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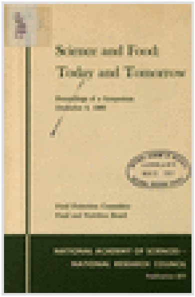

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The Food and Nutrition Board, established in 1940 under the Division of Biology and Agriculture of the National Academy of Sciences—National Research Council, serves as an advisory body in the field of food and nutrition. It promotes needed research in the broad field and helps interpret nutritional science in the interests of the public welfare. The Board may act on its own initiative or on request from public or private agencies.

The members of the Board are appointed from among leaders in the sciences related to food and nutrition on the basis of their qualifications of experience and judgment to deal with the broad problems that come before the Board. Appropriate contact with Federal agencies, scientific societies, and other associations is maintained through liaison representatives appointed from their respective organizations. Specific activities of the Board are carried on by committees composed of experts in each field. Members of the Board and its committees serve without compensation beyond their actual expenses.

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Science and Food: Today and Tomorrow

Proceedings of a Symposium
December 8, 1960

Chairman: Detlev W. Bronk, *President*
National Academy of Sciences
National Research Council

Food Protection Committee
Food and Nutrition Board

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The articles published in these Proceedings were presented at a symposium sponsored by the Food Protection Committee of the National Academy of Sciences—National Research Council on December 8, 1960. The purpose of the symposium was to present for public information viewpoints of industry, scientists, and government on the contributions of science to the maintenance of the food supply and discussion of some associated problems. The Committee wishes to express its appreciation to all those who prepared papers and presented them at the symposium and to Dr. D. W. Bronk, President of NAS-NRC, who served as chairman of the symposium.

The papers printed here express the views of the individual authors, not necessarily those of the Food Protection Committee or the National Academy of Sciences—National Research Council. They are published in furtherance of the aim of the symposium—public information. The Committee is pleased to be able to make them available in this way.

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Introduction

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Chairman, Food Protection Committee

In discharging its responsibility toward assuring that the quantity, kinds, and quality of foods necessary for maintenance of health and productivity of the population are available, the Food Protection Committee has increasingly become conscious of the need of a broad understanding of the contribution which science makes to our food supply and our absolute dependence upon the continuing effective application of scientific knowledge in order to assure continuing abundance of healthful food. During the past three decades great strides have occurred in food production, distribution, marketing, and conservation. Our national food consumption and nutritional health have benefited greatly therefrom. We are experiencing the forceful emergence of industrialized food—a development which has almost eliminated the obligatory seasonal marketing of foodstuffs, which has presented the consumer with an unparalleled variety of foods of high nutritional value, and which has shifted the burden of food preparation from the household kitchen to the industrial kitchen. All of this is at a monetary expenditure of a slightly smaller fraction of consumer income than was consigned to food twenty years ago.

During the next fifteen years in the United States there is anticipated a population growth to 230 million, to feed which we would need about 200 million more acres of crop land if the yields per acre were to remain the same as in 1956. We do not have an additional 200 million acres and, in fact, will not need them because of the rising productivity on the farms and the better utilization of foodstuffs which are possible as a result of scientific developments and application of science throughout the food chain.

Denied the full application of scientific knowledge, resources, and imagination, this country could be in a vastly inferior nutritional position by 1975 or shortly thereafter.

What are some of the scientific developments and applications which constitute our resources for food production? I include among these the improvement of crops and farm animals by plant and animal breeding; the extension of our scientific understanding of soils and soil needs for maximum production; the ingenious application of our scientific knowledge and resources to meet these needs; and the control of diseases of plants and animals, as well, indeed, as of human diseases. Such disease control may be compared to preventive medicine in man, although we must add to our consideration of it the potential influence on other animals, including man, of the use of the preventive measure. I believe further that these resources should include new and improved methods of preservation and of maintenance of sanitary and hygienic foods, whether these embrace new techniques of food processing, better packaging materials, or different and more beneficial procedures for sterilization of foods and prevention of enzymatic changes and oxidative rancidity. Adaptation of food preparation to meet today's and tomorrow's demands resulting from changed economic and social conditions must continue. It is the responsibility of industry to assure that these alterations are made without sacrifice of nutritional values or introduction of increased hazard and that they are associated with maintenance or improvement of nutrient quality.

Ethical industry has accepted this responsibility and has found that doing so is beneficial to the industry.

In our continued evolution of a system of food production and distribution in a changing economic and social order we have taken advantage of numerous labor-saving mechanisms, such as the tractor, the milking machine, the automatic feeding and watering devices, the herbicides, the rodenticides, the pesticides, the many devices and substances which make it possible economically to distribute appealing, wholesome, and nutritious food products in a ready-to-eat or partially prepared state.

I see the disappearance of the old distinction between agriculturally and industrially produced foods. Rapidly the boundaries between the two are dissolving. In a technologically advanced society it is inevitable that this occur.

Our concern is to assure that these rapidly evolving changes are beneficial and not harmful, that the benefits are associated with a minimum of hazard, that those who bring forth new developments are aware of their responsibility for proper appraisal of these developments prior to widespread application.

A major responsibility, therefore, of those concerned with food protection is to assure the fullest sound application of scientific knowledge in order to insure continued availability of adequate healthful foods. Bias, bigotry, and faddism must not be permitted to influence laws and regulations of this country in such manner as to interfere with the full use of our nutritional resources, be these resources agricultural or industrial. Thus, the interest or reaction of responsible groups must not compromise the nutritional quality nor the safety of our food supply. Only through widest public understanding of those forces concerned with provision of foods, of the contributions to abundant healthful food supply made by the many segments of America's resources can we have developments most advantageous to the American public.

In an effort to help us meet this responsibility the Food Protection Committee has arranged this symposium which deals with the broad subject of science and technology in relation to foods.

Mindful, however, of the responsibility which we all have, individually as scientists and collectively as a nation, for bettering the nutrition of less abundantly fed nations, we have included in this program consideration of the contribution which the application of existing scientific knowledge can offer to those regions of the world where severe limitations of food continue to result in prevalent deficiency states.

It is our sincere hope that this symposium will afford a vista of such breadth that those gathered here, as well as those whom we teach and influence, may see in proper perspective the varied concerns, and no longer have vision blocked by unnecessary barriers or by limiting features perhaps desirable in the past, but currently obsolete.

Technologic Revolution in Agriculture, Contributions of Science[1]

J. G. Harrar
Vice President, Rockefeller Foundation

The agriculture which is practiced today is as unlike that of fifty years ago as are our modern systems of communication and transportation different from their counterparts at the turn of the century. Although the nostalgic concept of agriculture as a way of life is still expressed on occasion, the fact is that modern crop and animal production is a highly competitive business, and unless producers are either highly efficient or heavily subsidized they cannot remain long in the business.

The major contribution to the evolution of agricultural practice over the past half century has been derived from basic research in the biological, physical, and engineering sciences in conjunction with improvements in educational patterns, agricultural services, and transportation facilities. Among the most striking are engineering developments which have enabled the agricultural producer continually to improve his productivity and at the same time reduce manpower requirements. A variety of modern machines, singly or in combination, prepare, plant, and fertilize the soil, carry out necessary cultivation operations, apply pesticides, fungicides, or herbicides, and ultimately harvest the final product. A myriad of other mechanical devices are involved in the procedures of preparation, preservation, or transformation essential to the conversion of crop and animal products into foods or other materials essential to modern standards of living. The next development in mechanized agricultural production will un-

(1) A summary prepared by Doctor Harrar of his presentation at the Symposium.

doubtedly bring an increasing degree of automation into the entire pattern.

Of at least equal importance and dramatic benefit to agriculture has been the broad spectrum of chemical compounds which intervenes at every stage of the agricultural process. Modern fertilizer practices have contributed enormously to increased production as a continuing result of research on essential micro- and macro-elements. Similarly, animal metabolism has been controlled to an increasing degree through the use of compounds with specific effects. The protection of crop plants and domestic animals from predators, pests, and weed competitors has reached a high level of efficiency through the use of elaborate chemical substances designed to provide external or systemic protection or prophylaxis. The result has been increasing quantities of high-quality products and a gradual diminution of the annual tribute levied upon the business of agriculture by pests and pathogens.

Most plant and animal products require the applications of chemistry to essentially every step in their conversion into consumer products, and modern foods, feeds, and fibres have all benefited from chemical transformations or enrichment. In fact, the food industry has undergone major evolution, if not revolution, during the past two decades with the result that high-quality, attractive, domestic, and exotic foodstuffs are available to the American public in continuing supply at reasonable prices.

Without in the least deprecating the benefits of technology in the agricultural industry, it is evident that the success of agricultural production is in essence a triumph of research. The advances which have been made during recent years in biochemistry, plant and animal physiology, microbiology, nutrition, and related disciplines have produced the knowledge upon which present progress has been built. The efficient utilization of this increasing body of knowledge is fundamental to further developments and emphasizes the necessity for continuing and intensified effort for research on all fronts.

Superficially, it appears paradoxical that in spite of the spectacular progress which has been made in the more developed areas of the world, there are still vast numbers of people who are underfed, insufficiently clothed, inadequately housed, and barred from reasonable opportunities for decent standards of living. Many factors combine to permit this deplorable situation, and these cannot be easily and immediately changed. The frequently expressed thesis that the application of the modern scientific method to agricultural production on a worldwide basis can readily double or treble world food production is meaningless in the present social context. The problem is not purely one of manpower times mechanics, but rather one consisting of an array of complex considerations, including climate, geography, resources, social and political systems, educational patterns and economics. Thus, while science has much to offer in contributing to the alleviation of undesirable human conditions, science and technology alone are insufficient to the task. They must be joined with intensive and extensive efforts in related disciplines in order that humanitarian efforts may not become simply veneers over unsatisfactory situations, but rather growing points which can develop into patterns of continuing progress and excellence.

The scientist has a great opportunity and responsibility in the matter of applying his knowledge to situations where it is urgently needed. His opportunities come through his ability to use his understanding and experience for desirable results. His responsibilities involve the understanding of problems in their broadest context and the willingness to interpret his own field so that it will be understood by others and to coordinate his activities with those of representatives of other disciplines in order that advances can be made on the broad front essential to social and economic progress.

The more developed countries of the world cannot indefinitely preserve the *status quo* without reference to the demands of the less fortunate nations of the world. This fact is recognized, and serious efforts have been launched with the object of helping to improve standards of living and opportunity in those nations where the needs are manifest. We are learning each day that this is a most complicated and difficult endeavor, and that scientific, technical, and other skills are only part of the variety of tools necessary to success. Of great importance is an increasing body of individuals who can practice their professions or apply their knowledge successfully to other cultures in such ways as to contribute demonstrably to material and other forms of progress and at the same time create patterns of excellence which will in themselves ultimately be taken over, continued, and expanded by the qualified nationals of the country concerned.

The dramatic success of modern science and technology has brought with it both massive benefits and major responsibilities. If human welfare is to advance globally, the benefits deriving from science must be made to apply effectively to the responsibilities which confront all the more favored nations toward helping others to work toward national goals compatible with their potentials.

Contributions of Science To Supplying Food for a Changing World—Solutions to Problems from the Chemical Industry Standpoint

DAVID H. DAWSON
Vice President, E. I. du Pont de Nemours & Company

It is an honor to me and to the Du Pont Company to have been invited to participate in this symposium. The success of your committee in organizing it is indicative of the extent to which the scientific, governmental, and commercial communities are pursuing common objectives. We are here to pool our thoughts toward increasing contributions to the world's food supply from creative scientific research, with assurance that the benefit of these contributions will far outweigh any hazards, real, unknown, or imaginary.

It may be accepted as self-evident that enormous strides have been made in the past half-century in this country's methods of producing and distributing foodstuffs. Thereby we have been able to almost double our yield per acre, with about one-fifth of the manpower per unit produced; we have increased the variety and improved the quality of foods available; we have largely rebuilt the distribution mechanism in such a way as to lower cost, reduce spoilage, improve variety, and decrease risks to the consumer.

It may also be accepted as self-evident that the population growth of the next half-century will be of such magnitude as to necessitate further advances, perhaps even greater than those which have already been achieved. Looked at solely from the standpoint of this country, these would seem to be readily attainable and, in fact, almost within reach. In today's world, such an insular point of view is completely untenable, and on a world-wide basis the problems grow in magnitude and complexity to such an extent that major advances are clearly required and no longer easily foreseeable.

The advances of the past, and those to be expected in the future, have been, and will be, contributed from many sources. Of the greatest importance have been the radical innovations in agricultural machinery, the lower cost and freer availability of electrical energy, improved utilization of water resources, the improvements in the quality of plants and animals, and their resistance to attack by weather and natural enemies.

