

# THE WORLD OF FOOD AND NUTRITION



*by*

**E. V. EVANS**

*Professor of Biochemistry, Nutrition and Food Science*

*An Inaugural Lecture delivered on 12th February, 1970 at the  
University of Ghana, Legon.*

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# THE WORLD OF FOOD AND NUTRITION

It is my privilege, during the current series of Inaugural Lectures, to speak on behalf of a Department which has not been so represented before. It is an opportunity to give a partial introduction of the Department to many people, both those on the campus and those from outside the University, who may be unaware of any of the Department's roles (for it has several, as the triple-barrelled name suggests). This lack of familiarity may be a result of the fact that the Department is still a relatively new one, and two of its disciplines, Nutrition and Food Science on which I shall concentrate today, are relative newcomers to University circles at least as separate named subjects for study. This latter is true for Universities in general and particularly so in this part of the world.

The Department, founded in 1963, can no longer claim to be the newest in the University; it did occupy that position for a recent period of perhaps two or three years. At that same time it also had another distinction, a rather frivolous one, perhaps, in that it was one of two Departments that could lay claim to having the longest names of all Departments within the University. The other Department with which we tied on this score was the Department of Agricultural Economics and Farm Management. In order to equal this other Department (which has 36 letters in its name, incidentally) we did, it must be confessed, have to count a comma as equivalent to a letter of the alphabet, but, any type setters' Union or any telegraph company will confirm the validity of this approach.

However, we lost all claim to top honours for the longest name a year or so ago when the Institute of Statistics was rechristened as the Institute of Statistical, Social and Economic Research. This latter name is unlikely ever to be seriously challenged as far as length is concerned.

To return to our own nomenclature, those who still find our name a bit cumbersome, and who sometimes point out this fact to us, will likely receive some relief from the burden in the not-too-distant future when present plans for the separate development of Biochemistry are implemented. Thus, today may possibly be not only the first but also the last occasion on which the Department of Biochemistry, Nutrition and Food Science is represented at an Inaugural Lecture.

The title which has been chosen for attention today is, you will agree, a very broad one. Obviously, the broad area covered by this title must of necessity be treated very selectively, and in the time available, very incompletely. And, in one more digression before launching into that selection, may I say that the omission from the title of any mention of the subject Biochemistry was not perpetrated with any intention of slighting our colleagues in the Biochemistry section or of symbolically speeding them on their way into their separate Department. It is, of course, essential always to recognize and to record the basic and indispensable role played by the subject Biochemistry in the fields of both Nutrition and Food Science and the importance of sound training in Biochemistry for all who are studying for activities in these fields. It is not only a hope, therefore, but an expression of doctrine when one stresses that very close co-operation between the Biochemistry unit and the other two disciplines must be maintained and expanded even when operation under separate mastheads has been established.

Now to look at the World of Food and Nutrition.

General discussions centering about food and nutrition present difficulties. A lecturer on these topics is always at a disadvantage

as compared to speakers on other specialized topics because his audience is never a neutral audience. Someone has complained that everyone is his own expert on foods and on nutrition. This is a hazard not faced, I think, by speakers on subjects such as atomic structure or other topics which are more detached or abstruse than ours.

Foods and eating occupy a very central and a very personal part of every human being's existence, for they are, from birth to death, part of daily experience—either in fact for the fortunate ones or in anticipation for the less fortunate. It is not surprising, therefore, that everyone has definite, perhaps vivid recollections, some pleasant, some not so pleasant, concerning certain foods and about eating in general. Each person usually has some definite ideas about what foods can do, convictions as to what foods are good for him or his family and what foods are not. Many of these ideas and view points may be correct and valid, some may be partly so, but many, unfortunately, may be totally wrong and without foundation. It is regrettable that the last-named (i.e. the wrong ideas) are the ones which often seem to be the most firmly and stubbornly held.

The varying beliefs of individuals concerning foods and dietary practices are the consequence of many factors and influences. Among these one may mention family and community environments, viewpoints expressed and patterns followed in the household of an individual's childhood, beliefs held on religious, quasi-religious or symbolic grounds by those around him especially during the early developing years but also throughout life. To a not-inconsiderable degree in recent times many erroneous opinions common among members of the general public can be attributed to misinterpretation of valid or essentially valid information produced and circulated by qualified individuals and agencies. One cannot overlook, of course, the considerable misinformation that results from publicity emanating from those who choose to write and talk on topics related to food and nutrition in sensational

terms in order to attract attention or simply to make a better story. The extreme examples in this area, of course, involve the quacks who, usually for monetary gain, promote spurious dogmas and products. A further source of confusion and wrong emphasis (if not outright misinformation) concerning foods and nutrition has been and continues to be the advertising approaches employed by certain commercial interests in the promotion of their particular types of foodstuffs and related products of nutritional orientation. It may not be too irrelevant to note that "Truth-in-advertising" campaigns and honesty controls with respect to merchandising in general have been initiated recently in many countries of the world by government agencies under the influence of public opinion. However, varying means of control over misleading and fraudulent claims concerning food and drug products have been exerted for some time in a number of countries of the world. There is need for an expansion of such controls into countries such as Ghana which do not as yet possess them. This will, presumably, go hand in hand with the development and acceptance of the international food and drug standards now under development.

So far I have been using the words "food" and "nutrition" without having made any attempt to define what we mean by these words. The word "food," of course, is one about which little doubt can exist. We can accept that everyone knows what it means at least in the context of feeding human beings but if you were to press for a definition one could say that, for our present purposes, "food" refers to all of the products or substances, singly or combined, which one eats and which contribute to the satisfying of hunger, the maintenance of life and the nourishment of the body. There are, of course, other uses of this word in other contexts.

