(3) The formulation of the dynamics of water. This involved, (*a*) explaining why the roots of plants when grown in nutrient solutions become different from those grown in the soil; (*b*) formulating the pattern as to how they become different; (*c*) describing how the hydroponic technique is arranged for various species in various climates to meet the requirements of a changed root system; (*d*) interpreting the significance of differences in roots in other characters in plants, and (*e*) integrating these phenomena in the evolutionary history of vegetation.

The functions of water in hydroponics are dynamic and physiologic, in agriculture they are physiologic only as the solid matter of the soil provides the dynamic functions. In soil water exists largely as a film around solid particles, hence has little or no hydrodynamic properties. Its dynamics is that of the solid matter to which it adheres. Water in the free state in hydroponics precludes or markedly restricts (*a*) anchorage for roots, (*b*) fixity of position for roots, (*c*) resistance to penetration with its induced stimulus of roots, (*d*) temperature differentials with their induced effects, (*e*) moisture saturated atmosphere affecting production of root hairs, (*f*) and other physical conditions which affect the tectonics of roots.

The mass of the nutrients required by plants is too small to be an appreciable part of the dynamics of the medium that supplies them, hence their functions are physiologic only. The non-nutritive materials create the dynamics, control the physical influences and determine physical conditions which affect the growth of vegetation. Water is the chief non-nutrient material used in hydroponics. Its dynamics is the foundation on which the art and the science of hydroponics is formulated.

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VITAL RESEARCH OF AGRICULTURE

EXPERIMENTAL study of plants and animals for the purpose of feeding, clothing and sheltering the human race should be called "vital research." Webster defines "vital" as "essential to the continuance of life" and "necessary to life." Thus, the word accurately describes research that will aid the producer to supply food, clothes and shelter, as well as raw materials for industrial uses. The benefits are commonplace in times of abundance, but are likely to be dramatic when there is a scarcity of the daily essentials. The responsibility of the agricultural industry to provide ample food is heavy now and will be tremendous in the postwar period.

Much agricultural investigation is of the vital type, since it attempts to solve some producer's or consumer's problem that is impairing production, quality, food value or return for the consumer's dollar. Farmers, farm advisers (county agricultural agents) and scientists at the agricultural colleges are daily pointing out and working to solve such problems. The broad objective is not only to furnish plenty, thus eliminating the specter of starvation, but also to provide the particular kinds of food that are essential for human vigor. These general characteristics apply also to studies outside the field of agriculture—for example, medical research.

It is essential for a group of research people to have a goal; a definite, simple objective is necessary to the industry served, both for training young people to solve problems and for guiding mature workers. Naturally vital research, with its broad problems, its fixed goals and often its limited time for accomplishment, demands scientists of wide training. Frequently it requires the cooperation of several workers in related fields, since the practical production of plants and animals involves wider extremes of heredity and environment than some other types of research. The investigator must keep abreast of agricultural, industrial and economic trends if he is to assist the producers in applying scientific principles intelligently to their problems.

A recent statement in the *A.A.A.S. Bulletin* is of interest in this connection: "There appear to be two principal important functions of the Association in the near future, as there have been in the recent past. One is to keep ever before scientists the fact that science as a whole is much greater and richer than any of its parts, and that extreme specialization and isolation will in time lead to sterility and decline. The other is to emphasize the obligations of scientists to society and, reciprocally, to make clear to the intelligent public how greatly society depends upon science.[1] It is hoped that these two simple goals and the results of vital research will enrich science, besides insuring the essentials of life. Considering the frequent occurrence of new problems and the ever-changing trends of agriculture, it is difficult to see how "sterility and decline" will take place in vital science if the vital-research worker keeps firmly in mind his role of service to industry.