Some of the most noteworthy advances have been achieved by the widespread use of synthetic chemical products throughout the process of growing and distributing foodstuffs. Many have become so widely used and accepted that there would seem little point in elaborating on them here. I should like to, however, for two reasons: First, because there has of late been so much emphasis on the dangers and risks in the injudicious use of chemicals that even reasonable and well-informed people may lose sight of their positive values and accomplishments; and second, because our view of the needs of the future may become clearer as we examine the accomplishments of the past.

Fifty years ago, the output of the chemical industry was about four per cent of that of today and was largely confined to simple, basic inorganics. The whole spectrum of synthetic organic compounds was just being unfolded in university laboratories and their commercial applications being tentatively explored.

The first, and possibly still the most important, contribution of the chemical industry has been the availability of low-cost soil nutrients, principally nitrogen. Stemming from Haber's work on nitrogen fixation, aided by the war-generated demand for nitrates, furthered by the utilization of lower cost hydrogen from petroleum and natural gas, synthetic ammonia and its derivatives are now increasingly supplying the nitrogen requirements of the soil. Along with this basic development have come many others—the low-cost synthesis and use of urea, improved methods of application, improved availability of the necessary phosphates, and better compounding of mixed fertilizers. Their use is doubling each decade. The higher yields of many of our crops, our ability to avoid the waste of "farmed-out" land, and perhaps even some of our farm crop surplus problems are due in large part to developments of the chemical industry and its agricultural cooperators in this area.

As the output of his land increased, the farmer has had more economic justification for expenditures for the control of predatory insects, diseases, and competing weeds. These challenges led to a second major advance in a succession, during the past 20 years, of new organic insecticides. DDT was followed by other chlorinated hydrocarbons and more recently by the organic phosphates and the systemic insecticides. The reduction that these products have made in the multi-billion dollar annual crop and livestock loss due to insect pests cannot be evaluated. Their economic justification has been, however, abundantly proved.

Another major advance has been made in the chemical control of weeds, estimated to add about $5 billion annually to the cost of crop production. 2,4-D and the other phenoxyacetic acid derivatives, and most recently the substituted urea compounds, have all found important applications. Millions of man-hours of labor have been saved, and the full economically justified usage of such herbicides is still far from being attained, even in this country.

The third area of crop protection is plant disease control. Protection of growing plants against disease, blights, and rots starts with treatment of seed with such compounds as the organic mercurials. Dithiocarbamate fungicides have become widely used for protection of foliage and fruit.

Other applications of new chemical agents, while individually less impressive in their contribution to lower labor costs and improved agricultural yields, in total are comparable to these. Typical are the use of plant growth regulators such as those used to prevent premature dropping of orchard crops and the defoliants to aid harvesting. In the production of livestock and poultry, comparable advances have been made through the addition to feed rations of synthetic chemicals such as urea, methionine, the antibiotics, and the vitamins.

The further processing of these agricultural products into foodstuffs has since time immemorial demanded the use of simple, naturally occurring chemicals such as the sodium chloride in salt, the sucrose in sugar, and the acetic acid in vinegar. The wide range of synthetic chemicals has extended and increased the effectiveness of these—as preservatives, antioxidants, emulsifiers, stabilizers, bleaches, and colorants. While no single chemical or group of chemicals has been responsible, in total their use has been a major factor in producing greater variety, more safety, greater availability, increased attractiveness to the consumer, and higher nutritive value in the food consumed by the American people.

The chemical industry has also participated in the radical improvements which have been made in food distribution through improved packaging materials. By tailoring transparent protective films to the unique requirements of each foodstuff, such developments as the prepackaging of meat and poultry have been made possible. The loss in the distribution system has been reduced, hygienic standards improved, savings in transportation and storage space achieved, and certainly a wider—sometimes bewildering—variety of more attractive foodstuffs has been offered to the American housewife.

These accomplishments bulk large in the total advances which have been made in this country in the efficiency of producing, and in the quality and safety of, the food supply for our people. They give us security against disastrous crop failures, and provide some relief in the farmer's cost-price squeeze. Finally, they give us some assurance that our farms and food industry can meet the food requirements of future generations without hardship. Now, how have these chemical contributions come about?

Fundamental, of course, has been the development of basic chemical knowledge—the result of the productive creative efforts of many scientists, in university laboratories particularly, but also in industrial research and in government laboratories. Chemical science had first to conceive and then to make this almost infinite variety of compounds, each unique in its chemical structure and frequently also in its biological effects on plants, animals, insects, and man.

Second has been the willingness of agriculture, frequently with the strong leadership and urging of state and federal agriculture agencies and the food industry, to undertake the necessary experimentation and to risk the new and untried.

Third has been a healthy and growing chemical industry which was able and willing to devote large expenditures to research and to proceed with plant and capital expenditures when success was far from assured.

Fourth, and most basic, was an economic system and government climate which promised rewards to the inventor and innovator and allowed him a maximum degree of freedom to explore the new, with due, but not excessive, regard for the risks involved, both to himself and to the users.

Now let us turn to the future and the problems which it presents. They would seem to be, in essence, two. First, how do we extend the advances, already made and to be made in the future, on a world-wide basis and particularly to the under-developed countries whose needs are greatest? And second, how do we achieve the necessary continued advances, and in what areas are they most needed?

The first of these—the extension to under-developed countries—is of the foremost importance, but one which is clearly beyond the scope of the speaker and which will be treated at length by other speakers at this meeting. The second presents difficulties enough, and I would prefer to devote my limited time, and yours, to it.

Without minimizing the accomplishments of the past or the opportunities of the future, it seems clear that the maintenance of our rate of progress will not be easy and will perhaps require even greater efforts that have been made in the past. I will mention only a few of the troublesome areas where concentration of that effort seems indicated.

Three basic fields of study seem to promise the greatest advances in the application of chemicals to agriculture and food. First is the chemistry of life processes in living cells. Second is the perfection of evaluation procedures, particularly of analytical techniques. These two fields of study take us into microcosms at the molecular level. The third is an almost equally challenging macrocosm—the teeming mass of minute plant and animal life, called the edaphon, which inhabits the soil and of which we have yet only limited knowledge and understanding.

I can deal only briefly with the edaphon, so will take it first. It consists of molds, bacteria, yeasts, fungi, algae, protozoa, nematodes, mites, and various other forms of life. Many of them exist at the expense of plant roots and are thereby responsible for serious crop losses in the field.

The normal edaphon develops a natural balance between harmful and beneficial organisms. As we approach the control of harmful organisms, we must be sure that we do not also kill off the beneficial ones, or turn them into harmful ones, by upsetting their environment and possibly destroying their normal sources of nourishment.

Now, let's look at the study of chemistry in living cells. The behavior of chemicals in living systems depends on intricate chemical reactions in the enzymes and nucleic acids of individual living cells. These reactions are sensitive to slight influences and they occur in successions and combinations which are presently difficult or impossible to duplicate in the laboratory. As a result, development of products for biochemical activity depends too often upon the classical Edisonian or empirical approach. This is inevitably slow and wasteful. Success is all too often the result of chance rather than skill.

A better understanding of these processes would bring us closer to prescribing molecular formulas to fit given biochemical needs. These might be aimed to promote desirable biochemical effects as in nutrition, regulation of growth, or influencing genetic factors. Or they might be aimed to inhibit undesirable forms of life, such as harmful bacteria and viruses, fungi, or predatory insects.

Understanding of biochemical activity in living cells would help also to overcome some of our major problems in establishing safe levels of human exposure to synthesized chemicals. It would help us to anticipate the metabolism, dispersion, and disposal of these compounds in the human body, and to understand the body's own detoxication mechanisms. It might allow us to simplify or even to eliminate the present cumbersome procedures of bio-assays with laboratory animals.

The second fundamental problem is that of testing and analytical techniques. At the present time, and for several years, we have run toxicological tests with as many as 450 laboratory animals and compiled a 300-page volume of data. With all this we can still only demonstrate effects of some particular recognized magnitude. We cannot demonstrate the absence of any effect at all. Toxicity is not a specific measurable characteristic like melting point or molecular weight. It is related to the other conditions in a living system which is exposed to its influence.

Again, in our chemical analyses, we can be accurate only to a point. Our analytical procedures cannot prove an absolute zero. We cannot prove the presence of a smaller amount of chemical than we can detect. Our whole concept of tolerances is based on analytical methods of finite sensitivity, and the term zero can only mean "less than can be detected by a method of appropriate sensitivity." If we are accurate down to one part to one million, then anything less than that represents zero by our analysis.

Since both our bio-assays and our analytical methods leave us in the position of having proof only when we have failed, we have to resort finally to scientific judgment on the basis of what is known now because so much is still unknown. If we find no negative evidence, we can assume that we have succeeded. But we can't prove it.

The need for greater analytical accuracy, however, is not just for the establishment of safe levels of commercial chemicals. It is basic to all our fundamental studies. We have to identify and measure the various synthetic and natural compounds in controlled or uncontrolled biochemical reactions in order to know the chemical situation we are working in. We have to be able to differentiate infinitely small amounts of compounds from closely related or similar chemicals.

Progress in these and other areas may be confidently expected. It will require continued dedication to basic research by our government and university scientists. But to a very important extent it will depend also on the willingness of the chemical and food industries to support the research which it requires, and then to take the capital risks involved in manufacturing and marketing the products that research has uncovered.

The willingness to risk capital has been subtly but profoundly influenced by the changes in legislation and in legislative climate which have developed in the past several years. I refer to the increasing emphasis on the risk involved in any chemical additive to food—whether directly in the handling and manufacture of foodstuffs, or inadvertently through pesticides or animal feeds. This seems to reflect a public—or at least a legislative—desire to reduce the risk of any harmful effect of any chemical additive to foods, and preferably to make that risk approach zero.

Now to argue against the reduction of risk to the consumer—all other things being equal—is patently foolhardy. But it is possible—and essential—that we argue that all other things are rarely equal, and that to eliminate risk would be to bar progress. Certainly we did not allow the very great risks involved to interfere with our development of nuclear weapons and power; every advance into the unknown has and will involve risk, and generally the greater the magnitude and rate of the advance, the greater the risk.

We must not, and really we cannot, eliminate risk. We should be trying only to eliminate those risks which are not consonant with potential benefits. And we should carefully avoid segregating the two considerations. Basically any consideration of the extent of risk without simultaneous evaluation of the potential benefit is, I submit, in grave danger of effectively preventing progress, or at least ensuring that it be achieved distressingly slowly. The problems involved in increasing food supplies faster than population growth are of such magnitude that we need to accelerate and not to hinder their solution.

If it can be assumed—and I see no reason to assume otherwise—that recent legislative trends faithfully reflect public attitudes, it would appear that the basic problem before the chemical, food, and agricultural industries is to convince the public that governmental controls and administration should not be concerned solely with the elimination of risk, but rather with a judgment of risk versus gain. To do this is no mean task, but it will not be accomplished unless there is proper understanding of the achievements already made and those required in the future, and unless our conviction that considered risks are not only advisable but essential are forthrightly and cogently argued.

Meanwhile, the chemical industry, with others, finds itself faced with the necessity of living under present legislation and its able administration. In doing so it is encountering and attempting to solve two very real problems.

The first of these is the cost, and equally important the time required, to establish the safety, not only of new, but of many established food additives. In years past, the time elapsed between discovery of a new chemical compound later proved to have biological activity and the start of its commercialization has been from four to seven years. Under present conditions, it would be longer. The cost of establishing safety is in the order of half a million dollars for a single product and involves testing over a period of several years. These costs must inevitably appear, in due course, in the price of the product. If any product fails after the expenditure of some large part of this cost, some other product must bear that cost.

My own company has for many years accepted the responsibility of satisfying itself that its products, if properly used, do not expose its customers and consumers to undue risk. It has also accepted the responsibility of educating its customers in the proper use of its products. To facilitate such investigations, it established as long ago as 1935 the Haskell Laboratory for Toxicology and Industrial Medicine and has since maintained and expanded an able staff dedicated to investigations in this field. Despite such a history, we have found that the task of meeting the requirements of recent legislation has added significantly to the cost of this work and, more importantly, has slowed the pace of our research efforts. We do occasionally say that, rather than pursue the long trail of "proving safe," we would prefer to turn our research efforts elsewhere.

And this introduces the second dilemma which the chemical industry faces—the increased difficulty of justifying research in view of added burdens of "fool-proof" testing for safety. I do not subscribe to the thesis that has been propounded that industrially supported research in the food additives field will shortly disappear. Obviously it will not—the stakes and opportunities are too great; the needs are too pressing.