We find ourselves in a very different situation, on the other hand, with respect to the word "Nutrition." This word has various meanings for various people. Some use it in a very narrow sense referring to the actual feeding of people (that is, the most applied aspect of the subject). In its simplest use this may refer to an individual or a family; in broader use it may involve the feeding of

whole populations. Others use "Nutrition" as a convenient descriptive word to summarize the broad aspects of the state of health of people with respect to what they eat or, in other words, of the adequacy of their diet. (We hear the terms "good nutrition," "adequate nutrition," "poor nutrition" in this connection). To others, "Nutrition" means the scientific studies of various processes, primarily biochemical, which food components undergo inside the living body. Still others may think primarily of defects or deficiency symptoms which may occur in the living body when certain food constituents are inadequately supplied.

Many attempts have been made by numerous people in the nutrition sphere to concoct a relatively concise definition of nutrition. No one has been successful in producing such a statement which has had wide acceptance. Most of the definitions have been criticized as being too narrow, too restrictive, but these are, as you might expect, definitions coined by nutritionists or nutrition scientists who have specific interest in relatively limited areas of the subject. Their major critics are, similarly, those whose view of the field of nutrition is either considerably broader or perhaps equally restricted but to a different area of the subject, an area not taken into consideration by the author of a particular definition.

The availability of a neat and valid definition for this subject would be a convenience on many occasions, (including the present). It may not really be a vital requirement although there have been fairly frequent expressions of opinion that nutrition cannot be an effective discipline until its identity is made clear and everyone recognizes it as deserving of a place of its own. Such expressions are, of course, often engendered by problems encountered in attempts to obtain adequate financial support for teaching and research in the field of nutrition. In any event, as indicated previously, much effort has gone into attempts to create an acceptable definition for this discipline. It may be of interest to refer to two or three examples of definitions which have been proposed recently.

The Council on Nutrition of the American Medical Association in 1963 proposed a definition which, while moderately comprehensive, is rather cumbersome and involved and certainly does not merit the description of "concise" or "neat." It is much too involved to be quoted profitably here, although it has been fairly frequently quoted in print.

In their most admirable textbook on Nutrition published in 1967, Professors Ruth Pike and Myrtle Brown of the United States defined Nutrition as "the science that interprets the relationship of food to the functioning of the living organism." This is obviously a scientifically-orientated view rather than one encompassing the applied as well as the scientific aspects of the subject. Sir Harold Himsworth, former Deputy Chairman and Secretary of the Medical Research Council of Britain, in an address at ceremonies held at the famous Dunn Nutritional Laboratory at Cambridge University in 1968, included the following as his definition: "Nutrition is the analysis of the effect of food and its constituents on living organisms." This proposal, again scientifically-oriented, brought criticism from (among others) a fellow-Briton, Professor John Yudkin of Queen Elizabeth College, University of London, as being far too narrow. Professor Yudkin offers ("reluctantly" as he says,) the definition that "Nutrition is the relationship between man and his food." He feels that many important areas are excluded by the Himsworth and other definitions; these exclusions are such topics as the study of world food problems, the relationships between food production and population growth, and many others.

Whether or not one accepts his definition, one can readily agree with Professor Yudkin's statement that it is easier to describe nutrition than to define it. I shall resist the strong temptation to offer yet another brief definition and be content to outline as briefly as possible some of the many facets of this discipline we call nutrition.

Perhaps before doing so I should attempt to maintain good relations with certain other disciplines by digressing once more to

acknowledge that our usage of the term "Nutrition," as is probably quite evident from what has been said in the foregoing, is restricted primarily to the nutrition of man and other animals. At the same time, consideration of the nutrition of micro-organisms closely associated with and, in some important instances, symbiotic with, these animals must, of necessity, be included. However, to plant scientists, especially plant physiologists, and to soil scientists the word "nutrition" as they use it professionally refers to the provision of required nutrient substances to plants and the utilization of these substances by the plants. I mention this point solely to assure the plant and soil scientists that human and animal nutritionists are not unaware of their claim to a share in this name and to indicate that their activities fall outside our sphere of immediate concern, although by no means entirely outside our sphere of interest. All matters influencing the production of plants and plant products which serve either directly or indirectly as foodstuffs for man or for the animals on which man, in turn, relies for certain types of foodstuffs, must of necessity be of interest to anyone concerned with the feeding of the human population. The science of plant nutrition has very important implications for the science and practice of human and animal nutrition.

We return now to the promised outline of some of the facets of nutrition. You may or may not agree with the order of presentation of the various aspects but the order probably matters little for our present purposes.

First of all nutrition is concerned with obtaining and utilizing information on the composition of foods, particularly their content of nutrients. A food constituent (either a chemical compound or a chemical element) is considered as a nutrient if it is capable of participating directly in the support of life processes. Not all constituents of all the foodstuffs commonly consumed meet this definition although the major part will do so. The nutrients, partly for convenience but chiefly on the bases of their chemical nature and of their functions in the living organism, are classified as carbohydrates, fats (lipids), proteins, vitamins, minerals and water. There

are thus six classes of nutrients and it is worth drawing particular attention to the fact that water is considered to be a nutrient.

A second aspect of nutrition closely related to the first is the consideration and study of the factors which influence the composition of foods; that is, the absolute and relative amounts of nutrients which the foods contain. Many pertinent comments could be made on this aspect but we shall pass them by for the moment.

