCH AS A CAREER

THE production, storage and distribution of an adequate supply of food and raw materials constitute the primary function on which all civilization has been founded. The raw materials are at the present time of various kinds. Primarily they had to do with clothing and shelter, so cotton, wool, leather and wood have always been the major products. The number of products used for food and raw materials has increased from time to time and the proportion has varied as opportunities for new uses and wider distribution have developed. While adding to the total of production and consumption, they have not materially changed the dependence of the world upon the staples of centuries past.

During the past century America has been producing an excess of food. She has offered opportunity for development to her own growing population and to the crowded populations of Europe. As long as there was an abundance of rich and fertile land available for cultivation, the major effort of agricultural research has been to increase the production per man and that effort has been so highly successful that one agricultural worker can to-day produce four or five times as much food as his grandfather could. The major portion of the nation's rich and fertile acres has now been taken up. If this nation is to continue to develop for another century, as she has during the past, those engaged in agricultural research must redouble their efforts and increase the production per acre as they have in the past increased the production per man. The European nations reached this condition a long while ago and those nations that recognized the problem and put forth the greatest efforts in the development of food production have grown the most rapidly in wealth and power. The field of agricultural research therefore offers to the coming generation of

scientific workers a wonderful field for individual advancement and, at the same time, outstanding opportunity for national service.

AGRICULTURAL RESEARCH EMBRACES MANY FIELDS

Agriculture is not a single science but the application of many sciences to the agricultural problem. Almost every agricultural problem has a chemical and a biological phase. Many of them involve problems in physics, physiology, bacteriology and genetics. The soil problems lead into geology, while irrigation and drainage have many relations with engineering. The biological sciences have been split into many fields, such as plant pathology, entomology, parasitology, as well as applied subjects such as agronomy, animal husbandry, horticulture, forestry and dairying.

WHO SHOULD UNDERTAKE AGRICULTURAL RESEARCH?

Those who love nature, who take a keen delight in plants and animals, who are interested in life's varied manifestations, who love the great outdoors and outdoor life should be especially interested in agricultural research. In a field as broad as this there is of course every variety of occupation, but in a large majority of the cases those who engage in solving the problems related to agricultural development keep closely in contact with the soil, the plant or the animal and at least a part of their work is of necessity in the open. Research in itself keeps the mind young and growing. Agricultural research affords opportunities that make for health, long life and the physical strength that is required for accomplishment.

The field of agricultural research is so broad that there is opportunity for every one who has a trace of the research spirit. Some position can be found into which one's abilities and capabilities can be fitted. The student, however, who desires to fit himself to reach the highest positions of responsibility, or to make the major contributions to the progress of science, must see to it that his educational foundation has been of the broadest and most fundamental character. Much of the research in the past has been on superficial problems. The great problems of the future are in the solution of fundamentals—problems in most cases involving many of the sciences—and the broader one's foundation in these sciences the more likelihood there is of unlocking nature's secret. Many a man has approached the threshold of a great discovery only to find himself baffled by his lack of training, while some other man with no greater ability but with a broader knowledge of methods of related fields has found the key and unlocked the door of knowledge.

THE QUALIFICATIONS FOR SUCCESS IN RESEARCH

A relatively small number of men and women go to college. A still smaller number should be encouraged to take up research work. Just what the qualities are that make up research ability are hard to define. No examination was ever devised that could determine. Brilliancy in student scholarship is no test. Darwin and Pasteur, two of the greatest research men of the last century, were indifferent students. In other cases, brilliant students have been brilliant research men. Scientific research requires absolute honesty and integrity of purpose. No man should look forward to a career in research who is not fundamentally honest and conscientious. A spirit of public service, of responsibility for the advancement of the nation or the race, is a major asset. A desire to cooperate with your fellows, ability to organize and direct the actions of others, all contribute to success. The vital outstanding factor that makes for success in research is vision, ability to look into the future, to keep an open mind, to hold all information as relative and subject to revision or new interpretation or even to be discarded, if the necessity arises, and an entirely new concept substituted. Vision carried to the extreme becomes visionary. Open-mindedness in the same way becomes skepticism, and yet progress in the research field is conditional upon these attributes of mind. If they be well balanced and coordinated and accompanied by the other essentials there are almost no limits to the possibility of accomplishment. Without them there may be substantial accomplishment—many contributions to the sum total of human knowledge—but the great discoveries will be for others.