But it will be difficult to expand such research to the extent that world food problems of the future justify, and it might even decline—simply as the result of the economic factors which have been introduced.

We in industry must earn a profit in order to exist; we invest in research with the firm conviction that it will, in the long run, add to our ability to earn. To a considerable degree every research project is competing with every other one; as we add to the cost of doing the research, and subtract from the potential earning capacity of the resultant development, we make this research effort less attractive relative to the others. Decline in order of attractiveness it must, and some may well drop off the bottom of the list and join in the forgotten limbo the other good ideas we would like to develop, but won't.

These are problems of magnitude—the ability of the industry to solve them, only the future will reveal. But while we work on them, we should not neglect the basic one discussed before—that of demonstrating to the public and its legislative representatives that we are concerned here with a field in which, as in so many others, some risk is not only justified but essential; that to eliminate risk is to forego progress, and that public interest demands that governmental action be based on a balanced judgment of risk versus benefits to society.

The Relation of Modern Food Science to Nutrition

C. G. King
Executive Director, The Nutrition Foundation

A major characteristic of science is its tendency to become quantitative. The early stages of progress, however, are generally more imaginative and perhaps more creative, but subsequent reasoning and applications develop best when guided by the discipline of quantitative data. In this respect, the science of nutrition is no exception. Neither is the science of food.

In today's discussion, I want to emphasize certain quantitative aspects of food science in relation to nutrition practices.

The Hindu mother sitting in the doorway of her home near Calcutta follows the centuries-old ceremony of massaging her infant with mustard seed oil while the child is held naked on her lap in full sunshine. Before that, she spends hours gathering mustard seed and expressing a small quantity of oil. She has no knowledge of vitamin D, but she is confident that the ceremony is good for the child. Unfortunately she appears to have the same confidence that rubbing a black pigment around the eyes, or wearing a metallic belt, will also keep sickness and bad spirits away. Our North American Indians had a regular practice of gathering fresh root tips from the banks of streams to eat in midwinter, without having heard of vitamin C. Our own forefathers, in a new environment, lost a great many of their children in sickness and death from rickets, scurvy, and goiter because they had almost no knowledge of the chemical nature or quantitative significance of the nutrients in their food. Even today, there is evidence that many of our own congressmen and other key civic leaders have very limited understanding of quantitative concepts in the biological sciences. But even when they do understand, their freedom to legislate intelligently is circumscribed by the views of the public. This is one of the basic problems in democracies, so *we have no choice other than to take seriously and patiently our obligation to convey the lessons of science to the public.*

The *efficiency* with which our present population is protected in health by an attractive food supply available to everyone, is certainly a major factor in our increased economic strength and in our total potential for cultural progress.

There is real value in the concept of nutrition as "the science of foods and their relation to life and health." The goals of nutrition are fundamental too, but far more complicated than is generally appreciated. Stated simply, they are based on practices guided by learning:

(a) to identify fully the composition of foods,
(b) to find methods of accurately measuring all the nutrients or toxic materials present,
(c) to discover the functions of all the nutrients in their respective chemical changes inside the body, and
(d) to understand the health relationships of all nutrients at different levels of intake, on a life span basis.

There is no escape from the biological implications of the above ideas, but day-to-day living in the best light of each advance in knowledge is far from being automatic.

Too many people still have the *primitive concept of nutrition* as a pleasant meal and a comfortable stomach through the next few hours. Here, where excellent food in great variety is always available, the public can do very well if they are informed about the kinds of *food groups* that will furnish a balanced diet. However, the food situation is not static. Research progress, new products, changing environments and limited family cooperation all create a constant and serious need for *new and reliable information.*

To be effective the information must be convenient, attractive, interesting, clear, and concise. Without this kind of service the consumers and every segment of the food industry, from farm to grocery store and restaurant, is working against a handicap.

Meanwhile, clever but poorly informed, irresponsible and often dishonest propagandists, for their own advantage, confuse and mislead the public and cause both widespread economic waste and sacrifice of health. Nationally organized programs of confusion, fear, and falsehood are being conducted by faddists, door-to-door gimmick salesmen, certain unscrupulous "health food" stores, and a considerable number of writers and other artisans in the use of mass-media. So far there has been little restraint on such media through legal or other civic channels, nor has there been an adequate development of honest, effective information to serve the public. There is reason to hope that corrective measures can be developed to meet the public need. Government agencies, the food and related industries, leaders in mass-media of communication, professional organizations, and universities have a responsibility to study the situation carefully and to develop the necessary constructive programs. Until activities of this nature are developed, the public will not have the full benefit of research progress.

In the sense of making practical use of our food resources, the population has done reasonably well with its *normal pattern* of *regular meals* based on:

(a) animal source protein foods—meat, milk, fish and poultry products;

(b) cereal products—breads, biscuits, breakfast foods, and cakes;

(c) green and yellow vegetables and root crops—broccoli, potatoes, sweet potatoes, tomatoes, turnips, green beans, green peppers, and green peas;

(d) fruits, berries, and melons—oranges, lemons, grapefruit, strawberries, cantaloupe, bananas, peaches, apples, and avocados.

Since the educational campaign conducted during the years 1940-45, and the parallel advances in food technology, the classical deficiency diseases such as rickets, scurvy, pellagra, goiter, sprue, and other forms of severe vitamin deficiency have practically disappeared except for individual cases of gross personal neglect. Three large-scale studies in the United States and one in Canada have demonstrated a great improvement from the pre-1940 years; in typical communities (Philadelphia, Nashville, Denver, and Toronto) there was no statistically valid difference in the health records of those who had or had not used special dietary supplements in addition to their regular diets. Although anemia is still fairly common, only a small fraction of the cases can be attributed to nutritional causes—the major factors have been excessive blood loss and other stresses of a non-nutritional nature. When malnutrition had been a factor, the deficiency was usually iron.

The public and many educators are only vaguely aware of the built-in protection of nutrients in the present food supply. Much remains to be done, but the trend in furnishing safeguards of nutrients in the general food supply within the pattern of food groups just cited has already shown dramatic results. For example:

(a) Iodized salt quickly lowered the incidence of goiter from a major public health problem to a minor one. Increased use of seafoods, largely a result of improvements in technology, gave further benefits in this direction. Introduction of iodate instead of iodide by Dr. Nevin Scrimshaw and his associates proved to be important in areas where refined table salt is not available. If all salt were required to be iodized, as recommended by all specialists in this field, there would be still further advantages. These health gains have been made at very low cost and in the opinion of our best medical scientists, without any cases of injury from the practice.

(b) Vitamin D standardization of some fluid milk and of nearly all evaporated and dehydrated milk in addition to special infant foods has practically eliminated rickets and related minor deficiencies, at very low cost—and without injury. Occasional instances of excessive intake have occurred from the ill-advised independent use of high potency concentrates.

(c) The introduction of various types of enriched, restored, and other forms of standardized cereal products has become an important feature of increasing both the quantity and uniformity of consumption of iron, thiamine, niacin, riboflavin. Added milk proteins and scientific blends of cereal and legume protein foods, with or without added amino acids, or possibly fish flour, are of active interest also.

(d) Fortunately the margarine manufacturers adopted standardization of their products with vitamin A at an early date. The public has been protected on that score, while the use of margarine has greatly increased. A new trend is under way to include an increased content of polyunsaturated fats containing linoleic acid or its equivalent.

(e) Canned foods have been a major factor in making a great variety of stable high quality products available in nearly every home, village, and camp in the United States and Canada. Cooperation with farmers, scientists, and engineers has resulted in steady improvements in nutritive quality, safety, costs, flavor, color, and acceptance. By decreasing the overhead space, oxygen tension, and storage temperatures, by increasing the rates of heat penetration and cooling, by improvements in biological control, and by systematic checking on nutritive quality in relation to products and processing, the industry has rendered a notable service. One needs to travel or live in parts of the world where this type of industry is not developed to appreciate the value of this kind of progress.

(f) More recently, the frozen food industry has also conducted and reported to the public a nationwide study of the nutritive content of frozen foods to establish the value of its products and to serve as a guide to further progress within the industry.

(g) The cleaning, chilling, packaging, and refrigeration of fresh fruits and vegetables, and the comparable retail services for meats, poultry, and seafoods have been important factors in conserving both their nutritive quality and their public acceptance in local and distant markets.

In terms of research and education, I want to emphasize the point that *all materials in our food,* whether classed as essential, nonessential, or toxic, *should be evaluated nutritionally in terms of three zones or ranges in quantity.*

(a) In the lowest zone quantitatively, *no significant biological effect is observed.*

(b) In a second, higher zone, *biological effects will be evident,* and they may be either favorable or unfavorable. If favorable, a part of the task is to find the approximate *quantitative range that is optimum and desirable.*

(c) A third, higher zone will then be found where there is *clear statistical evidence of injury* irrespective of the effect at lower quantities of intake. *Initial clear signs of injury, however, are nearly always progressive with increased quantities.*

Complete data of this kind may require much research, but in practice, *this kind* of *approach* applies equally well to essential nutrients, nonessential nutrients, and materials that are commonly regarded as toxic or poisonous. Evaluation of food additives and residues can be interpreted on the same basis.

After an initial range of practical values has been established, further research is generally required to assess the effects of varying quantities of *other nutrients.* Both in agriculture and in human nutrition, many recent relationships of this nature have been dramatic, as illustrated by the wide zones of overlapping functions of selenium and vitamin E, copper and molybdenum, choline and methionine, or niacin and tryptophan.

The urgent need for the above quantitative kind of approach in evaluating food constituents can be illustrated also in terms of the *last eight "trace" or micronutrients found to be essential for optimum health.* Copper, zinc, manganese, fluorine, cobalt, molybdenum, selenium, and chromium were all studied biologically through several decades or centuries because they were definitely toxic. The last two were also regarded by some observers as carcinogens (causing cancer). Thus each of these elements, now identified as an "essential nutrient" in the second or intermediate quantitative zone indicated above, takes its significance only on a quantitative basis. In very minute quantities, they are biologically insignificant. At a higher level they apparently occur in all living plant and animal cells and in all native soils and water supplies. They all show a range of optimum nutritive value. Then in a third higher zone, they can be described as "poisons". The tendency for all living things to be much alike in chemical composition serves as a reasonably good but not fully adequate safety factor. A variety of foods tends to develop a good average effect. (For the past three decades, 1930 to 1960, a new micronutrient has been discovered, on the average, nearly every year.)

The need for lay as well as professional personnel to recognize the validity of this quantitative viewpoint in regard to food constituents is equally important in food production, in education, in establishing regulatory policies, and in formulating advertising claims.

With respect to the immediate problems facing the public and the food industry, the above point is illustrated in the three fields of food and nutrition research that are now most active. In the *technologically advanced countries* intense effort is being made to establish requirements for an ideal intake of fats in human diets. This problem is tied closely with efforts to conserve health, particularly in the upper age brackets. Despite the complexity of the problem and the life-span type of timing for the human and animal studies, new techniques of quantitative study are making it possible to progress fairly rapidly. Food scientists in industry are alert to making use of each quantitative type of new information in relation to new products such as shortening, salad oils, and margarine.

Closely akin to the problem of exact fat composition is the search to discover to what degree genetic trends and the intake of specific minerals, sugars, vitamins, proteins, and total calories *can affect the observed changes in fat deposition, blood clotting, hardening of the arteries, and glandular functions.*

In stark *contrast* to our problem of excess calories (and perhaps an excess of "rich foods") in proportion to physical work output in the technically advanced countries, the underdeveloped countries face one of their most severe health, social, and economic problems in the rampant deficiency of good quality protein foods. Accelerated progress in this field is likely to have an important bearing on the prospect for peace in each of these countries and in the world at large. *The penalty from protein deficiency is particularly heavy on the health of infants and small children in the approximate age range of six months to four years.* In view of Dr. Scrimshaw's discussion of this subject later in the program, I will only comment on two of the related points. *First, the advances* in this field of activity, both medically and in food technology, are greatly aided by new, rapid, and accurate micromethods of quantitative analysis. *Second, a very great practical advantage* is now evident from earlier basic studies such as those of Professor W. C. Rose in establishing the identity and quantitative requirements for amino acids in rats and in men, and the related work of Professors C. A. Elvehjem, Grace A. Goldsmith, W. J. Darby, and others, in identifying the biological balances between certain specific amino acids, vitamins, fats, and minerals.

Similarly, the fundamental work of Professors A. L. Lehninger, Konrad Bloch, Fritz Lipmann, E. P. Kennedy, Carl Cori, and others in discovering the pathways by which the glyceride fats and cholesterol-type products are formed and in part are used for energy now furnishes many of the best guides in attacking the problems of relating food practices to health.