The nutrients of foods once they are actually transferred into the body have a wide variety of specific roles to perform. These roles can be summarized as (1). The provision of structural materials to build and maintain body structures of all types (muscles, skeleton, organs, skin, blood, etc.). (2) The supplying of energy for body heat, for chemical reactions, for physical activity and (3), the supplying of controlling substances which stimulate and regulate the handling of the structural and energy components within the body. The study of these roles in the body is a matter of interest in the science of nutrition.

At this point, having introduced the term "energy," it may be desirable to point out that our list of nutrients did not include this term. This is so because energy is not a nutrient. Rather, it is a property possessed by all of the nutrients which are organic chemical compounds, and, for practical considerations, primarily by the carbohydrates, fats and proteins. As is well known, energy is tied up in the chemical bonds which hold atoms together in combinations to form molecules of chemical compounds. In the carbohydrates, fats and proteins the bonds of particular concern are those involving carbon and hydrogen. When these bonds are broken during the process of oxidation, either inside or outside the body, energy is released. It should be stressed here that we are concerned only with the chemical bond energy, not the energy inside atoms.

The potential energy thus contained in nutrients, and hence in foodstuffs, and the kinetic energy released and utilized to varying degrees within the body, is measured and expressed in kilogram-calories, often called simply calories. This word conjures up various pictures in listeners' minds and I should have liked to have had time to comment on it further.

The processes and mechanisms by which the living body digests, absorbs and utilizes the consumed nutrients for energy and structural and other functions are topics for attention in nutrition science. Substances taken into the gastro-intestinal tract (that is, swallowed) are said to be "ingested." Not all of the nutrients ingested by animals (including human beings) are digested and absorbed, and not all of the nutrients absorbed are necessarily fully utilized. It is a significant fact that all of these processes (digestion, absorption and utilization) are influenced by the combinations in which the nutrients are consumed, that is, by the dietary mixture, and also by the prior treatment of the diet components (storage, processing, cooking, etc.) as well as by the past and present nutritional and general medical status of the individual. Effects are also exerted on these processes by various aspects of the physical, social and emotional environment in which the individual finds himself. The study of all these influences falls within the scope of nutrition.

The nutrition scientist utilizes animal experimentation to supplement chemical and biochemical studies and measurements in predicting and evaluating the values of food materials. Although the laboratory rat is a widely-used experimental animal for these purposes, it might be noted that the pig is sometimes a better choice for use in evaluating foods for human use.

The nutritionist shares with the physiologist, the biochemist and other biological scientists an interest in studying the functions of nutrients in the body. He is concerned to study the mechanisms by which these nutrients enable the body to perform the tasks, to

maintain the conditions and conduct the processes involved not only in merely remaining alive but also in growing, reproducing and performing profitable and creative activities both physical and mental.

As a quantitative scientist the nutritionist is interested in determining the amounts of the various nutrients which are necessary to permit the optimum functioning of the body and the most desirable level of performance. As a consequence of such interest and the accumulation of information on nutrient requirements, nutrition workers are able to make recommendations as to the most desirable intakes of various nutrients. These are the so-called Dietary Standards or Recommended Dietary Allowances which are widely available and used. These are, of course, still far from complete and undergo frequent revisions as more complete and more reliable information becomes available from continuing studies.

Another aspect of nutritional concern is the recognition and elucidation of what happens to the body, or within the body, when nutrients are inadequately supplied. In other words, the nutritionist concerns himself with the undesirable symptoms which result from deficiencies of one or more nutrients. These deficiency effects are very diverse, depending upon the particular nutrient or nutrients which may be deficient or in wrong proportions. (Incidentally, you will note frequent reference to proportions as well as to absolute amounts of nutrients). Some defects are shown in gross body structure (for example, failure of growth or deformities of the skeleton). Some inadequacies are detected as interference with body performance (e.g. reduced working ability from a wide variety of nutritional causes, blindness from lack of vitamin A, abortions or other failures of reproduction from a variety of deficiencies). These nutrient shortages also produce less evident but equally important internal structural or functional shortcomings. Improper and inadequate production of enzymes, hormones, blood consti-

tments and other vital body components are but a few examples of this type of defect. These defects, in turn, eventually limit general body performance and capabilities very seriously as well as giving rise to specific deficiency symptoms. Inadequacies in the body's supplies and utilization of nutrients also give rise to many secondary problems such as increased susceptibility to infections, increased tendency to organic disorders, and impairment of rate of recovery from infections and injuries.

The defects which have been mentioned are, you will notice, defects in the physical structure and physical performance of the body. The fact that an inadequacy of nutrient supply or utilization can seriously handicap the physical welfare of the body has been recognized for a considerable period of the relatively short history of nutrition science. Only recently, however, has serious attention and research been directed to the possibility that inadequate nutritional status may also have very serious consequences in terms of mental development and learning ability. Although significant studies in this sphere on human beings are of necessity long term ones and are therefore expensive and difficult to conduct, sufficient work has been done to date to indicate convincingly that very real and extremely important influences on mental development and learning behaviour are exerted by the level of nutrition, particularly of infants and children. Satisfactory quantitative evaluation of these differences will, incidentally, require the development and improvement of techniques for the assessment of intelligence, mental development and learning ability as well as adequate recognition and control of the influences of the social and cultural environment on the subjects.

