The systematization which mathematics gives to a science is never static, and the science thus organized takes on a directed growth. Some investigators will always be concerned with the reorganization of the axiomatic base of the system, and especially with the possibility of decreasing the number of the axioms. Other students of the science will be making additional deductions from the accepted body of propositions, and new propositions obtained thereby will furnish the suggestion for more experimentation. In fact, the mathematization of a science must never be regarded as a substitute for experiment, for experimentation is continually necessary for confirmation of the theoretical structure. One experimental result contrary to that predicted by the mathematical theory may be sufficient to cause a thorough revision of the theory, or perhaps relegate the whole thing to the grave of false hopes. Of course, many factors must be considered before a theory is actually discarded; for instance, a simple theory furnishing quite approximate results may be employed in preference to a very complex theory which is considerably more accurate in its interpretation of nature.

There is a strange fact about all these mechanistic devices which have been invented and employed by man in his effort to comprehend nature. They are first called laws of science, then, perhaps, laws of nature. After a while man is inclined to forget that they are products of his own imagination, and comes to believe that they are real and a part of creation. This fact has been responsible for many unfortunate attitudes and points of view. So some comments pertaining to the true relationship between a mathematical theory and that portion of nature which it is designed to interpret may be appropriate.

First of all, it must be emphasized that modern science recognizes the ultimate complexity of nature, and any theory which science may employ is too simple to have exact structural similarity to any part of nature. The mathematician may seek a linear formula that best represents the trend of a random set of points which are distributed, however, so as to suggest a straight line; in like manner, the scientist systematizes his study by the use of a mathematical pattern which can reflect only the general behavior of the data of his science. Moreover, it is doubtful that there is a unique theory to be sought by the scientist laboring in any field, for as Bliss[7] has said, "There are always more mathematical theories than one whose results depart from a given set of data by less than the errors of observation." The Ptolemaic and Copernican theories of the solar system furnish illustrations of two essentially different theories which, after slight modification of the former, describe equally well the behavior of the planets. The modern popularity of the Copernican theory is due chiefly to its relative simplicity.

A serious misunderstanding in regard to the mathematizing of science is apparent in the writings of some popularizers of scientific theory. In many instances, such writers read into nature a lot of fantasy which has its origin in some mathematical property of the theory under discussion rather than in the data from nature which the theory is designed to systematize. Of course, an adequate discussion of such matters must penetrate deeply into the subject of scientific methodology. An example of this type of misunderstanding is to be found in the insistence of some persons that the universe is finite, simply because the finite geometry of Riemann has been used with considerable success as a correlating agent of the data of the astronomical universe. Similarly, there is no justification for stating that continuity is a property involved in a set of data when a calculus of continuous functions has proved valuable in studying it. Many mathematical properties, as a matter of fact, are ideal, and their precise mathematical meaning could not be realized in the physical universe.

It should be evident by now that there are many interesting problems involved in any consideration of the relationship of mathematics to the sciences. In truth, as a field of study, science and philosophy have only touched the fringe. Real progress in analyzing the many difficulties involved demands more investigators with greater versatility of interest and preparation. Mathematicians need to become more familiar with the sciences, and many scientists must appreciate that a knowledge of mathematics consists of more than a mere ability to manipulate a few mathematical symbols. In the meantime, humanity awaits the many fine accomplishments which will result from a greater mutual understanding between mathematicians and the scientists.

FORTIFICATION OF FOODSTUFFS[1]

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IT is doubtful whether a single nutrition conference, out of the many that have been held in the past year, has not given some attention to the fortification of foodstuffs with vitamins and minerals. The interest of the public and of the food manufacturer in the problem is evidenced by the increasing number of

[7] G. A. Bliss, *Am. Math. Monthly*, v. 40, p. 472, 1933.

[1] Nutrition Conference: University of California, Berkeley, California, May 3, 1941.

vitamin-enriched foods in grocery stores and the endless array of vitamin products on the shelves of every drug store.