In summary:

(1) Supplying generous and balanced quantities of all the nutrients known to be required for human growth and health in a great variety of attractive, stable, convenient, low-cost, and commonly used foods is now a well established practice in the United States, Canada, Western Europe, and other technically advanced areas of the world.

(2) This fortunate situation does not decrease the need for continued emphasis on increasing research and education. The outlook for good dividends from intensive research and education is brighter now than ever before. They will serve well in the face of rising population pressures, precautions against the risks of war, needs for increased efficiency in protecting health, and in the crucial competitive need for strengthening the constructive economic and social forces in all parts of the world.

(3) The first requirement for meeting successfully the situations that lie ahead will certainly be for competent and

adequately trained personnel with a high sense of social responsibility. No other asset is quite so urgent.

(4) The growing interdependence of men in different fields of science, in different types of industry, and in different areas of civic responsibility, stands out more clearly now than ever before. Our faith in democratic forms of society demands that we share more actively in carrying this kind of understanding to the public. Voting and eating are close relatives in a very large family.

What Modern Food Science and Its Application Mean to Developing Countries[1]

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Preceding speakers have described some of the remarkable progress which has been made in the processing and handling of food in the last few decades. Before closing the morning discussions, it is very appropriate to recognize that these advances which largely mean only added convenience to the highly developed countries may be a matter of life or death for very large numbers of people about whom we must also be concerned if our own way of life is to have a reasonable chance of survival.

One reason for this urgency is that modern communications and transportation have brought a knowledge of something better to even the most isolated countries and as a result, national aspirations are rising. At the same time, other technical developments such as those in medicine and public health, are resulting in populations increasing too rapidly to be fed without the application of modern food science teamed with agricultural and industrial technology. In other words, scientific and technological developments in other disciplines have made imperative the application of science and technology to the feeding of human populations.

Before attempting to describe what the advances in food science and technology mean to developing countries, it is desirable to review the present nutritional status of their popula-

[1]INCAP Publication I-196.

tions. Even today, after more than ten years of direct contact with the nutritional problems of such areas, I am frequently surprised and shocked by new evidence of their seriousness.

Awareness of nutrition problems passed through the period when the major vitamin deficiency diseases were being identified —scurvy, beriberi, rickets, pellagra, and the like—and is now in an era in which protein malnutrition receives the greatest emphasis. Perhaps the full understanding of the significance of mineral deficiencies still lies ahead. This protein era began when Brock and Autret made a survey for WHO and FAO of kwashiorkor in Africa and reported to the second meeting of the joint FAO/WHO expert committee on nutrition which met in Rome in 1951. It was apparent from their report that kwashiorkor was not just an exotic disease confined to what was then known as the Gold Coast and today is Ghana, but that it was also common throughout nearly all of Africa and a direct consequence of dietary protein deficiency (1). Members of the committee recognized then that the same syndrome had been described under a variety of other names from Latin America and the Middle and Far East. It was still several years before the close correlation between kwashiorkor prevalence and mortality in the 1 to 4 year age group was understood, but we now know that the best indicator of protein malnutrition in a country is likely to be its mortality rate for children in this age group.

Table 1 gives mortality rates for infants and for children 1 to 4 years of age, in several Latin American countries, as multiples of the corresponding U.S. rates in 1955. The high infant mortality in technically underdeveloped areas is notorious and yet it is not more than two to four times greater than the U.S. rate while that for children aged 1-4 averages 20 to 40 times the U.S. rate for each year of the four-year span. Guatemala with about 1/50 the population has almost the same absolute number of deaths in children 1-4 as the United States.

Table 1 also includes the only comparable figures which I was able to obtain for Africa and the Middle and Near East; no data of this type are available for many of the countries where nutrition problems are even more severe than suggested here.

TABLE 1. INFANT AND CHILD MORTALITY IN UNDERDEVELOPED AREAS
(Multiples of 1955 U.S. rates)

LATIN AMERICA			AFRICA AND ASIA		
Country	Infant Mortality	Mortality 1-4 years	Country	Infant Mortality	Mortality 1-4 years
Ecuador, 1955	4	26	Egypt, 1947	8	45
Colombia, 1956	4	18	Algeria (Moslems), 1948	6	35
Guatemala, 1955	4	39	Federation of Malaya, 1947	7	22
Brazil, 1956	4	11	Singapore, 1947	5	14
Mexico, 1955	3	22	Ceylon, 1952	3	21
El Salvador, 1956	3	21	Thailand, 1947	2	16

To illustrate the significance of these figures, Guatemala can be taken as representative of technically underdeveloped areas. It is a country with one of the highest mortality rates for children 1-4 years of age in the world and yet there is nothing in the official vital statistics, as tabulated in the country or reported in Pan American Health Organization-World Health Organization publications, to indicate that malnutrition is an important causative factor. Locally it is recognized that kwashiorkor is a major cause of hospital admissions and deaths. INCAP undertook to investigate the causes of each child death in four predominantly Indian villages with combined mortality rates which closely approximate the national average (2). The results for the 222 deaths studied are shown in Table 2. We found that nearly 40% of those 1-4 died with edema, skin lesions, hair changes, apathy, and the other

TABLE 2. CAUSES OF DEATH OF CHILDREN UNDER 15 YEARS OF AGE IN FOUR HIGHLAND VILLAGES IN GUATEMALA, 1956 AND 1957

Cause	Official vital statistics	INCAP investigation
Congenital malformations and diseases peculiar to early infancy	43	49
Diseases of the respiratory system	35	42
Diseases of the digestive system	21	37
Infective and parasitic diseases:		
whooping cough	12	17
intestinal parasites	58	0
other	9	10
Other specified causes:		
kwashiorkor	0	40
other deficiency disease	1*	3
other	2	0
Ill-defined or unknown	41	17
Not investigated	0	7
Total	222	222

*Died in a hospital in Antigua, Guatemala signs of acute kwashiorkor. Equally significant was the fact that, of the remainder, nearly all died in the course of relatively brief episodes of either diarrhea of infectious origin or complications of common childhood infections, none of which would be fatal to any significant number of well-nourished children.

The conclusion is unmistakable that, even if it were impossible to take other health measures, improved nutrition alone would not only eliminate the nearly 40% of all deaths caused by kwashiorkor alone, but also decrease the number of deaths apparently due primarily to infection. None of this could be deduced from the official vital statistics, and one of the reasons for the failure of health officials to realize the tremendous impact which measures to improve nutrition could have on the health of the people in technically underdeveloped regions stems from acceptance at their face value of inadequate official vital statistics as to causes of death. If the concepts of the INCAP study are applied to vital statistics from other regions, the true significance of the high mortality figures which I quoted earlier for various other countries is apparent.

Just as the results of this study were a revelation to us and lent new impetus to efforts to improve the nutrition of children in the INCAP area, including the development of low cost protein rich mixtures of vegetable origin, recent results of another type have given us a comparable shock and stimulus. Urinary creatinine excretion is traditionally considered to be a stable estimate of relative muscle mass. In INCAP studies of urinary creatinine excretion among lower income children in Guatemala, we expected to find confirmation of the retarded growth and development suggested by the results of measurements of height, weight, and bone maturation. We were not prepared to find the urinary creatinine excretion of preschool children in a rural Guatemalan village to be in the same range as previously obtained in children with acute kwashiorkor (3). In other words, as far as this particular estimate of protein nutriture is concerned, these children would have to be classified as cases of kwashiorkor. Of course, they do not have clinical kwashiorkor, but the underlying protein malnutrition, sometimes referred to as prekwashiorkor, which characterizes nearly all of the preschool children in population where kwashiorkor is prevalent and which produces the very marked retardation in height, weight, and bone maturation for height in Guatemalan children. These same children averaged nearly four years retarded in bone maturation when they reached school age. The high mortality in preschool children is among those with pre-kwashiorkor who developed kwashiorkor when the added stress of infection is superimposed or who die when the infection itself proves overwhelming because of lowered resistance.

There is also evidence that the deficiencies which bring about retardation in physical growth and maturation are associated, physiologically or culturally, with retarded intellectual performance. Direct support for this has come recently from studies of the group of Gómez at the Hospital Infantil of México who found a direct correlation between low scores on the Gessell and Goodenough tests and the degree of deficiency in weight below standard values (4). The evidence that performance on intelligence tests is also affected by malnutrition, is a further indication of the urgency and purpose of efforts to improve the nutritional status of children in technically underdeveloped areas. Decreased stature due to malnutrition may conceivably have some adaptive advantage where nutrition deficiency is common, but the associated retardation in intelligence and increase in mortality and morbidity are obviously extremely undesirable.

In looking at the health problems of technically underdeveloped areas from the viewpoint of the harmful effects of poor nutrition and attempting to appraise the benefits which the application of agricultural and food science can bring, we must also avoid the errors of the blind men describing an elephant only from the parts each is touching. When the parasitologist, malariologist, and nutritionist look at the same child with edema and swollen abdomen and are each convinced that he has seen the consequences of intestinal parasites, malaria, or malnutrition, according to his respective specialty, a situation not at all unheard of, it is time for objective evaluation by persons broadly conversant with tropical medicine and public health. On the other hand, in most technically underdeveloped areas, the error lies in overemphasizing the role of infection and underestimating both the direct and indirect role of nutrition in producing the characteristically high morbidity and mortality rates. The true relationship is, of course, one of synergism in which the adverse consequences of both simultaneously are more serious than those of either one alone. Nevertheless, we can be certain that improved nutrition alone will help to lower morbidity and mortality due either to infection or malnutrition and that it will result in improved growth and development, both physical and mental. These can be felicitous consequences of the recent developments in agricultural and food science discussed today.

The discussions have also given at least a partial answer as to the way in which improved nutrition may be achieved in areas where proteins of animal origin are in short supply and largely beyond the present purchasing power of a large proportion of the population. I have witnessed in urban and rural health centers in such areas the struggle of physicians and nurses to give practical instructions for improving the diet of a malnourished child. They have been taught to emphasize the importance of milk as a protein source for children and time after time instruct a mother with a totally inadequate income for the purpose to give milk to her malnourished child. The net result is that the mother must either ignore the advice entirely or give her child a tiny quantity of milk in large amounts of water. In either case, the result is likely to be the development of kwashiorkor and death.

For similar economic and cultural reasons, recommending the other conventional sources of protein of good quality, eggs, meat, and fish, may be equally unrealistic. The usual result is that the health worker continues to give this impractical advice because there seems to be no alternative, and concentrates on the things that he can more obviously do something about—such as treatment of acute illnesses, preventive immunizations, and latrine construction and other environmental sanitation measures. Nutrition is not neglected because of lack of interest in the problems but because of frustration in attempting to cope with it. Agricultural and food science and technology can break this vicious circle of frustration and apparent apathy by providing sources of protein and other nutrients, that are both cheap and effective. Vegetable mixtures for this purpose hold great promise. For Central America, the development of INCAPARINA a vegetable mixture containing 27.5% of protein of a quality in the range of that of animal protein and costing about 1 cent a glass, has changed almost overnight the possibilities of doing something immediately about the serious malnutrition which prevails among young children in Central America. For some areas, increased supplies of milk and eggs may be the measures of greatest importance. For others fish flour and meat meals or soya products may be useful. Certainly no single measure on food should be considered a panacea to the exclusion of others. All practical sources of quality protein and other essential nutrients will have to be exploited adequately to feed the growing population of the world. If modern food science and technology can be applied in developing areas, marasmus should virtually disappear and kwashiorkor need no longer occur. There will not be thousands of children permanently blinded as a result of vitamin A deficiency in Indonesia and other parts of South East Asia as well as, sporadically, some in Africa and Latin America. Application of present knowledge of enrichment procedures would eliminate pellagra from Yugoslavia, the Middle East, and parts of Africa where it is still prevalent, and beriberi from the countries of South East Asia. Infantile beriberi in which the breast-fed child dies very suddenly as the result of a deficiency of thiamine in his mother's milk is actually increasing at the present time as machine milling of rice replaces the less efficient hand pounding which leaves some thiamine with the grain. The true magnitude of the problem is seldom fully understood even by professional nutritionists. This is partly because all surveys are necessarily based on the study of relatively small numbers of individuals. It is hard to visualize the problems encountered in small groups multiplied by the hundreds of thousands or millions of persons in a similar socioeconomic and nutritional situation in a given country. Picture individual cases of marasmus, kwashiorkor, pellagra, beriberi, keratomalacia and other major deficiency diseases multiplied by a million and whether the period covered is one year or ten, they become a staggering human problem.