ADVANCED TRAINING

With the increasing complexity of all the

sciences the research field is becoming more and more restricted to those who are especially trained for the work. In a complicated subject like agriculture this is especially true. The great advancements of the past have been made by those who have brought the best training to the problem and it is hardly worth while for any one to look forward to that field in the future unless he is willing to undertake adequate training for this service. A statistical study of those who have contributed most to their respective sciences shows that over seventy per cent. of them have earned doctor's degrees. These men represent the education of a generation ago when doctor's degrees were relatively rare as compared with the present time. If this is true to-day, how much greater will the percentage be in the generation to follow!

Three years of advanced training may at the first glance seem formidable. It is, however, relatively easy to obtain under existing conditions. At least one year of graduate work should be taken immediately after graduation. During this year the student will become familiar with the research problem in his major field and have extended his breadth of vision in two or more related lines. The results of this year's work should lead to a final determination as to whether or not he is fitted to enter a research career. If he has been reasonably successful in his major subject it will now be possible for him to obtain employment in the chosen field. That employment should be selected with reference to opportunity offered, rather than salary. A research position in an experiment station or government laboratory, or an assistantship in a scientific department with part time teaching and an opportunity for research, will give opportunity to further try out capabilities and inclinations. Two or three years' work of this kind, making use of every opportunity for acquiring additional training and experience and in demonstrating capabilities along administrative or cooperative lines, are of more value in determining success than are generally realized. Following this, two more years of graduate training under the direction of one of the great leaders in his chosen field should complete the fundamental preparation for his life work. By making use of a scholarship, a fellowship or an assistantship this can be accomplished with relatively small financial outlay. By this time the student will have learned that there is no end to study and development and that every opportunity of obtaining greater breadth of training and especially of making contacts with leaders in the related sciences should be embraced.

OPPORTUNITY FOR SERVICE

Despite the wonderful progress that has been made in the last generation, the opportunity for still further discoveries is unlimited. Every time a problem is solved, three or four new ones are opened up and any worker entering the field will find that there is a crying need for more knowledge on every hand. Who knows that we are using the best breeds of animals that can be developed? For the most part we have been content to continue with those our ancestors used, in many cases without material improvement. It is possible that the introduction of wild strains or the crossing of other domesticated species might easily give us the foundation for the development of still more economical producers than those we are using at present.

In the nutrition field every new investigation, instead of solving our problems, simply opens up further avenues requiring research. The discovery of the existence of vitamins explains why previous nutritional investigations were not conclusive, but the investigation is still to be made that will explain the vitamin.

The plow is one of the most ancient of agricultural implements. It is also one of the most modern. Recent investigations have shown that under certain conditions greater yields have been obtained by omitting the plow. We need to know more about the physics, the chemistry and the biology of plowing. The same is true of tillage in general. The crops of a generation ago have been largely superseded by more productive varieties. Is there any reason to believe that still more profitable forms can not be developed?

Notable progress has been made in bud selection in certain citrus fruits. This same process may be equally valuable over a much wider field of horticulture. The factors of productiveness and hardiness need much careful investigation to determine their causes. The

forestry situation is becoming acute. Our fathers destroyed the forests to get rid of them. Our sons will have to develop anew what their ancestors destroyed. Reforestation involves problems in almost every field of science.

The present methods of control of insect pests have been almost entirely the development of a single generation. The field is as yet hardly touched. Almost every one of our major insect pests needs further investigation. The chemists should combine with the entomologist to study the attractiveness of different grasshopper baits and when they have solved this problem they will find an almost unlimited field in the development of attractive substances to assist in the destruction of injurious insects. The control of plant diseases needs the combination of the chemist, the plant physiologist and the pathologist to work out the intricate problems of the lethal relations of host and parasite. We have been working with a small number of standard insecticides and fungicides. Who knows that modern chemical research does not offer a dozen more efficient compounds than those in present use?

This country has established an enviable reputation for the success of its eradication programs. Contagious pleural-pneumonia, seven outbreaks of the foot-and-mouth disease and many small outbreaks of gipsy moth have been completely eradicated. The citrus canker has been eradicated from the commercial citrus growing regions and is rapidly being eliminated from the remainder of the gulf region. The sweet potato weevil has been greatly restricted in the commercial areas. The Texas fever campaign is approaching completion. The progress of the pink bollworm, the barberry and the tuberculosis eradication programs is very promising. These have been made possible by persistent research that has developed methods. Hog cholera, contagious abortion, the ox warble, the codling moth, the boll weevil and a host of other pests and diseases offer equally favorable opportunity for great national eradication movements as soon as the research workers have perfected the methods that will make them possible.