There are numerous examples of work that will fulfil the qualifications for vital research. The use of proper environment and non-bolting strains has prevented the premature seeding of celery and other biennials; a change in plant composition has led to increased fruitfulness; yield and sometimes quality have been improved through the use of hybrid seed corn or onions; the deficiency effects of essential ele-

[1] "Democracy in Science," *A. A. A. S. Bulletin*, 3: 50–51, 1944.

ments in both plants and animals have been discovered, and the proper corrective measures applied. A quickly devised procedure for combating mites has saved many tons of tomatoes for processing; an accurate method for determining butterfat content of milk has greatly advanced the dairy industry and inaugurated new research projects; disease control has made livestock concentration possible and stabilized financial investments therein; the amount of labor required to produce crops and improve quality has been reduced through labor-saving machinery; and a more accurate knowledge of the labor requirement of various crops has provided essential data on their relative desirability for food production during periods of stress. In projects of this sort the worker has been closely in touch with the needs of the industry.

The Hatch Act of 1887, in establishing agricultural experiment stations, defines their purpose as follows: "To aid in acquiring and diffusing among the people of the United States useful and practical information on subjects connected with agriculture, and to promote scientific investigation and experiment respecting the principles and applications of agricultural science." Vital research is the purpose of this act. The early agricultural studies indicated a desire to solve vital problems affecting the food security and health of our citizens and thus to increase our agricultural wealth. This point of view predominated for some time. With the increase of staff members, there gradually developed at some stations a group primarily interested in more indirect applications or in merely widening our horizon of knowledge. The value of much of their work and training has been proved repeatedly, but most vividly when the war suddenly focused our attention on providing food, shelter and clothing. For the first time in many years, workers in other sciences were striving with agricultural personnel towards a common goal. The constructive gains made through this cooperation must be preserved. Vital research needs the cooperation of all workers.

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THE ACTION OF AMINO ACIDS ON COLOR CHANGE IN FUNDULUS

In the course of some work on Fundulus it was noticed that those fish that were injected intraperitoneally with a mixture of amino acids turned dark in a few minutes if they were light or if they were dark and removed to a light environment they remained dark.

The fish were injected with a mixture of amino acids[1] in 15 per cent. solution containing amino acids as derived from the acid hydrolysis of casein fortified with tryptophane. The approximate analysis as furnished by the manufacturer is: Total nitrogen 2 per cent., alpha amino nitrogen, approximately 75 per cent. of total nitrogen, tryptophane 1 per cent. of amino acids, calcium 0.01 per cent. to 0.02 per cent., sulfates 0.01 per cent., phosphates, iron and magnesium a trace. pH approximately 4.0.

The fundulus were removed from the aquarium and immediately injected intraperitoneally through a 27-gauge needle with doses ranging from 0.05 cc to 1 cc of the mixture of amino acids. They were placed in containers of either aerated or running sea water, some of which were over light backgrounds and others over dark.

With doses of 0.5 cc and 1 cc none of the fish turned light and those that were light before injection turned dark in about five minutes. Controls uninjected and injected intraperitoneally with 1 cc of sea water turned light when placed over a light background. The controls injected with 1 cc sea water survived, as did those injected with 0.5 cc amino acid mixture. Those injected with 1 cc of the amino acid in the morning died during the night; their abdomens were very red and swollen.

This information is published for the benefit of those interested in color changes in fish, as the writer has no intention of pursuing this problem.

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A STRANGE COINCIDENCE OF ERRORS

In clearing out old papers I am reminded of a most curious coincidence of errors which hitherto has never been fully published. My late colleague, F. E. Fowle, and I determined the dispersion of rock salt, as published by Langley in Volume I of the *Annals of the Smithsonian Astrophysical Observatory* in the year 1900. Our values of wave-length and refractive index were fitted by a least squares solution to the 5-constant formula of Ketteler, by the late Professor H. H. Kimball, of the Weather Bureau. I have his original manuscript before me. Kimball computed from his constants, derived entirely from our work, the indices of refraction corresponding to the wave-lengths 13.96 microns and 22.3 microns, which had shortly before been observed by Rubens and Nichols, and by Rubens and Trowbridge.[1] The following are

[1] Marketed by Frederick Stearns and Company, Detroit, Mich., under the name of Parenamine. I am indebted to the manufacturers for a supply of this substance.

[1] *Ann. der Phys. u. Chemie*, Bd. 60, 1897, pp. 454 and 733.