The food production needs are also staggering. For example, dietary surveys show that the diet in rural areas of Guatemala includes as high as 80% corn and obviously limited amounts of other foods. When national food needs in Guatemala were calculated on the basis of a minimum adequate diet as close as possible to the pattern and cost of that already consumed, the inadequacies of agricultural production of food crops were more apparent. In Figure 1 you will note that the only item in excess was sugar, which was being consumed as empty calories directly or after being converted to alcohol. National production of corn was inadequate for human consumption even without taking into consideration the large amount of corn going into animal feeds. Furthermore, there was a need to increase production of dairy products nearly 400%, eggs 300%, fruits and legumes 200%, and meat 100%.

This is one approach to evaluating the food needs of a country but it is not entirely realistic. The market at that time already appeared saturated with milk—at 20 cents per quart, with chicken —at over $1.00 per pound, and with eggs—at prices as high as 8

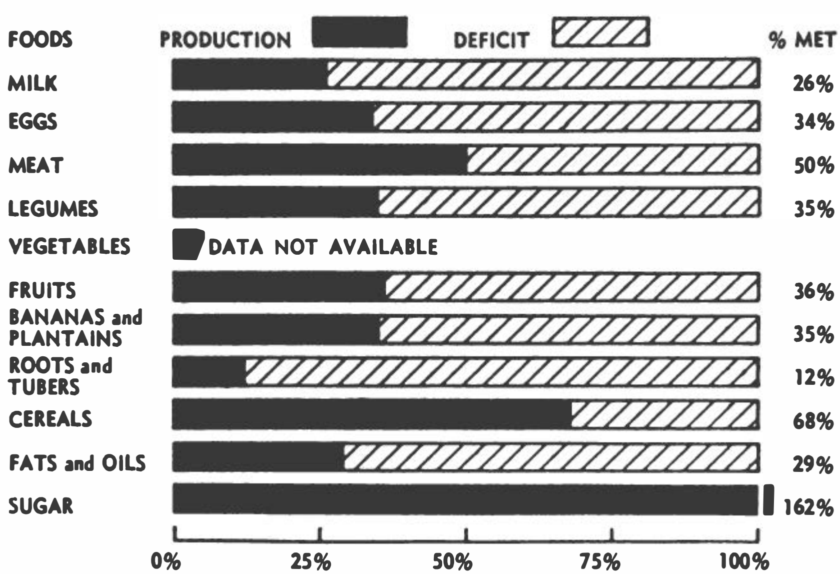

FIGURE 1. Available food production compared with actual food requirements in Guatemala in 1955. (Prepared by Klein and Saks, Washington, D. C. in collaboration with INCAP.)

cents apiece even in rural areas. More production at the same prices would not have helped the lower socio-economic groups very much. But since this survey was made in 1957, a few large producers, adopting U.S. poultry production techniques including pure breeds, batteries of individual cages, high protein rations, hormones and antibiotics, and frozen storage, lowered the price of eggs to 4 cents apiece and of poultry to as low as 39 cents per pound. The result is that a level of poultry and egg consumption only recently assumed to be *completely impossible* is now a reality. In contrast, although milk production has increased, prices have not fallen and producers are finding it impossible to dispose of all of their milk. The details may vary, but the principles are the same for all underdeveloped countries. Techniques are required which will make goods cheaper as well as more abundant. To rely on economic development to bring sufficiently increased purchasing power to pay needlessly high prices, is to court disaster.

There is too much evidence in whatever continent we look to forget that malnutrition and political instability are handmaidens. The application of modern agricultural and food science to the solution of the nutritional problems of technically underdeveloped areas will most certainly give them a better chance for achieving political stability and balanced economic and social development. The greatest danger lies in the difficulty of conveying by a general statement like this, the current urgency of the situation. Time is running out in many parts of the world and each effort is important. A disaster whether natural or man-made always seems worse if it occurs in our own country and more serious still if it is in a state or town which we personally know well.

I have tried to point out the mass disasters which are occurring *daily* in technically underdeveloped countries and about which something can be done through application of the measures described in this symposium. I have no doubts as to the adequacy of the means available now and in the future for solving the nutrition problems of technically underdeveloped areas, but I am deeply concerned as to whether we will apply them in time.

If we are to do so effectively, we must learn to understand and take into account the viewpoint of the people we propose to help. A few examples may help to clarify this point. When an agreement is signed which puts United States technicians in control of the entire agricultural research and extension of a foreign country and then they and the national personnel working with them are prohibited from doing research or giving advice on crops competitive with those in surplus in the United States, local nationals are understandably dismayed. A disposal of United States surpluses abroad in ways that sound magnanimous but which actually interfere with the development of a country's capacity to feed itself, do not really deceive local leaders. In arranging for the commercial production and distribution of the INCAP-developed low cost vegetable mixture for human feeding in Guatemala, the local management of two companies under U.S. control were unable to present an acceptable offer because the margin of return expected on new foreign investments required a price which would have defeated the purpose of the product. In order to make investment in essential or important new industries in technically underdeveloped areas attractive and safe, some other way than a relatively quick return, must be found to compensate for the excessive risk and political uncertainties involved. Many of the industrial operations taken for granted in this country are simply impossible at the present time in most technically underdeveloped areas because of the lack of long term investment capital and the very high interest rates which presently prevail.

Similar principles apply to the education and training of technical personnel. Technically underdeveloped countries are not technically underdeveloped because their people are malnourished, but rather they are technically underdeveloped *and* underfed because they do not have sufficient technicians of all types. Cooperative arrangements for a foreign educational institution to receive help from a U. S. university are not likely to be successful if they are looked upon primarily as an opportunity for faculty members to gain experience and for their students to do interesting thesis work. The U. S. institute must be willing and able to understand the needs and purposes of the local institution and see that benefits of the association are mutual. Even more important in terms of the numbers of persons involved is the need to consider more seriously the real needs of foreign students who come to the U. S. It is not right to expect them to do *all* of the adapting to a strange educational system and a program often bearing little relationship to their needs. No U. S. institution should be encouraged to accept a foreign student in a program which is ill adapted to his needs, and conversely those institutions which do accept a large number of foreign students have a strong moral obligation to attempt to provide the type of training which will be useful to them. A great deal better job needs to be done in the handling and teaching of foreign students from technically underdeveloped countries in the U. S. today.

Only if both industrial organizations and educational institutions in the more highly developed countries recognize the urgency of the problems and make *more* rapid progress toward understanding and helping to meet the needs of technically underdeveloped areas, will the advances in knowledge which you have heard discussed this morning have the dramatic and incalculably desirable effects which have been optimistically described.

SUMMARY

In summary, I am very pleased to have been asked to talk about implications of food science and technology for technically underdeveloped areas because they are dramatic and can be far reaching. They are much more important for the future of the world than the mere improvement of an already favorable food situation in the highly developed countries. They are of incalculable importance because they are the only means by which some countries will be able to cope with the problems caused by an increase in the national aspirations of people everywhere and by the application of advanced technology in other disciplines. Many of the advances in food science and technology of which we have heard today should, and I trust will be, part of action programs which will eliminate the prolonged period of retarded growth and development after weaning, characterizing most preschool children in technically underdeveloped countries, reduce the high mortality from marasmus, eliminate kwashiorkor, lower morbidity and mortality from infections, improve the learning and working capacity of older children and adults, and be a major factor in economic and social programs and in the preservation of freedom in those countries now classified as underdeveloped. These advances become available at a very critical juncture in the history of the world and a far greater sense of urgency and purpose is required to insure their effective applications. They can mean a brighter, safer, happier and freer world for everyone—if their significance for technically underdeveloped areas is also realized and they are applied in the proper manner—and in time.

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Food and Health: Medical Aspects of the Modern Food Supply

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I am honored to be included in this group of experts in the fields of food and nutrition. I'm not entirely sure why I was included. Some years ago, when Alexander Woollcott was asked to speak at the convention of a fraternity of which he was not a member, he likewise confessed, first, that he felt this was an honor, but on second thought, wasn't it a chance for the fraternity brothers to laugh a little at what those other fellows, non-members, looked like? I certainly am a non-member, just a physician with a hobby of nutrition. So not being the expert on this panel today, I expect I was put in for comic relief.

The science of nutrition as a part of medical practice was already important around the turn of the century, but the science itself was very young, especially as practiced by physicians. Foods were generally "natural," little processed or preserved. There was much discussion in medical circles of acid and alkaline foods, of feeding a cold and starving a fever. Little or nothing was known of vitamins, and the medical understanding of deficiency diseases was just beginning. In fact, in 1912, an expedition to the South Pole was planned without any source of ascorbic acid (vitamin C) in the ration. This is particularly remarkable in that 160 years had elapsed since James Lind, 1753, physician to the Royal Navy, conducted a beautiful piece of clinical investigation which clearly proved the therapeutic benefits of lemons in curing, and for that matter, preventing scurvy.

In the last 50 or 60 years, however, food science and the science of nutrition have, of course, progressed dramatically. Along with this has gone a great deal of effort on the part of many to acquaint the consumer with various aspects of modern knowledge of nutrition. It is uncommon today to find a woman's magazine without some "authoritative" article on nutrition. Such magazines usually contain advertising, directed to the housewife as well as other members of the family, which conveys considerable information, although sometimes it must be confessed misinformation as well. Food faddists and food quacks have capitalized on the new interest in nutrition, and their material likewise finds a ready consumption by housewives and other consumers. This is a sizeable and important problem to grapple with for those concerned with nutrition and for the food industry itself. Important as it is, this is not the major matter I would like to discuss, although we will return to it. Chiefly, I would like to suggest that closer working ties between physicians, the food industry, and nutrition scientists might accomplish a great deal in the field of medical nutrition and so-called special-purpose foods.

May I illustrate this by giving two examples: First, foods for sodium-restricted diets. The general use of sodium-restricted diets by physicians has only been spread widely in the last ten years. This is surprising since the effectiveness of restriction in the intake of salt was known to be related to fluid accumulation in heart disease in 1901. In 1922 Allen and his colleagues first advocated salt restriction in the treatment of hypertension. Still little use was made of sodium-restricted diets until Kempner, in 1944, advocated his "rice-fruit diet" and attention became focused upon sodium-restricted diets. The use of sodium-restricted diets in the past ten years has increased immensely so that now, for example, on the medical wards of my own Boston City Hospital it is the most frequent special diet prescribed.

Now, it is not easy to develop a severely sodium-restricted diet; much more is necessary than simply eliminating salt at the table and in the cooking of food. Many natural foods contain sodium, especially animal foods, the very foods which are likely to contain the most and highest quality protein and the greatest content of the vitamins of the B complex. Moreover, many foods have sodium added in one form or another during processing and packing. For example, peas which are normally quite low in sodium, but otherwise nutritionally valuable, are frequently floated off brine during a process which usually contributes a considerable amount of sodium to both the tinned and frozen product. Thus, to prepare a diet adequate in calories, protein, vitamins, and other nutrients, and yet restricted to a low figure in sodium, requires a great deal of knowledge on the part of the physician and dietitian, cooperation of manufacturers who produce foods, and finally transmission of all the available information to physicians and dietitians.

Believing that communication of this sort of information to physicians, dietitians, food industry, and others was important, the National Research Council's Food and Nutrition Board prepared in 1954 a report on this subject which contained a table of the then known sodium content of foods, together with commentary on their value and use. During the past years the Council on Foods and Nutrition of the American Medical Association has issued statements on the sodium content of certain foods and the use of sodium-restricted diets and, prior to the discontinuance of its acceptance program, provided information to the physician through the Journal of the American Medical Association concerning the actual sodium content of foods as processed and packed by the food industry. In addition, several manufacturers, notably, first, Doctor Bills of the Mead Johnson Company, have produced information about the sodium content of foods. Unfortunately, now that the Council on Foods and Nutrition acceptance program is no longer in force, physicians and others perusing the American Medical Association's columns can no longer learn about the food produced specifically to be low in sodium and for use in sodium-restricted diets and are not, then, informed of the new foods available for this situation or changes in manufacturing which may alter the sodium content of foods.

Perhaps you think the physician is now well educated in this realm; such is not the case. Nutrition is not an interesting subject to most physicians until they are driven to learn something about it, and most are unable to keep up with the current literature, particularly when it is not directed to the physician in this field. It is just not possible for the physician to keep up with the finer ramifications of this subject. To fill in this breach many food industries and industry associations have in their advertising described to the physician the sodium content of many foods. In most instances this advertising has been helpful and educational, but sometimes not. The physician is not in a position to know what to believe, or what not to believe, unless it comes from some relatively authoritative source.