The discovery of the colloids has opened up a new field of investigation into hundreds of agricultural problems, few of which have as yet been touched. No one can predict the advances possible before this line is exhausted. Our ideas of the plants' sources of nitrogen are being constantly modified. Here is opportunity for exhaustive research. The recent developments in our knowledge of the relation of insects as transmitters of plant diseases and especially the recent discoveries of organisms connected with the mosaics open up a wonderful field of research in which many scientific groups must combine. The influence of meteorological factors on plant and animal development is an almost unworked field. The whole subject of the water requirements of plants, the movement of water in its relation to irrigation and drainage, need much further study. The chemist, the physicist, the biologist and the engineer are all needed in the solution of these problems.

The problems in production have been the major field of agricultural investigation in the past. With the concentration and specialization of populations the problems of marketing and distribution are becoming equally or even more important. The economist must now join forces with the other scientists in the solution of many of the most intricate problems. To further itemize would be superfluous. Every ramification of the field of agriculture offers wonderful opportunity for individual effort, as well as opportunity for contribution to national welfare and human development.

NOT NECESSARY TO GRADUATION IN AGRICULTURE

From the above outline of the problems it is readily seen that a comprehensive research into a complicated agricultural problem requires the services of men trained in many fields of research. The great contributions in most of the applied sciences, such as agriculture, engineering and medicine, have been made by those who have approached the problems through the pure sciences and this will probably be even more noticeable in the future as the superficial problems are solved and the fundamentals are undertaken. There is, therefore, no reason why a graduate who has majored in any of the fundamental sciences should not look forward to a career in agricultural research with every expectation that his chances of success will equal or exceed those who ap-

proach the problem from the standpoint of the more technical agricultural training.

WHAT A RESEARCH CAREER OFFERS

One of the first effects of the World War was to place the scientist and the teacher in an almost hopeless financial condition. One of the secondary effects has, however, been to bring to the attention of the people of all civilized countries the value of science and especially of organized research as an important factor in the preservation of their national unity. The final result promises to be an increased opportunity and recognition for the scientist in general and especially an appreciation of the increased necessity for continued research in the development of any industry.

For the man just out of college or having completed a single year of graduate work, the greatest opportunity will usually be in connection with the educational institution or government bureaus. A few years' experience with its accompanying accomplishment and broadening of vision, combined with educational training, will place the individual in line for further advancement in these organizations or for opportunity to enter the commercial field. With the present trend in salary standards, the research scientist in agricultural lines may look forward to a relatively early opportunity to enjoy a salary that will support his family in reasonable comfort and still allow a margin for accumulation. As he advances in his profession and gains a position of leadership the margin of possible accumulation will increase rapidly. By this time his position will give him social standing and opportunity that others can only purchase by the expenditure of much larger sums of money. In addition, with the growing recognition of the value of the work of scientific men, larger and larger financial rewards are being paid to the best men.

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THE ART OF MEDICINE

IN the dome of the magnificent structure of contemporary medical education, across the ceiling, are inscribed the words, "Mene, Mene, Tekel, Upharsin."[1] Below, in the alcoves of laboratory science, there may be made out, perhaps less distinctly, the words, which, traced by the Hand, foretold the fall of Babylon: "Thou art weighed in the balance, and art found wanting."

A writer on the medical art, rich in the modern spirit, but not contemporary with us, has said[2] "This is the great error of our day in the treatment of the human body, that physicians separate the soul from the body."

The idea that the patient is a person who is sick, and that the healing art is to make a sick person well, will dominate the medicine of tomorrow, whether the art is applied in time to prevent, or only so late that cure is not possible.

Just now the point of view of psychobiology is becoming recognized as the one from which the physician must regard his patient.[3] How can the student of medicine get this point of view? Best, by example, from his teachers who have it, who treat patients as persons in distress, with dis-ease, seeking the physician for relief. But also, more formally, by a study of the personality as Meyer has indicated.[4]

This point of view involves a reorganization of the medical curriculum. The logic of the present arrangement is clear. It is to study structure, then function, then defective or "diseased" structure and function; and finally, cases of disease, applying the already acquired knowledge of structure and function.

The reorganized curriculum will have a different logic. The patient, a sick person, will be studied first and chiefly. On the hypothesis that function and structure are inter-related, the student will use pre-laboratory methods, and then will go to the laboratory to get help in solving problems which the patient presents. The student will begin with the obvious, or more nearly obvious and go on to the less obvious, or the hidden. He will learn first to use his own senses, then try instruments of greater or less precision.

The course in clinical medicine will be the major course for the four years. It will be the only major course, comprehending surgical therapeutics as well as the other forms of

[1] Daniel, v. 25.

[2] Plato-Charmides, translated by Jowett.

[3] Yerkes, R., "Relation of psychology to medicine," SCIENCE, Vol. liii, No. 1362.

[4] Meyer, A. See Curriculum of School of Medicine, Johns Hopkins University.