The arguments in favor of vitamin fortification are essentially these:

(*a*) The American housewife on her usual diet of about 2,000 kilocals. per day is unable, despite much ingenuity in the selection of foodstuffs, to satisfy her requirements for the various vitamins as computed from the generally accepted standards.

(*b*) Any given foodstuff, such as milk, for example, varies greatly from day to day, season to season, or place to place, in its vitamin content; incidentally, food tables that purport to give the vitamin values for various foodstuffs are notoriously inaccurate and misleading and have to be used with the greatest of caution.

(*c*) The incidence of malnutrition, especially of subclinical vitamin-deficiency disease, is high. In some cases malnutrition is endemic. Usually those in the low-income groups are the greatest sufferers but in many cases even the well-to-do are afflicted because of bad dietary habits.

(*d*) The use of highly processed refined foodstuffs, as instanced by white flour, C. P. sucrose and margarine, deprives us of valuable food factors present in crude or raw products. Additional losses of considerable magnitude may arise through faulty kitchen technique.

Of the several arguments that have been advanced against the fortification of foodstuffs there are only three or four that need to be regarded as serious:

(*a*) Fortification with pure vitamins is necessarily expensive, even though we make due allowance for the increasing economies that are being effected in quantity production.

(*b*) The removal of vitamins during the processing of foods and their subsequent restoration to the same or even to other foodstuffs is a practice repugnant to one's feeling for the fitness of things: it does not make sense.

(*c*) Enrichment with pure vitamins fails to give recognition to the fact that there are almost certainly additional accessory food factors, as yet undiscovered; the inference is that, were it feasible from the standpoint of food technology, fortification with crude concentrates would be better than with pure vitamins. This argument rests upon the very plausible assumption that 50 mg of pure ascorbic acid are not the equivalent, nutritionally, of 50 mg of ascorbic acid in the form of citrus juices and that 4,000 units of pure vitamin A or carotene are not equal to the crude products or original foodstuffs from which the carotene or vitamin was derived.

It is conceded by many that the problem would be partly solved if we would reconcile ourselves to the consumption of whole-wheat bread instead of ordinary white bread, for B-complex deficiency is one of the common characteristics of low-cost and low-calorie dietaries. At the same time it is perfectly clear that many of us are so stubbornly constituted that we can be reminded day after day of the virtues of whole-wheat bread without paying any heed to such salutary advice. The difficulty is twofold: our dietary habits are very deeply ingrained, and real whole-wheat bread is more expensive than white bread.

I wish to propose that the problem, in so far as bread is concerned, be attacked by establishment of a price differential in favor of whole-wheat bread. This obviously calls for a direct government subsidy, but it follows that the federal government could seek reimbursement through the taxation of white bread. If the millers and bakers can provide us with whole-wheat bread we are quite justified in transferring white bread to the category of taxable luxury goods.

But a very pertinent question is whether such a scheme would work. Would the consumption of whole-wheat bread be increased? Orr and Lubbock[2] have pointed out that in England the price of a banana was 2d in 1900. By 1937 the price had fallen to 1d and the annual consumption of bananas increased from 2½ million bunches to 20 million bunches. Between 1923 and 1935 the price of grapefruit fell 50 per cent. and the annual consumption increased from 1,200 tons to 59,500 tons. These increases were due to a combination of propaganda and fall in price. In the case of whole-wheat bread we now have the propaganda but not the favorable price. It may be contended without any reservations that the creation of a sufficient price differential in favor of whole-wheat bread would increase its consumption, but determination of the "sufficient" differential is entirely a matter of trial. This program has two real merits: it is capable of immediate execution, and it is conducive to the well-being of the low-income groups who are now the greatest sufferers from malnutrition.