To add, then, to the already wide variety of spheres of activity and of natural science disciplines which impinge upon and interact with the science of nutrition we now seem to have introduced into our discussions sociology and psychology and perhaps other related disciplines. But it should be noted that, before the recently intensified interest in the relationships between nutrition and mental

development just mentioned, there had long been recognition that food consumption patterns are very much influenced by psychological, sociological, cultural and other factors including religion. This was hinted earlier in my remarks. Differences between different population groups with respect to what foods are consumed and what are not, what foods are acceptable and what are shunned, what are permitted and what are banned, can often be attributed to one or more of these factors. Differences in food consumption patterns resulting from these factors can contribute to differences in nutritional status between populations and certain high incidences of particular nutritional shortcomings may be attributable to the food habits of the people concerned.

What about the role of economics in nutrition? No one would think of denying that economics plays a very vital role in the food consumption patterns of people all over the world and consequently in their nutritional status. It is widely recognized that, unfortunately, large masses of the world's population and important segments of population within most countries of the world, even the wealthiest countries, are malnourished not primarily because of cultural or religious restrictions and not always because of ignorance of proper diets (although frequently one or both of these may also be operative) but simply because they cannot afford to buy sufficient food of the right type. The factors of trade and transportation enter here along with other aspects of economic development and status.

This has been a not-so-brief description of the field of nutrition and the other disciplines and factors with which this subject is concerned and with which it is interrelated. Perhaps a brief definition would have been more acceptable after all! I hope, however, that it will be apparent how the subject nutrition, viewed in its broadest sense, involves and uses the processes and information from a wide variety of disciplines in the physical sciences, biological sciences, medical sciences and social sciences. It is certainly not the intent to claim or suggest that every individual nutritionist or nutri-

tion scientist, or even any paragon among them all, is an expert in all of the many areas of study and knowledge which have been cited. If anyone has taken this implication from my remarks, I apologize and humbly request that such an interpretation be discarded. But it is the hope that every person who styles himself (or herself) as a nutritionist does recognize the significance and impact of each of the many disciplines which have been mentioned, and others which were not mentioned but perhaps should have been. Statistics, physics and political science are others in the latter category. Each nutritionist, depending upon his special interests and activities, will himself employ techniques of perhaps several of the disciplines to varying degrees and will call upon specialists in the other disciplines for frequent assistance.

### **History of Nutrition**

Man has had to sustain himself throughout the ages, as have all species of animals, by consuming food as availability, acceptability, and whim have dictated; in other words by indulging in practical nutrition. But such understanding of the scientific bases of nutrition as we now possess has been accumulated only relatively recently. Nutrition as a science is comparatively new. It is true that many written records of past ages, even well before the Christian era, did make certain observations about foods, in general and in particular, and about their effects upon the consumer. Some of these were reasonably astute and correct and can be justified on the basis of scientific information acquired many centuries later, chiefly in the present century. For example, Cato the Censor about 200 B.C., in writing a book for the Romans on farm management, went to great lengths to describe the health-giving properties of cabbage. We now know, of course, that cabbage can be a good source of minerals and vitamins (notably ascorbic acid), particularly if eaten raw or lightly cooked. Although it has been learned recently that cabbage also sometimes contains factors which can predispose to goitre if consumed in very large quantities, on balance cabbage is still a very desirable food and Cato's advice was sound.

There does seem to have been a tendency, on many occasions, for speakers in this forum to find the occasion to make references, usually complimentary, to figures from the classical world of Greece and/or Rome, a trend which I now seem to have joined. With due apologies to the classicists, however, it must be recorded that not all of the immortal opinions expressed on the subject of foods by the scholars of that age can be favourably accepted. Hippocrates, the Father of Medicine, although he is reported to have placed emphasis upon diet as a part of his therapy, which is in itself a sound approach, nevertheless mixed some reasonable advice with some very unjustifiable claims and practices. Among the latter one may mention the use in the treatment of dysentery of linseed, wheat flour, beans, millet, eggs and milk, and an insistence on the use of boiled fish in the absence of fever but of roasted fish if fever was present. He also stated that beef (and likewise, goat's flesh) was difficult to digest and caused aggravation of melancholic disorders. Thus this famous physician of the fifth century B.C., despite his many revered contributions to the field of medicine, obviously had little understanding of nutrition and held some strange and unfounded opinions about foods.

Other writings from the classical period might be mentioned, for example, the book entitled "The Sophists at Dinner" written late in the second century A.D. by Athenaeus, a Greek living in Rome. Although this book has an honoured place as the oldest book devoted to cookery and to foods in relation to health, it contains gems of absurdity and misinformation which make pikers of the quacks of later generations, including the present.

Customary as this little excursion into classical history may be for local inaugural lectures, and whatever the reason for such tendencies may be, it is not every speaker who makes a bow in the direction of the theologians and the Bible scholars as I now propose to do.

Some of the earliest recorded information on specific uses of foods, their relation to physical well-being and on certain taboos or restrictions, is found in the Holy Bible, notably the Old Testament.

The records of the beneficial qualities of liver and of other internal organs in treating certain problems of vision (e.g. in Tobit in the Apocrypha) are obviously inexact reporting of the actual use made of these materials. Nevertheless they do contain implications of effects which in current times we know can be attributed to Vitamin A which has important roles in vision and which is found in generous amount in the livers of most animals (including fish).