This story of sodium-restricted diets is one of the better handled, I believe. Furthermore, it is not one involving to any great extent major items in the diet and therefore not very large amounts of food.

More recently the doctor has become concerned about fats in the diet. This is the second example of the problem I am discussing. Certainly the complications of atherosclerosis are one of the most important medical problems today. Among other things the quantity and quality of fats consumed appear to be related to the cause of atherosclerosis. There is a great deal in the professional medical literature on the subject. There are many conflicting opinions; but most everyone now agrees, that is among the experts, that a person clearly afflicted with this disease should make some marked changes in the fat content of his diet toward the inclusion of more unsaturated fatty acids and less saturated fatty acids. This involves a much larger number of persons and presumably a larger bulk of food than the alterations required for the sodium-restricted diets. Thus, this is of great concern to agriculturists and members of the food industry, as well as to physicians and dietitians. Because of this great interest and its obvious importance, both the Food and Nutrition Board and the Council on Foods and Nutrition have publications on this subject, and yet when it comes to the physician and nutritionist working together to make a special diet for the treatment of atherosclerosis for a particular patient, many practical facts are lacking and physicians find them hard to obtain except perhaps from the popular TV screen and certain popular advertising.

There are many other examples: foods for aging persons, for infants, and those used in many other diseases. These two examples, however, point out to some degree, I hope, what I consider to be a major problem for the food industry today; that is, the provision of information for the physician on the composition of foods and their utility as special purpose foods and their use for special diets. Such information should be published promptly and must be up-to-date, easily available, as reliable as possible, and uncolored by the necessity to promote a particular type of food or food product. I believe that this is somewhat akin to the problem in the drug industry which hopefully will, before long, itself form an organization to pass on to the physician reliable material concerning the indications and the contra-indications for drugs. The food industry might even take the lead, although the problem is even more complicated than that of the pharmaceutical group.

My proposal, then, is that those manufacturers producing special-purpose foods, or believing that their foods may be useful for a special purpose, have a group of scientifically trained impartial personnel which would make the best possible judgment of the food, learn as much as possible about its composition, method of preparation where this is germane, indications and contra-indications for its use, and then communicate this information discreetly but clearly to the physician, nutritionist, and others concerned, for their use. The organization of such a group would be difficult, to say the least, and clear-cut rules would have to be laid down for its operation. Nevertheless, this would seem to me to be a real contribution to medical care. Furthermore, and here I return to the physician's customary lack of interest in nutrition, I believe this would stimulate his interest in food and food products as the powerful therapeutic tools they are in medical therapy.

The Meaning of Safety as Regards Food Additives

R. Blackwell Smith, Jr.
President, Medical College of Virginia

Safety, in relation to food additives, has been defined as the practical certainty that no harm will ensue when a particular material is used in a specified manner. It has also been stated that safety is the practical certainty that a particular use of a given substance is without appreciable hazard.

If one examines these statements on the meaning of safety, it is apparent that safety is really a negative quality, the absence of hazard. The concept of safety, then, represents no positive state, but rather is emblematic of an instinctive urge, shared by all organisms having a minimum level of intelligence or environmental awareness, to be free from the threat of harm, i.e., danger or hazard. It is not susceptible of complete fulfilment, save possibly in the grave where any further hazards that may exist are certainly not related to food additives.

That this concept or idea we call safety is really a manifestation of the basic instinct toward self-preservation, is probably the reason why the idea of adding chemicals to foods stimulates in the minds of the uninformed, to whom any *chemical* is something unnatural and therefore to be feared, an irrational and emotional, revulsive reaction. Since in technical areas such as this more people are uninformed than otherwise, one can see why this subject has provoked the writing of reams of nonsense during the past ten years. It has provided almost perfect grist for the mills of the professional alarmists, such as the poison pen pushers with literary royalties in mind; those unscrupulous and cynically provocative writers who thrive on sensationalism; those politicians who see here an almost perfect chance to appear in the noble role of protectors of the helpless and the weak; those who apparently take positive delight in shivering anticipation of dangers unknown and perhaps non-existent; and some few dedicated but legalistically minded bureaucrats who firmly believe the public interest cannot possibly be protected save through ever more complicated and restrictive regulatory enactments.

Alarmed and stimulated by such vociferous and formidable threats to the use of chemicals to promote a better food supply, a perfectly legitimate and often necessary practice, many who know better have responded with soothing syrup of the "everything is perfectly fine" variety, pointing out that since everything is chemical in nature, one need have no fears whatsoever concerning the use of chemicals—or additives, if you will—in connection with the production, processing, improving, preservation, packaging, and storage of foods. This, too, is nonsense.

This fact should be faced. There are potential hazards associated with the use of food additives, but these can be controlled through the application of knowledge and common sense, just as society controls the adverse potential of other accepted hazards incident to everyday living. At the risk of belaboring the obvious, it might be pointed out that every potential social advance presents alternatives imposing value judgments which cannot be avoided except at the risk of stagnation. Almost always when progress is made, a risk of some nature is incurred and means devised to minimize or contain that risk. So—to cite only one example—it has been in the field of transportation, and so it is and must be in the provision of an adequate and wholesome supply of food.

Many years ago public policy accepted the risk incident to the necessary or unavoidable presence of limited amounts of potentially deleterious substances (pesticides) in food under certain conditions. More recently, as has been pointed out frequently, the growth of the pest population on the one hand and the human population on the other has resulted in a competition for food so intense that a multitude of pesticidal substances of varying nature and properties has become necessary for the production of an adequate food supply. Again, public policy as reflected in statutory enactments has accommodated itself by liberalizing the restrictions of earlier legislation and requiring only that a pesticide be useful, not necessary or unavoidable as demanded earlier, provided data can be adduced to support the establishment of a safe level of use, or tolerance. Essentially similar provisions, so far as demonstration of safety is concerned, have now been enacted with respect to chemicals, other than pesticides, present in foods consequent to technological use or added to confer qualities believed to be desirable.

In referring above to the liberalization of the restrictions of early legislation, no decrease in the protection offered the public is implied, nor to the best of my knowledge and belief has there been any such decrease. Liberalization has nevertheless taken place in the sense of statutory recognition of the truth that there is no basis in fact for the idea that any substance either is or is not a poison, or either is or is not innately poisonous or deleterious. This idea, the so-called "per se" concept, had served to create confusion and to delay recognition of and attention to the real issue, i.e., whether a particular *use* of a chemical additive is safe (relatively free from harmful potential).

For many years pharmacologists, toxicologists, and other scientists concerned with such matters sought without success to develop a generally satisfactory definition of a poison. The truth, belatedly recognized, is that substantially every substance, including pure water and table salt, may be harmful if a sufficient quantity is swallowed or otherwise introduced into the body; and conversely, it is a generally accepted fact that there is no substance sure to kill or harm if swallowed or taken otherwise, provided the amount taken be sufficiently small. That this harmless amount in many cases may be so small as to approach zero doubtless accounts for the popular characterization of substances known to be harmful in relatively small amounts as *poisonous*. To recapitulate, an additive or other chemical is not and cannot be of itself either poisonous or non-poisonous, hazardous or non-hazardous, harmful or safe; but every additive or other chemical may be safe at some level or mode of intake and hazardous at some other level or mode of intake. The question, then, is not one of *whether* but essentially one of *how much*.

Procedures are available which generally are adequate to the task of answering the question of *how much* of a food additive can be used safely. These involve, first, the scientific determination of the maximum amount of a given additive which can be administered or fed to animals without the production of injury, and, second, an estimate by extrapolation of the amount which can be safely consumed by man. The applicable technical procedures have been described by the Food Protection Committee of the National Academy of Sciences—National Research Council (1), the United Nations WHO—FAO Joint Expert Committee on Food Additives (2), Lehman and his coworkers of the United States Food and Drug Administration (3) and others.

These procedures involve long-term animal feeding and other studies leading to a determination of the highest "no-effect" level in the species studied. They are cumbersome, time consuming, and costly; and they stand in need of improvement or replacement. Workers in the field are bending every effort toward this end. The interpretation of the data obtained is a complex matter as is their extrapolation to the human, and both require the expert skill which can be acquired only through extensive experience. Nevertheless, for a given additive, the means available permit the identification with practical certainty of safe levels of use. Absolute assurance of safety cannot be provided either by present methods or by those reasonably to be anticipated in the future, but the risk involved can be reduced to a level believed to be negligible.

The major exception to this generalization concerns proposed additives found to be carcinogenic when studied by the long-term animal feeding tests now routinely employed in the study of most additives. The cause or causes of spontaneously occurring cancer are still unknown, as are the modes of action of chemicals known to produce cancer when fed or otherwise administered to animals. There is recent evidence that a dose-response relationship may be defined for chemically induced cancer in animals. Thus it may be theoretically possible to calculate a non-carcinogenic feeding level in animal species for which oral dose-response curves have been accurately defined for a given carcinogen. However, there presently exists no accepted basis for the extrapolation of such levels to man. Yet it seems doubtful one should conclude at this time that no additive which produces cancer in any species of animal by any route of administration may ever be shown safe for use in the human food supply. Glucose itself has produced malignant disease in mice when administered under certain conditions not paralleled by human food use of this common nutritive substance. Although cancer is probably the most alarming reaction a proposed additive can produce, further studies may develop information which could lead to the safe use in food of other chemicals known to produce cancer in animals under certain special conditions.

To return to more general considerations, it seems possible that a relatively simple matter, an understanding of the meaning of safety as regards food additives, has perhaps been impeded by the great acceleration of scientific and technological progress which has taken place in recent years. The development during the last great war, and more recently, of a large number of new and effective pesticidal chemicals, and the demonstrated need for such weapons against insects and other pests, have resulted in a tremendous pressure for their use. The rapid development of new chemicals technologically useful in packaging, in improving the palatability or attractiveness of old food products, or in the development of new food products having great consumer appeal, has created pressure for the early use of many new additives in this category. It is not remarkable that those directly entrusted with the responsibility of maintaining the integrity of the food supply should approach conservatively the problems involved in the almost simultaneous introduction of so many new chemical additives, nor that others of conservative mind should express concern.

The understandable tendency of the developers and the agricultural and food industrial users of these new pesticides and other additives to press for their early if not immediate use, their often expressed impatience in suffering the checks on their programs imposed by the limitations of the only methods available for the demonstration of safety, and their frequent complaint that technological progress is being placed in grave jeopardy by these checks, to the certain detriment of the national welfare, inevitably have generated defense reactions among those having the statutory obligation of containing such innovations to the extent necessary for the protection of the public health. More heat than light has developed in some instances, and in this atmosphere it has been difficult to attract attention to a few simple and comforting truths.

First: Safety in regard to food additives means the scientific establishment of reasonable certainty that a given use of an additive will not be harmful. The goal of safety as here defined is one which can be attained without major difficulty, but not inexpensively or with the celerity which is desirable.

Second: Absolute proof of safety of a given use of a food additive cannot be adduced, but the methods used to establish safety are believed to provide data which give far greater assurance of human longevity than do data relative to the safety of riding in automobiles, crossing the street, climbing ladders, standing in the bath, or many of the other common activities in which we routinely engage.

Third: This country has the world's most abundant and wholesome food supply—convincing evidence that the methods required for assurance of safety have not completely stultified agricultural and food industrial progress and, further, that these methods have served to guard effectively against the introduction of harmful uses of food additives.

The American people are deeply indebted for this healthy state of affairs to three groups—an active corps of scientists expert in the pertinent fields of inquiry; an alert and resourceful agricultural and related industrial group which seeks unremittingly to use every applicable scientific advance in behalf of a more wholesome and abundant food supply; and the able and effective people of the U. S. Food and Drug Administration, whose labors have aided sound progress in this area, despite the fact that they must operate under regulatory statutes of necessarily negative import.

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Applications of Science in Assuring Safety of the Food Supply

GEORGE P. LARRICK
Commissioner of Food and Drugs, U. S. Department of Health, Education, and Welfare

Since the turn of the century, rapid advances in science and technology have, as you know, caused great changes in our social and economic organization.

Nowhere has a developing technology had greater impact than upon our food industry. Basic agriculture has been drastically altered and made many-fold more efficient by the mechanization of equipment and the adoption of mass production methods. Improved fertilizers and modern, more efficient pesticides are available.

Similar far-reaching technological advances have occurred in the preparation, packaging, and distribution of foods. Bacteriological and enzymic studies of the causes of decomposition and food spoilage have led to the development of heat processing with automatic controls, improved methods of pasteurization and refrigeration, and the phenomenal growth of the frozen food industry. New preservatives and mold inhibitors have come into use. Improved materials such as metal and plastic foils and container linings and coatings have resulted in more convenient food packages. Improved methods of transportation make possible the safe and rapid distribution of perishable foods to our expanding urban population centers.