Pure vitamins and even vitamin concentrates might well be conserved for therapeutic purposes where a clinical syndrome of vitamin deficiency is in evidence. Wheat germ, dry yeast, rich sources of ascorbic acid, fish liver oils, etc., are to be recommended in the treatment of subclinical deficiencies, and in virtually all cases where the circumstances are appropriate for deliberate enrichment of dietaries—the feeding of the armed forces, of workers in the defense industries, of civilians exposed to special hazards and strain (residents of communities subject to bombing) and of children in schools. In the last-mentioned instance it

[2] "Feeding the People in War Time," Sir John Orr and David Lubbock (Macmillan, 1940).

is hoped that the existing school lunch program will be so extended as to see to it that every child, regardless of economic status, will receive in the schools one thoroughly good meal every day. Apart from the immediate effects of this program, as reflected in the improved health of our children, there is one long term result of immeasurable value—the formation of sound dietary habits.

Let us be well aware of the fact that for children and adults alike education and propaganda are alone insufficient to effect any appreciable improvement in nutritional practices in measurable time. There is much that must be done that can and should be done speedily.

There is reason to believe that the flour-enrichment program of Great Britain has not progressed far, if at all. In any event, it would be unfortunate if the program failed to develop beyond that for which legislative provision has thus far been made. To supplement the present scheme of fortification it is desirable that the consumption of whole-wheat flour and bread be encouraged by reduction of price through a government subsidy. Of necessity the milling of the grain would have to be done in Great Britain because of the failure of whole-wheat flour to keep well when stored. However, the 12 per cent. of residue from fully extracted wheat is a valuable foodstuff for domestic animals and could be put to a profitable use.

SCIENTIFIC EVENTS

THE OFFICE OF SCIENTIFIC RESEARCH AND DEVELOPMENT

The President of the United States issued on June 30 an executive order establishing the Office of Scientific Research and Development in the Executive Office of the President and defining its functions and duties. Dr. Vannevar Bush, president of the Massachusetts Institute of Technology, now chairman of the National Defense Research Committee, has been appointed director. The first part of the President's order reads as follows:

By virtue of the authority vested in me by the Constitution and the statutes of the United States, and in order to define further functions and duties of the Office for Emergency Management with respect to the unlimited national emergency as declared by the President on May 27, 1941, for the purpose of assuring adequate provision for research on scientific and medical problems relating to the national defense, it is hereby ordered:

1. There shall be within the Office for Emergency Management of the Executive Office of the President the Office of Scientific Research and Development, at the head of which shall be a director appointed by the President. The director shall discharge and perform his responsibilities and duties under the direction and supervision of the President. The director shall receive compensation at such rate as the President shall determine and, in addition, shall be entitled to actual and necessary transportation, subsistence and other expenses incidental to the performance of his duties.

2. Subject to such policies, regulations and directions as the President may from time to time prescribe, and with such advice and assistance as may be necessary from the other departments and agencies of the Federal Government, the Office of Scientific Research and Development shall:

a. Advise the President with regard to the status of scientific and medical research relating to the national defense and the measures necessary to assure continued and increasing progress in this field.

b. Serve as the center for the mobilization of the scientific personnel and resources of the Nation in order to assure maximum utilization of such personnel and resources in developing and applying the results of scientific research to defense purposes.

c. Coordinate, aid, and, where desirable, supplement the experimental and other scientific and medical research activities relating to national defense carried on by the Departments of War and Navy and other departments and agencies of the Federal Government.

d. Develop broad and coordinated plans for the conduct of scientific research in the defense program, in collaboration with representatives of the War and Navy Departments; review existing scientific research programs formulated by the Departments of War and Navy and other agencies of the Government, and advise them with respect to the relationship of their proposed activities to the total research program.

e. Initiate and support scientific research on the mechanisms and devices of warfare with the objective of creating, developing and improving instrumentalities, methods and materials required for national defense.

f. Initiate and support scientific research on medical problems affecting the national defense.

g. Initiate and support such scientific and medical research as may be requested by the government of any country whose defense the President deems vital to the defense of the United States under the terms of the Act of March 11, 1941, entitled "An Act to Promote the Defense of the United States"; and serve as the central liaison office for the conduct of such scientific and medical research for such countries.

h. Perform such other duties relating to scientific and medical research and development as the President may from time to time assign or delegate to it.