The Bible made frequent references to food and not the least among them are the food laws given to Moses and recorded in Leviticus, particularly in Chapter 11. Here are the admonitions against the consumption by the Hebrew people of meat from certain animals which have the hoof cloven but do not chew the cud, for example swine and the hare, and those which chew the cud but do not have cloven hooves (e.g. the camel). The consumption of flesh from fish which have fins and scales was approved but not from fish lacking these features. These and other pronouncements are the root of dietary rules for orthodox Jewish people today as they have been for centuries. Other religious groups have similar or varied dietary restrictions. There are other religious groups, including Muslims, who do not eat pork. Attempts have been made by nutrition and food scientists in recent years to ascertain whether sound scientific explanations of these dietary restrictions can be advanced on nutritional or health grounds. In not many instances has this been possible, although there are exceptions. It has been suggested, for example, that the ban on pork was probably justified at the time on the grounds of, first, the high incidence of trichinosis, a disease caused by the ingestion of pork infected with the parasitic worm *Trichina spiralis* and, secondly, the poorer keeping qualities of pork as compared to beef, e.g., because of the greater suscepti-

bility of pork fat to rancidity. Simple methods for controlling both of these problems are now available and the validity of the restrictions on these grounds, if these were really involved initially, would seem no longer to exist.

One more Biblical reference. Students of nutrition have often had it pointed out to them that the earliest nutrition experiment with human subjects is recorded in the first chapter of the Book of Daniel. A quartet of Jewish youths, including Daniel, who were captured by King Nebuchadnezzar's Babylonian armies were being trained in the King's court. They were to be given preferential treatment and food equivalent to that eaten by the King so that they might develop equally with some similarly-favoured Babylonian young men. But Daniel and his friends declined the fancy menu, or as it is reported: "the King's meat and the wine that he drank." Instead, as it is recorded in verse 12, Daniel said to the chief eunuch: "Prove thy servants, I beseech thee, ten days; and let them give us pulse to eat and water to drink." He went on to request that, at the end of 10 days, they be compared with the others on the more regal diet.

Jumping to the observations of the experiment we read: "At the end of ten days their countenances appeared fairer and they were fatter in flesh than all the youths who did eat the King's meat." The word "pulse," according to the experts, should be taken to mean "vegetable foods" and not just beans and other legumes which this word is now used to describe, and the king's "meat" was terminology referring not to animal protein but to various rich and fancy items of the court menu. Thus the virtues of vegetables were considered to be established.

To those who are inclined to agree with me that ten days was a far too short experimental period for such a feeding comparison, it might be pointed out that the differential feeding regimen was apparently continued for a much longer period and it is recorded later in the chapter that after a three-year period "among them all was found none like Daniel, Hananiah, Mishael and Azariah" i.e.,

the experimental group. They were adjudged "ten times better in wisdom and understanding than all the magicians and enchanters that were in his realm." Did I say earlier that the influence of nutrition on mental capability had only recently become a subject of study?

Now, this experimental report from the book of Daniel, while interesting, does give rise to certain doubts. One wonders, for example, just how closely the experiment was controlled, and one looks in vain for descriptions of the objective measures and instrumentation employed for evaluating the physical and mental performances of the two groups. There is also no indication that King Nebuchadnezzar's statisticians were consulted either before or even after the experiment was performed. And, finally, we are given no information whatsoever on the qualifications of the editorial board which accepted Daniel's paper for publication.

Having spent far too long on the classical and Biblical periods of nutrition history I shall have to give brief attention to only a few of the nutritional milestones of later years. As one who was once a Canadian school boy, I cannot fail to mention the name of Jacques Cartier whose exploits were obligatory syllabus material for every pupil in my day and, I believe, ever since. Jacques Cartier was, as you probably know, one of the early French explorers to sail up the St. Lawrence River and reach what is now the Canadian province of Quebec. He and his crew spent a miserable winter (1535-36) at Stadacona, an Indian village on the site of the present city of Quebec. During the severe winter, all of the total of 110 men were seriously ill, and a considerable number died. The ailment, which Cartier described in such perfect detail in his log and in a later report as "La Grosse Maladie," was in reality scurvy, a nutritional disease resulting from lack of ascorbic acid. Scurvy was the centuries-old scourge of sailors on long voyages and it continued to plague sailors and explorers for centuries after Cartier. The significance of the Cartier story lies in the seemingly miraculous cure that was achieved through the use of a remedy suggested by

the local Indians. An extract of the leaves and bark of a coniferous tree was consumed by the men and the scurvy symptoms, even the most severe, cleared up very quickly. Modern study has shown that such a preparation would contain ascorbic acid.

Perhaps the outstanding name in the early history of vitamins is that of James Lind, an English naval physician, who published a "Treatise on Scurvy" in 1753 and a second edition in 1757. In the second edition he reported a controlled experiment among a group of scurvy patients on board a naval vessel. In this he established the worthlessness of some of the then-current medicinal so-called treatments for scurvy, but more important he showed that daily intakes of oranges and lemons (now known as rich sources of ascorbic acid) could cure and, presumably, prevent scurvy. Unfortunately the value of Lind's work was not recognized until many years later, and even though the British Navy eventually established mandatory daily issues of lemon juice to its sailors, the lives of many seamen and explorers were lost to scurvy.

The success of Captain James Cook in his three-year voyage (1768-1771) of exploration of the Pacific Ocean in the small ship "Endeavour" has been attributed to his recognition of the need to prevent scurvy and the fact that this could be done by the use of vegetables, greens and fruits. In this 30,000 mile voyage not a single member of the 94-man crew was lost to scurvy, as the result of Captain Cook's tyrannical insistence on his crew consuming these protective foods which Cook had learned about from his careful observations on previous undertakings. Captain Cook's second voyage to the Pacific in 1772-1776 was equally successful from the point of view of both exploration and the defeat of scurvy. Regrettably, general acceptance of his example for feeding sailors was not forthcoming and, even into the present century, crewmen on long voyages were prone to suffer from scurvy.