To illustrate these profound changes, contrast a modern "supermarket" with the typical corner grocery of a former generation. Some of you may remember the latter—the cracker, flour, and pickle barrels, the bins of dry beans and peas, the bulk cheeses, the haunches of meat hanging in the old walk-in icebox—not to mention the ubiquitous sheets of fly-paper. Now walk into a modern, air-conditioned, fluorescent-lighted food market. There are literally thousands of competitive items—fresh fruits and vegetables in and out of local season, frozen meats and fish, and an array of canned, frozen, and "ready-to-serve" meals—all attractively packaged and displayed. Some foods, such as milk and bread, are supplemented or enriched with nutritional components they would normally lack. It can be truly said that applications of science and modern technology have made our food supply the most abundant and diversified in the world.

But while this advance of science has contributed greatly to the abundance, variety, and wholesomeness of the American dietary, it has also brought entirely new problems of food law enforcement and new possibilities of hazards to health.

Fifty years ago, food chemists were dealing with such crude and flagrant adulterations as copper sulfate in peas, watered milk, and powdered brick in annatto. Obviously, the detection of such abuses did not require elaborate scientific techniques. While fairly adequate balances, refractometers, saccharimeters, and microscopes (usually of European manufacture) were available to the food chemist, simple physical operations or the classical methods of gravimetric and volumetric analysis usually served the purpose.

Contrast the primitive problems of food adulteration with those facing the modern food and drug scientist. He must now contend with such problems as the radioactive contamination of food crops by fall-out; the bacteriology of frozen precooked foods; organic pesticide residues in food crops, milk, and meat; the presence in foods of possibly carcinogenic food additives. These new problems are very extensively evident in the present regulatory programs of the Food and Drug Administration.

Fortunately, the technological advances which have revolutionized our food and drug industries have also to some extent given the food and drug scientist new tools which he can apply to these new enforcement problems. He now routinely employs equipment which was unknown or unapplied in a former day; spectrophotometry; bioassay; paper, column, and gas chromatography; electrophoresis; photofluorometry, to mention but a few.

Merely for example, let us make brief note of the progress of "colorimetric" analysis during the past 3 decades. Older chemists usually compared colored solutions by sighting down Nessler tubes. For quantitative estimations they sometimes used a colorimeter of the Dubosq type, equipped with plungers immersed in the colored solutions, which were held in cups mounted on movable stages. Spectrophotometry, as we know it today, was virtually unheard of, but during the 1930's it began to be applied. In 1936, the Administration acquired a Bausch and Lomb spectrophotometer. It consisted of a light source and cell holder and a polarization photometer mounted in conjunction with a glass prism spectrometer and eye-piece. It cost $980 and we were very proud of it. However, it became obsolete with the advent of the photoelectric recording instruments. Nowadays, the scientist watches while the magic pen draws accurate spectral curves, not only in the visible region, but also in the heretofore unused ultraviolet and infrared regions of the spectrum.

We have been able to acquire a number of these instruments for our Washington laboratories and field districts. They have become essential in our work on the many products for whose identity and purity we are responsible.

Chromatography is another new and extremely useful analytical tool. In one or another of its forms it has been applied to the analysis of foods for pesticide residues and to the separation of drug mixtures and of fatty acid esters. Paper chromatography enables the analyst to separate and identify as little as one microgram of certain pesticides such as DDT.

We have recently established a tissue culture laboratory in our Division of Nutrition. Tissue culture technique permits the growth and reproduction of human and animal cells in an artificial medium. Then the effect on growth of a variety of chemicals (food additives, for example) may be observed in what is essentially a test tube manner. Sometimes nutritional changes too subtle to be detected in the intact animal may be noted.

Another technique which we have used to good advantage in testing for residues of the chlorinated organic pesticides is a bioassay using ordinary house flies. Flies react to virtually all the organic pesticides, and the fly toxicities of many of these parallel their mammalian toxicities in a quite remarkable manner. Thus, as we apply the test, 10 micrograms of DDT, 26 micrograms of methoxychlor, 0.8 micrograms of lindane, or 0.6 micrograms of heptachlor epoxide will consistently kill about 50 out of 100 flies.

The operations of our Division of Pharmacology, the largest of our Washington scientific groups, are, I am sure, familiar to this group.

It is of interest, however, that in addition to conducting normal procedures, new methods of detecting toxicity potential and evaluating safety are being explored by this Division and in other laboratories both in and out of the Food and Drug Administration. I have already mentioned the application of tissue culture techniques. Metabolism and other biochemical procedures may be capable of detecting adverse biological effects long before any pathology appears. Microbiological procedures—the use of bacteria as test animals—may be useful in this area. Such procedures as these, if successful, might be substituted for the long, costly animal feeding tests. We are endeavoring to explore this possibility to the extent possible with our limited research staff.

A comparatively recent problem concerns the contamination of foods by radioactive fall-out. During the past several years, we have examined about 6000 samples of about 50 different foods by a count of the "total beta radiation" of the ashed samples. Large-scale nuclear weapons testing ceased in October 1958, and recent analyses by the total beta method indicated a general decline in the total radioactivity of foods. However, significantly high values for tea, alfalfa, and spinach, harvested in 1959, have been maintained. Surveillance will be continued, and it is now planned to anlayze some samples of all foods for individual long-lived nuclides such as strontium-90 and plutonium. Testing of foods for radioactivity involves entirely new techniques and, of course, some expensive apparatus.

Corollary to the surveillance of foods for radioactivity is the use of radioactive tracers. We have used radioactive carbon-14 to trace the metabolism of certain pesticides and also to check the efficiency of the extraction procedures we use to remove pesticides from leafy vegetables prior to analysis.

There is hardly a scientific discipline which we do not employ in our work of safeguarding the Nation's food supply. A roster of our scientific personnel would list biochemists, nutritionists, bacteriologists, cicroscopists, statisticians and biometricians (whose advice assures more adequate sampling and proper evaluation of results), physicists (including electronic experts), colorists, toxicologists, pathologists, X-ray technicians, entomologists, radiologists, doctors of medicine and of veterinary medicine—all in addition to our staff of analytical chemists. In fact, some of our operations have become so specialized that they are not in the ordinary college curriculum. It has sometimes been necessary to conduct special training programs, or to send our people back to school for special courses.

Starting with the premise, which we accept, that neither legitimate business nor agriculture is out to poison the public, why do we need the personnel and equipment of the type I have just described? We think there are several perfectly valid reasons. In the first place, we believe there is no real disagreement with the view that industry both needs and wants rules by which it shall conduct itself to comply with the terms of the Food, Drug, and Cosmetic Act. We must make those rules. In some cases, for example, food additives and pesticide chemicals, we make the rules largely on our review and evaluation of extensive scientific data presented to us in support of specific proposals.

These rules are formally announced in the Federal Register. We have several devices for being sure that these are readily available to those who may be affected. Having made and announced the rules, however, our job has really only begun. In the field, there is the problem of constant educational methods and investigational operations, the latter being designed to find out whether the rules are being met. Where they are not, we must take legal action as provided in the statute. In any action we start, however, we must first be convinced that we have a sound set of facts based on good scientific principles which will enable us, if challenged, to convince a court and jury that we are right.

I recall that former Commissioner Dunbar used to philosophize that it was the God-given right of every taxpayer to criticize the way Government officials go about their jobs. I can assure you that we get our share of that criticism. Some growers criticize us because we have not established tolerances which permit them to use specific pesticides on their crops, overlooking the fact that we probably never have been presented with data which would enable us to consider such tolerances. Growers who misuse pesticides and find themselves in the toils of the law feel that they have been discriminated against. Consumer groups often feel that we do not do enough checking to enforce the rules I mentioned.

People who are honestly interested in complying with the law, as well as those who are merely curious, object because we are unwilling and, in fact, are not authorized, to examine samples at their behest, since we are not operating a service laboratory. Some complain that our laboratories do not do enough basic research, when the limited facilities we have are not even enough to get the answers to the immediate problems we need solved in order to do a better job of enforcement of the law.

We can stand these criticisms. Where they point up things we can do something about, we are the first to want to do something about them. On the other hand, we hope that our critics will understand the fact that there are areas where we are limited by the terms of our law and by the facilities available to us so that we cannot do all that they may suggest at any given time.

We are firmly convinced that sound effective administration and enforcement of the Food, Drug, and Cosmetic Act in this area of pesticide chemicals, food additives, and color additives is not possible without an accompanying strong scientific research program directed and conducted by top-flight scientists who are equipped with proper facilities including the more modern instrumentation. It has been gratifying to us to note the increasing recognition by the Congress that these needs are paramount. Certainly, they will cost more money as science in these fields progresses, and we must demonstrate that we need to continue to go forward in these areas for the benefit of consumers, farmers, and manufacturers alike. I am sure that if we base our needs on sound programs we will be able to keep on acquiring the necessary tools and trained personnel.

How the Food Industry Meets the Demands of the Consumer

CHARLES G. MORTIMER
Chairman, General Foods Corporation

My pleasure in participating in this symposium is two-fold. I not only appreciate the honor of representing the food industry on this program, but I am also delighted to have a part in such a timely presentation of a vital subject that is being approached so constructively.

I want to compliment the Food Protection Committee of the National Academy of Sciences for staging today's symposium with the earnest objective that it serve as a public information device. My compliments, also, for inviting science and food writers to attend along with representatives of medical, dental, public health, nutrition, and dietetic organizations. These communicators can be of immeasurable help in getting across to our nation's consumers the knowledge that is being shared here—the news of scientific contributions to changing production and processing practices and, more importantly, the relation of these contributions to nutrition and public health.

It is my deep conviction that Americans need understanding, as never before, about the abundance and wholesomeness and healthfulness of our food supply. And I believe that dissemination of the information presented at this symposium can help create and build public awareness of the unmatched good which exists in our foods today.

Increasing public understanding of the subject of today's meeting, "Science and Food: Today and Tomorrow," is a mission which engages my deepest interest at the present time. For I appear before you today not only as a food manufacturer but also as president of The Nutrition Foundation, which is, as you know, the now 20-year-old manifestation of the food industry's continuing interest in problems of nutrition and public health. In that role I had the privilege of announcing not too many weeks ago a new and major step The Nutrition Foundation is taking toward increasing public understanding of the relationship between proper nutrition and good health.

The Trustees of The Foundation have authorized an Information Program to bring to the general public knowledge about nutrition in lay terms. What we hope to accomplish is to make the subject of nutrition as understandable and meaningful as possible. The 52 present member companies of The Foundation see such an effort to educate the public as a responsibility in our own area. And it's only frank to say that we are motivated as well by enlightened self-interest. For we recognize the enormous stake the food industry has in the public health.

We are undertaking this new venture to project and make useful to the general public some of the fine work accomplished by The Nutrition Foundation with the concept that it will provide an opportunity for The Foundation—and the food industry which supports it—to play an even more important role than heretofore as an instrumentality for serving the public interest. Because the general public needs continuing reliable information on the relationships between good food and good health, and assurance on the wholesomeness of the food supply, we see a continuing information program as filling a need that will render a valuable service, not only to the public, but also to research scientists and to agriculture. We view the program as a catalyst for uniting all segments of the food industry in a public service undertaking that is bound to redound to the credit of all who help sponsor it.

We believe the Program may do much to combat the confusion which exists today because of the conflicting theories about nutrition which are being promulgated increasingly by food faddists and quacks. A positive, forthright approach can also help to allay public fears resulting from scare-heads about food additives, pesticides, radio-active fall-out, and other modern developments. In fact, we believe the new Information Program could take us a long way toward achieving public understanding of the topic of my remarks this afternoon—how the food industry meets the demands of the consumer.

A first step toward increased understanding will be, I hope, to bring home to Americans the realization that we have the best, the safest, the most varied food supply in the world. We must point up the obvious fact that today's urbanized living precludes each family from growing its own food; that in a society such as ours we just cannot have the abundance of healthful convenience foods we enjoy without the pesticides, fungicides, antioxidants, mold inhibitors, antibiotics, and other chemicals which can be used—with proper safeguards that eliminate any risk whatsoever to the public health—in the growing, processing, and distribution of foods.

Public awareness of the ways in which the food industry is using the latest scientific devices and techniques to bring to America's tables more and better foods will do much, I'm sure, to avoid the possibility of such things as the cranberry "scare" of a year ago. And it can also help check the creeping notion that additives are "badditives."