There are sad records, too, of unsuccessful explorations in other areas, particularly the Polar regions, as the result of failure to

provide foods effective in preventing scurvy, or to put it positively, foods contributing adequate amounts of ascorbic acid to the diets. The tragic fate of Franklin and others in the Arctic and of Captain Robert Scott and his men returning from the South Pole was undoubtedly the result of scurvy; the rations of Scott's men provided plenty of calories, protein and most other nutrients but were almost devoid of ascorbic acid.

The success of Sir Edmund Hilary and his companion conquerors of Mount Everest was the result of superb advance planning, including very careful attention to the nutritional values of the diets.

The most recent and spectacular type of exploration, of course, is the exploration of space, the latest stages of which have included the moon landings. The success that has been achieved has depended upon meticulous planning and preparations in many spheres, not the least of which is that of providing nutritious, acceptable and manageable diets for the astronauts in their unusual and restricted environments. Each manned space flight has provided new information and revealed new problems in space feeding. As the duration of flights becomes longer, the problems increase. One of the big problems is that of keeping the weight of food down to the minimum compatible not only with nutritional adequacy but also with acceptability and the variety which seems to be necessary to maintain food consumption. The urge for restricting weight is the fact that the cost of lifting each one pound into space is quoted at over 150,000 dollars. One interesting example: an antimicrobial tablet was used for stabilizing the unused part of a packaged diet item after opening, that is, for preserving the left-overs; when the weight of this tablet was reduced to one-half, two pounds of load were saved, thus 300,000 dollars in cost.

## **Food Science**

Most of my remarks so far may seem to have been heavily weighted on the side of one aspect of my title, "nutrition" rather than "food" particularly as far as the science aspects may be concerned.

I hope that there can be no doubt in your minds, however, that nutrition is nothing without foods—one cannot talk about nutrition without talking, either explicitly or implicitly, about foods.

But, in all fairness to my colleagues in Food Science, I do want to say a few specific things about their fields of interest.

First of all, for those who are in doubt about what the term “Food Science” means, may I say that Food Science is the subject which is primarily concerned with an understanding of the nature and properties of food materials (including physical, chemical, biochemical and microbiological aspects), the variations and changes which can occur in these properties, and the scientific principles of methods of processing and preservation. Food Technology is an extension of Food Science in that it is concerned with the technological application of food science principles in the selection, preparation, processing, preservation and distribution of foods. The ultimate target of the efforts of food scientists (and food technologists) is (or should be) the production and distribution to consumers of food products which combine attractiveness (in flavour, appearance, and texture) with convenience of handling (shipping, storage, and preparation) and with, most important of all, high nutritional value. It should not be too much to hope that the world’s food industries, which in total and sometimes individually, are of massive size and significance in domestic and world trade, would also set the same targets for themselves in addition to the acknowledged and not necessarily ignoble targets of larger volume, wider variety, larger sales and hence larger profits.

We have mentioned food processing. Under this term in its broadest sense we include everything that is done to or that happens to food raw material from the time of harvest (whether it be harvested from plant or animal sources) until the time of its consumption by the human consumer. It is widely acknowledged that advances in food processing (including storage procedures) some simple, some more complex, throughout human history have

made important (and frequently indispensable) contributions to man's advances in the cultural, social, economic and physical spheres. Some very simple developments in food preservation, combined of course with the domestication of plants and animals, made possible very marked changes in man's living patterns and in his freedom to devote effort to intellectual, cultural and other activities including political. More sophisticated developments have made possible many other notable advances and achievements.

Food processing has involved the application over the centuries of many techniques and processes. Most of the effort until very recently was directed to the question of preservation. In the early days—in fact, until the last century or so—the principles behind the techniques used for preservation of food were not at all understood. It was sufficient that they worked, and in general they did, although there were, fairly frequently, disastrous and sometimes tragic failures. Some of the techniques of preservation used in very early times and still in use, sometimes in relatively simple and sometimes in highly elaborate forms, are heating, drying, smoking, salting, pickling, spicing, fermentation. Even cold storage and freezing were practised by primitive peoples who happened to live in parts of the world where nature provided the appropriate environment. Less effective but still useful cooling for storage purposes was practised in other areas by utilizing the limited cooling effect of water evaporation.

Among later additions to the preservation repertoire have been canning and irradiation as well as greatly improved versions of the earlier processes of drying, cold storage, freezing, sterilization and controlled heat treatment, chemical additions, fermentations, packaging and many others.

The obvious purpose of food preservation is to permit the carrying over of food supplies from the time of harvesting, when the supplies may be abundant and in excess of requirements for immediate consumption, to times when no harvesting is possible. Ano-

ther purpose is to transform the food into forms which are more convenient or more economical for transportation from initial source to consumer. Basic to the problem for both of these purposes is the fact that foodstuffs are biological materials all with susceptibility to various post-harvesting biochemical changes (deterioration). The susceptibility to these changes depends upon the nature of the foodstuff, ranging from extreme to moderate, but is always significant. The changes are produced by oxidation, the action of enzymes, etc. Another factor to be considered is that these food products, which we are viewing as being intended for man, are very highly sought-after as foodstuffs by other living organisms, both plant and animal. Here I am referring to bacteria, yeasts and moulds as well as to insects, rodents, birds, etc. If man is to have the benefit of even the majority of the food produced, its protection against these intruders is necessary. The application of the steps required for this protection must commence immediately after harvest to be really effective. Most of the protective steps, regardless of the particular technique employed, are designed to do one or more of the following: to exclude oxygen, to reduce or exclude moisture, to minimize enzyme activity, to eliminate or control micro-organisms already present, and to prevent the entry of insects or micro-organisms from the environment. Not only are these steps necessary to permit the retention of as much as possible of the food in a useful form, but they also are geared to the prevention and elimination of human illness and disease caused by micro-organisms or toxins carried in the food.