We need to achieve consumer comprehension of why and how chemicals and additives are used in growing, processing, and storing our foods. The food industry, trying to shore up the confidence in America's food supply which we feel is merited, is heartened by some of the support it has received from government. You are all familiar, I am sure, with the booklet titled "What Consumers Should Know About Food Additives" which the Food and Drug Administration published earlier this year. Many of you may not have seen, however, a leaflet which came across my desk a few weeks ago that was prepared by the Division of Food Control of the New York State Department of Agriculture and Markets.

"Food Additives—Friends or Foes?" is its title, and readability is encouraged by bold type on the cover which notes that the leaflet contains just 825 words that can be read in three minutes with the end result of—and I quote—"Peace of Mind." The gist of the pamphlet is in its last one-sentence paragraph which reads: "To answer the question: 'Food Additives—Friends or Foes?', we can definitely say, 'Welcome, friends!' "

The food industry is heartened, too, by the assistance and support the Food Protection Committee of your National Academy of Sciences has given, by stating publicly that there need be no hazard in the use of chemical additives provided adequate scientific programs are carried out prior to use. The Committee has also stressed the fact that no reputable manufacturer would add any chemical to food when a hazard to the public health is involved.

We look forward to your further help to emphasize again and again the fact that perhaps the greatest protection the public enjoys is the inherent sense of responsibility the food industry is demonstrating for the health of our people. We can certainly use all the support that can be mustered to get across to the consuming public what should be an obvious fact: that food processors have a big stake in keeping consumers of their products in good health; that the millions of good, lively, healthy consumers we serve today are the customers we want to continue to serve for as many tomorrows as possible.

An eye-opening example of the food industry's role—and self-interest—in improving the public health was given to the Grocery Manufacturers of America at their Annual Meeting this year in an address by Dr. Frederick J. Stare, Chairman of the Department of Nutrition, Harvard University School of Public Health.

Dr. Stare hypothesized a 45-year-old man whose life expectancy had been cut by a year and a half because he was 20 pounds overweight. To get that way, the man had given America's food industry a hundred thousand *unnecessary* calories' worth of business. But, Dr. Stare pointed out, had this man *not* consumed those additional calories, in the year and a half longer that he might have lived he would have been able to consume some 1,350,000 calories—or a net gain of more than one and a quarter million calories in food sales for this one person.

Dr. Stare suggested that the audience multiply the extra calories that could have been sold by the number of adult men in the United States who, if they ate less, could live longer to eat more. The good doctor concluded that the food industry would have a "tremendous new market," and I certainly agree with him.

We can take a long first step toward creating that tremendous new market, I believe, by increasing public awareness—even among those not interested in nutrition as a science—that eating is not something you do as instinctively as you breathe, that it is much more than just a habit. We must achieve much wider understanding among consumers that nutrition is a process—the life process through which our bodies grow and are maintained and energized.

Another challenge to the food industry is the still increasing mobility of America's population and its shifts to urban and suburban living. During the last few decades this changing America has motivated the entire food industry to accelerate its pace of innovation to a startling tempo. Even so, we see trends in today's living which point to further major changes in America's foods and eating habits—and thus still greater challenges for our industry. Let me review some of these with you.

Women, particularly those who hold jobs outside the home, want to spend less time in the kitchen. One out of every three employed persons today is a women, and the number of women in the nation's work force has nearly doubled in the last 20 years. While this trend is by no means new to any of us, it does portend an ever-increasing demand for high-quality time-saving convenience foods of the kind which have been accepted so enthusiastically by millions of homemakers. Their purchases are the best kind of evidence that they are happy to be freed from peeling, washing, cleaning, squeezing, mixing, and other prepreparing of the food they serve three times each day.

Although American homemakers have shown ready acceptance for convenience foods with "built-in maid service," all of us in the food industry know that convenience alone will not sell a food product to consumers. Homemakers have high standards of quality, taste, and nutrition as well as of convenience—and they want all four values in every product.

Instant coffee offers a good example. The first patent for an instant coffee—then called, by the way, a "dried cup of coffee"—was issued about the time of the Civil War. Yet it wasn't until after World War I that soluble coffee was commercially available. Measured by today's standards that product was pretty terrible stuff. But research and development finally produced a gooddrinking-quality soluble coffee after World War II. Today, more than one out of every three cups of coffee served in this country is made from the instant form.

Then, too, *there has been a substantial rise in the educational level of our whole population. This means that the housewife of tomorrow will be increasingly sophisticated in her selections and more alert to her family's nutritional requirements.* Every day we in the food industry see clear indications that, while homemakers want foods that can be conveniently prepared and which take the drudgery and gamble out of cooking, they also want to make sure they maintain balanced diets for their families.

More and more, consumers are relying on processors to build nutrition into their family diets, and those processors who enjoy the homemaker's confidence are stressing increasingly the nutritive value of their various foods. A new line of baby foods my company introduced earlier this year is, I think, a good case in point.

We felt there would be a market for baby foods that are convenient and easy to prepare and that still offer high nutrition combined with natural taste. So we developed—and are now marketing on a limited basis—a 23-item line of frozen instant baby foods which are being well received by pediatricians and mothers alike. These products are partially dehydrated and then frozen and are sold in aluminum foil envelopes, four to a box—each envelope equaling one average serving. The product can be home-stored under normal refrigeration. The contents of the envelope—free-flowing crystals to which water or milk is added—can be rehydrated right in the baby dish for instant and work-free serving.

While this new baby food line is significant in itself because of its high nutritive content, fresh flavor, color, and vitamin retention, the process by which the new line is produced has broader interest to our industry, I believe. It is a combination of dehydration and freezing, and its success thus far holds promise that dehydro-freezing may well be applied to many other uses.

Another low-temperature preservation process, not yet in commercial use because of its high cost, is "freeze drying." Here food is first quick-frozen, then dehydrated by sublimation under high vacuum. When and if industry, government, and university research scientists combined lick the problem of present high cost of this process, I'm sure we shall see many freeze-dried foods on grocery shelves.

As you scientists know, there are other new and promising food preservation techniques in various stages of development—irradiation, antibiotics, ultrasonics, and so on. So it would be inappropriate for me, as a layman, to go into them. Let me, instead, point up two more trends in foods and eating habits which I believe will have a major impact on the food industry in the years to come.

There has been a great deal of talk in recent years about our burgeoning population and how we are going to feed the world's growing millions. But overlooked by some—or perhaps I should say underestimated—has been *the minor revolution that is taking place in the age distribution of that population and its potential effects on sales of food products.*

In the next five years, we are told, the group from 15 through 19 years of age will jump almost 30 per cent, against 9 per cent for our total population. By 1965, close to half of the people in the United States will be under 25. This change in age distribution, together with the longer life span made possible by our advances in medicine, is bound to spell different nutritional requirements and taste preferences to be met—foods especially suitable both for the very young and for our senior citizens.

The last trend I would like to mention has to do with where people eat their meals. Perhaps you haven't noticed it in your family, but *more people are eating out.* Sales at eating places have risen almost 20 per cent in the last five years, but at the same time hotels, restaurants, and other institutions are finding it increasingly difficult to employ enough qualified help.

Here, too, is an opportunity. Food processors, building on their knowledge in the frozen foods field, may find a way to offer an entirely new *kind* of service to an important group of consumers by supplying hotels, restaurants, hospitals, and so forth, with products where the services not only of the kitchen maid but of the dietitian and the chef as well are all built in at the factory. As a matter of fact, my own company is working on this possibility of providing "chef service." We are still in the experimental stage, but I am able to tell you that we see the opportunity of providing the managements of hospitals, hotels, restaurants, schools, airlines, in-plant feeding establishments, etc., with a wide variety of appetizing, well balanced, nutritious meals in a way that will help them hold the line against increased preparation costs.

By keeping abreast of trends such as those I have mentioned—as well as other trends which come to light through market research activities, studies of shopping habits, talks with the food trade, and so on—the food industry has been able to keep pace with consumer demands. But in our highly competitive business, keeping up with today's demands is by no means enough. We must be ever alert and sensitive to tomorrow's wants and needs. We must anticipate what homemakers will want as a logical next step in their insistence on better living, and we must develop products long before consumers actively want them.

Let's make no mistake about it: The driving force behind filling consumers' food needs and wants—and even trying to anticipate them—is the profit motive of aggressive individual commercial food processors. In the food business perhaps more than in any other, if you don't give your customers what they want when they want it, you can be sure your competition will. That is the very heart of our free enterprise system, which is an out-growth of the traditional democratic principle of individual freedom of choice—and I, for one, wouldn't have it any other way.

This business of continually trying to outguess the housewife herself on what she will want next calls for a great deal of freedom, for the right climate in which to experiment, to invent, to innovate. It calls for the same type of freedom, for example, that the food industry enjoyed more than 30 years ago when quick-frozen foods were first introduced.

My company's close connection with the frozen foods industry may color my opinion somewhat, I will admit, but to me the growth and development of quick-frozen foods demonstrates impressively what a new food preservation process—if permitted to make its own way—can mean to the nation's economy. You are all familiar with the story of frozen foods, I'm sure. But I want to review it briefly to underscore my point that in the years ahead new facets in the business of feeding people can have tremendous impact on our way of life.

The frozen foods that were introduced more than three decades ago were not just more new products to be added to the list of those being sold in the usual way through the usual channels. They were the end products of a wholly new food preservation process, and with their introduction entire new industries had to be created to produce, store, transport, and display them.

. Quick-freezing equipment had to be designed, manufactured, and installed.

. . Farm machinery had to be invented to harvest crops faster in order to retain farm-fresh flavor in the foods to be frozen.

. . . New refrigerated warehouses capable of holding frozen foods had to be built.

. . . . Trucks and railroad cars which could maintain frozen foods at zero degrees Fahrenheit had to be designed and constructed.

. . . . . Retail store freezers to keep and display the new products had to be developed and built.

. . . . . . Freezer compartments had to be made an integral part of home refrigerators so that frozen foods could be stored by consumers.

. . . . And, most importantly, consumers had to be persuaded that this revolutionary new method of food preservation was in no way associated with the "cold storage" foods they disdained. The public had to be convinced that quick-frozen foods provided the advantages of prepared, ready-to-cook, garden-fresh fruits and vegetables—with quality and taste intact—at any season.

What a boost to the nation's economy from just one new food preservation process. Thousands of jobs were created solely to build and operate refrigerated freight cars and trucks, to set up storage and distribution systems. There was no such appliance as the home freezer. Frozen foods can take credit, I believe, for spawning that new major appliance—one that has achieved such popularity that there are 12,000,000 in use today.

No one can, of course, predict that the same kind of dramatic impact will be made on our economy by any of the new methods of food preservation now on the horizon. But one sure, everlasting fact that *is* predictable is that the foods resulting from *any* process will be judged finally—and found acceptable or wanting—by our boss in the food business . . . the homemaker. The proving ground for how well the food industry is meeting the demands of consumers is always in the home kitchen. That's where the decision is made. When enough such favorable decisions are made—when enough consumers can be persuaded to try a product and then continue to buy it—economical volume production becomes possible, thus bringing the unit price down to a good business level.

We are aided in our goal of providing more and better foods at lower costs by our tremendous American middle class. Because great numbers of our citizens have incomes well above those required for the bare necessities, the American tradition of "trading up" has become an influence in foods as it has in other consumer goods.

In this "trading up" process, consumers are more and more willing—even eager—to buy convenience, what in the food line has been called "time in a package." But appetite appeal and quality cannot be sacrificed to make a product convenient. And with the rising demand for higher nutritive values, it becomes apparent that food processors, to be successful, must build all these values into their products in order to satisfy *our* "Queen's" taste.

I foresee a time when we will be catering to a society that will be much more calorie conscious, one in which foods will prevent, rather than combat, obesity and other forms of malnutrition. A reformation of American eating habits in this desirable direction should not be too difficult.

The essential nutrients are known and available to the food industry. We have already made good progress in upgrading nutrition by offering consumers satisfying products with built-in flavor, appetite appeal, ease of preparation, and, in some cases, even pre-seasoning and pre-cooking. Our task now is to convince people that by eating properly, by utilizing America's wonderfully varied food supply intelligently, they can add years—and zest—to their lives.

Our land is blessed, as no other ever has been, with a food supply that is by far the best in the history of man. We must learn to use it wisely ourselves, and we must also treat it not only as a blessing, but also as an opportunity, as we continue the battle against hunger, the crusade for better health.

I hope you will agree the food industry's record of providing more and better foods to meet and even anticipate consumers' demands has been a creditable one so far. In the years ahead, we can reasonably expect to make it even better as a result of a clearer understanding of the vital role food plays in man's quest for peace. In a more highly educated, enlightened society—given a climate of freedom which encourages invention, innovation, and creativeness—I am confident we will be successful.