The preservation of foods by canning dates from the early 19th century when a French confectioner named Nicholas Appert demonstrated that food in glass bottles could be preserved by heating in boiling water and closing tightly. Soon thereafter, tin-coated iron containers were developed successfully for the same purpose; these later gave way, of course, to cans of tinned steel the covers of which are fastened by tightly interfolded seams of the metal rather than by solder. The success of Appert and his early successors was not based on scientific understanding of what was

happening to the food in their process and not all products were satisfactory, spoilage occurring frequently. It was not until Louis Pasteur in the 1860's demonstrated the role of micro-organisms in fermentations and food spoilage (and in other areas) that it was recognized that the destruction of micro-organisms (sterilization) was the key to successful preservation of canned and other products.

Tremendous advances have been made in the techniques and equipment for canning of foods, including all phases of the pre-canning preparation of the foods and the post-sealing handling and storage of the canned product. Consequently there is no comparison between well-processed canned foods of today and those of the earlier years of this century.

Time does not permit enlargement upon the many developments and advances, notably within the past 25 years, in the preservation of foods of many types by other procedures, notably freezing, dehydration, the use of additives of various kinds, and most recent of all, irradiation.

One of the features of many recent developments in the food industry is the increase in convenience foods which not only simplify meal preparation in ordinary circumstances but also make possible better and more varied diets in difficult environments. Various techniques and combinations of techniques in the spheres of pre-cooking, dehydration, freezing, packaging, etc., have made possible the removal from the kitchen (of the home, of institutions, etc.) much of the drudgery in the preparation of certain foods. This work has been transferred to the factory, where much greater efficiency can be achieved. It is to be hoped that all the benefits of this type of improvement will not be restricted to the more advanced countries of the world or to the more affluent people as they now largely are. Imaginative application of some of these techniques could make appreciable contributions to feeding problems in many parts of the world by minimizing losses in distribution and preparation of food and in freeing time for other productive activities.

The prime consideration in food processing has traditionally been one of preservation. We have just made mention of the trend to convenience foods. Another consideration of importance, one which now in the modern era receives more active and fruitful attention because of increased scientific and technological knowledge is the quality of the product in terms of its acceptability (flavour, odour, appearance, texture) and of its enhanced nutritional value. The question of improved digestibility as well as the retention of more of the nutrient content of the raw food material enters into the latter. In the past, many forms of processing not only diminished the highly-appreciated flavour and texture of fresh foods, but also caused, in many cases, severe losses of certain nutrients or the reduction of their availability to the body upon consumption. Vitamins, minerals and proteins in foods commonly suffered in this way. It is no longer enough just to enclose the food in the package (e.g. a can) and hope that it will not spoil. It is now possible for many foodstuffs, for example fruits and vegetables, to be preserved by canning or freezing (or by freeze-drying, in more limited current application) in such a way that the final product is a better nutrient source than so-called "fresh" fruits and vegetables that might be bought at the market. The reason for this lies in the fact that, in well-run preserving operations (and the emphasis is on "well-run"), food is harvested at the peak of its value and processed quickly to avoid any post-harvest deterioration, whereas materials bought "fresh" (perhaps better called "unprocessed") often have been held one or more days from harvest and have suffered changes in that holding.

Where losses of nutrients are still unavoidable, or where available raw materials are good sources of certain nutrients but lacking in others, another approach is possible and widely used. This is fortification or enrichment. Knowledge about nutritional requirements and the availability of techniques for preparing certain nutrients in pure or concentrated forms makes possible the addition of these substances to conventional or even unconventional food items to improve their nutritional value.

The use of the term "unconventional foods" brings up the question of the great and growing interest in the production and introduction of foods prepared from sources which either originate outside the spheres of customary food production (agriculture and fisheries) or which involve very drastic reprocessing of some of the agricultural and fisheries products. The major incentive for the development of these unusual food materials is the acute shortage of foodstuffs, notably but by no means exclusively with regard to protein sources, for very large and increasing populations in many areas of the world. It is not my intention to discuss the magnitude or the seriousness of that problem with which I am sure this audience is reasonably familiar. But I do wish to point out that the resources, potential and flexibility of the world's food industries as well as the ingenuity of food scientists and technologists and of nutrition scientists and others are being increasingly directed to the possibilities of solving the problem, at least in part, by the development and use of unconventional food materials.

The list of possibilities is long but one may mention the preparation of fish protein concentrate, the separation and processing of a very stable high quality protein from soybeans, the recovery of proteins from inedible leafy materials (surely the world's largest form of photosynthetic product), the production of yeasts which use chipped wood as their main source of food and the production of yeast on wastes from paper making, sugar-refining etc., and the production of algae such as *Chlorella*.

The most unusual, perhaps, of the recent possibilities and one which is undergoing extensive development is the production of protein from petroleum hydrocarbons by the action of microorganisms, primarily yeasts.

The foregoing are not just in the hypothetical stage. Varying degrees of production have been achieved and substantial quantities of products for feeding studies on animals and, in most instances, human beings are available. The case of the soybean

protein is particularly interesting. It is produced as fine fibres of a form not too unlike the synthetic fibres now widely used for fabrics and which can then be literally knitted up to produce textures resembling those of conventional foods like steaks, chicken, bacon and many others. Appropriate flavours and supplemental nutrients can be added. Several large food industries have invested large amounts of money in the development of the soy protein and its products and one company, at least, has a very large and expensive factory coming into operation, probably in 1970, at Cedar Rapids, Iowa, for the large-scale production of institutional and retail products.

The availability and the high nutritional value of any new products, of course, are meaningless unless the products are acceptable to the human consumers for whom they are intended. No one benefits from a highly nutritious food or diet which is not eaten because it is unacceptable either through unfamiliarity or lack of appeal to the consumer.

Much has been said about the difficulties (some even say impossibility) of changing food habits. It is true that most people tend to be very conservative about foods and do not easily make changes, and I would not wish to minimize the problems. But, perhaps too much emphasis has been laid on the role of tradition in this context. I am becoming convinced that the word "tradition" itself has acquired meanings or implications out of keeping with facts. Customs and behaviour patterns labelled as traditional are implied to have existed for at least several centuries and probably longer, whereas in fact some of them may go back not much farther than living memory, if that far. In another sphere, one even reads about people, e.g., in Britain or in Canada or the United States, going out for a *traditional* Sunday afternoon automobile ride. We shall probably soon hear about traditional space suits or traditional computer methods!

Food habits do change and can be changed. For example, in Ghana the wide acceptance of, and the growing eagerness to use, such previously unfamiliar commodities as canned milk, milk powder, canned fish and bread, to name only a few products (not to mention the nutritionally much less desirable soft drinks) attest to the possibilities of changing peoples' food patterns.

In the case of the admittedly more drastic changes involved in some of the unconventional foods, acceptance will have to be sought through the efforts of food scientists and processors to present the products at the outset in forms which are reasonably similar in flavour, appearance and usage to foods already familiar. The fact that a product may be a very nutritious one does not, as nutritionists have learned to their sorrow, guarantee that people will be persuaded to use it. In addition to being acceptable in the aesthetic sense, a product of this type to be successful must also be socially acceptable. In other words it must have, among other things, "snob appeal." Nutrition workers and agencies in various Latin American countries have reported that certain nutritionally valuable new foods, complete or supplemental, have failed of acceptance by the poorer population groups which they were designed to assist because the foods were designated and distributed for the poor and under-privileged. Thus there was a social stigma attached to their use. Where attempts were made and success was achieved in promoting the foods among higher income groups and where the foods were marketed through normal channels the response among the poorer populations was improved.

Thus there is obviously a big part to be played in the changing of food habits in desirable directions by the wise application of advertising and marketing techniques which have been successful in other spheres.

This has been, as warned at the outset, a rather wide-ranging and admittedly uneven treatment of only a few aspects of the very extensive and complex world of food and nutrition. I shall make no attempt to summarize the assortment of points presented.

Although I have already gone on rather too long, I should like to take two or three more minutes to offer an answer to the question which is probably most frequently asked of people in this field in casual conversations. It is the question having to do with the possibility that one may be able to obtain all of one's nourishment from a daily pill or pills. The question is prompted by the common knowledge that one can acquire vitamins and minerals in the form of tablets, capsules or pills, and is asked, and not necessarily facetiously, by people who are at least reasonably intelligent and moderately literate. One notes that such people are so convinced of this possibility that instead of asking "Is it possible for us to obtain all our nutrients from daily pills?" they ask: "When will we be able to?"

My answer to the former question is "Yes" if the word "pills" is in the plural, and to the second the answer is "It is probably technically possible now." Think, for example, of the wide-spread use of pelleted feeds for poultry and other livestock.

Now, before any colleague rises up to object, let me hasten to add this explanation and to emphasize that this is not a form of diet which has very much to recommend it. First of all it must be remembered that the maximum concentration of Calories (energy) in any of the nutrients is about 9 calories per gram, in the case of fat, with carbohydrates and proteins each containing about 4 Calories per gram. Using a diet composed of nutritionally acceptable proportions of these nutrients, to supply 2300 Calories per day as recommended by FAO for a woman of moderate size and activity, a daily intake of 495 grams (just over one pound) of these nutrients would be required. For a man for whom the FAO Allowances recommend 3200 Calories per day something over one and one-half pounds would be required. A pill of one pound or more is quite a pill! But the nutrients *could* be divided into numerous smaller pills, e.g. perhaps 500 to 1000 pills of the size of a common aspirin tablet, or appreciably fewer pills if the consumer is prepared to swallow larger ones. But what a drab prospect!

We assume, of course, that the individual would be allowed and would use his daily supply of water as the means of washing down the pills. And on this basis the proposition is possible. If, however, the consumer chose to dilute or flavour his water with a little alcohol to lubricate the process or to anaesthetize against the monotony, appreciable calories would be contributed by the alcohol and the consumer would be cheating in the game of obtaining all of his food requirement from pills.

To end this little fantasy may I say that members of the lunatic fringe who wish to do so may perhaps be able to keep themselves in existence (I won't use the word "alive") by the use of pills or other concentrated forms of nutrients. For the rest of us, fortunately, there will be the increasing output and expanded variety of increasingly nutritious food products which can add their own unique bright spots to the sometimes drab, often strenuous, days of life.

Both for those of us who now enjoy abundance and for those who do not, may eating continue to be or may it become, as the case may be, a nutritionally-satisfying, a sensually-rewarding, a socially-stimulating and a culturally-acceptable regular feature of daily living!

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