NUTRITION AND THE FUTURE*

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Many speakers on this subject retail the abysmal gaps in our knowledge in the past, the tremendous advances that have been made since then, and the optimistic future when all will be known and all understood. It is true that the advances made over the past 35 years have been considerable. We now know a great deal about the role of vitamins in enzyme systems, the part proteins play in the animal economy, and the importance of the mineral elements. When I was a student, Sir Frederick Hopkins used to devote one lecture to the vitamins and it was not a very long lecture. When I was working in Sir Rudolf Peter's laboratory at Oxford, I used to admire his persistence and wonder if ever vitamin B_1 would be isolated from the awful brew of autolysed yeast he began with. Such authorities and many other scientists worked away unheralded till about 1936, when what was called the Newer Knowledge of Nutrition was born. Why it was called *newer* I never discovered, since the old problems were still with us. However, at that time a spate of popular literature fell upon the public, and nutrition became the latest band-waggon to catch. It was unfortunate that at this time Sir John Orr, as he then was, published a valuable work, *Food, Health and Income*,[1] for this gave the purveyors of nutrition much fuel, and the popular press in Great Britain stated that one-third of the population was starving, which was the last thing Sir John meant to say. I do not wish it to be thought that this movement was altogether bad—the public conscience was drawn to the tremendous amount of malnutrition that did exist in various parts of the world, and from this sprang FAO and other organizations devoted to improving the nutritional status of under-developed peoples.

The great trouble at that time was our complete ignorance of dietary requirements and of the effect of lack in humans of specific nutrients. From this ignorance arose the belief, fostered by Lady Mellanby, that vitamin D was the cure for dental caries, by Lucius Nicholls that vitamin A was one of the specifics for neurological diseases, that vitamin E would cure sterility, and that large amounts of calcium were vital for the growth of schoolchildren. These beliefs all failed. As a result the Newer Knowledge of Nutrition gradually simmered down into the age-long ignorance of nutrition which had been always with us. Great technological advances were made during the war years, and methods of food preservation and desiccation, which conserved the value of various articles of diet, were successfully introduced. It was inevitable that, during a time of emergency, research into nutrition should take such a course, but it was not very fundamental to an advance in this field.

I cannot but feel that we nutritionists have manœuvred ourselves into rather an invidious position. With our boasting about the Newer Knowledge of Nutrition it is true that we have awakened the public to the importance of this subject, but with the result that wellfed or overfed people take large amounts of vitamin preparations or of various patent foods, and read certain books which advocate dietary practices which all of us here feel dubious about.

In spite of all this, no class of society, of any economic status, or anywhere in the world, can be guaranteed to be properly nourished. This may be due to ignorance, bad feeding habits, greed, or poverty. The rich may eat too much fat, or the wrong type of fat, as well as too many calories, which can harm their hearts and put up their weights; their children may eat cariogenic diets; poorer people may eat too much carbohydrate, and the economically under-privileged have diets low in protein and protective foods. When I was at the Rowett Research Institute, a centre staffed with nutritional experts, I noticed that even many of them ate very queer diets and had ulcers.

Since the late 30s the responsibilities of nutrition have expanded to cover far more than merely what we eat and why. Food production and distribution, newer and better methods of crop cultivation, population increase, even atomic power, now lie in the confines of nutrition. For the last decade these problems have been creeping up on us, but I know of hardly any concrete proposal for their solution, and now they are staring us in the face.

I have called this talk Nutrition and the Future, but I might as well have called it the Challenge to Nutrition, or No Cause for Complacency in Nutrition.

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POPULATION GROWTH AND FOOD PRODUCTION

Population Growth

Malthus many years ago promulgated a 'law of population', that the number of persons tends to grow faster than the food supply, and he suggested various 'positive' and 'preventive' checks as the only way this could be controlled—'positive', by such things as war, disease and famine, 'preventive', a restriction in the growth of the population. Recently Julian Huxley[2] has commented on the sudden increase in the population of the world as an explosive process, and without example in history. Prof. K. Davis, of the UN Population Commission, has stated: 'This explosive human multiplication cannot continue indefinitely. How this growth is eventually stopped, and when, will play a tremendous role in human destiny'.

The dietary problems this state of affairs has created have led to several thoughtful articles. Harrar[3] has analysed the position and comes to a hopeful conclusion, but the solution is entirely in our own hands. I remember Sir Stanley Davidson saying to me several years ago that in his opinion the scientific aspects of nutrition had been solved, and that the problem now boiled down to distribution and economic aspects. The following facts show that this assessment of the position is indeed wide of the mark, and would still be so even if everybody could afford to buy all the food he wanted.

In 1700 the world population was 500 million, in 1900 1·25 thousand million, and in 1950 2·5 thousand million. It will probably double over the next 40 years and by 2050, if the population growth continues at the present rate, it will be nearly 13 thousand million. At this rate of expansion, the outlook is indeed frightening, since the increase in food production in the world is not at present even 2% per year. One group of scientists seems to regard the future as chaos, and presumably expect that some catastrophe will drastically reduce the population. Others hope that a solution will be found, and not far off, whereby food production can be increased by improvements in technology and similar means.

World Food Production

Even at present food production is inadequate and does not amount to 3,000 calories on an average per head per day. Harrar estimates that only 25% of the world population get more than 2,750 Cals., while 55% get less than 2,200 Cals. per day. The way things are going, those with the highest standards of living will probably find themselves in a situation when the luxuries of 1940 and 1950 are sad memories. This will not benefit anyone—the decrease in living standards of this group merely representing a contribution to the increased number of people in the world, the rich getting poorer, and the poorer, poorer still. I do not want to deal with the question of population control but, as can readily be seen, it is a fundamental problem in our survival.

There are a number of factors aggravating this food shortage, some of which we could improve. One is the difference in efficiency in different countries, due to natural barriers to efficient crop production, public-health difficulties, poor natural resources and education. What can happen when these difficulties are overcome has been shown by the Mexican Agricultural Program.[4] This was undertaken jointly by the Mexican Ministry of Agriculture and the Rockefeller Foundation, and as a result wheat production in certain areas has been increased to a phenomenal degree, and as a by-product an excellent group of young Mexican agronomists has been produced. Using mechanization in the USA, 2–4 man days are needed to produce rice at a rate of 3,500 lb./acre, but in certain backward rice-growing areas of the world, 400 man-days are needed to produce 700 lb. or less per acre.

As will be admitted by all South Africans, the use of the soil has been in the past little short of disastrous, and all over the world millions of acres have been rendered useless, or will take a long time to recover. It seems that we shall never have more than 4 thousand million acres on crop production, and erosion is still reducing this acreage. Besides this, the use of land for other purposes, urban and industrial, is eating away the available land, with no substitution. One cannot but hope that in many parts of the world, especially Africa, land now dormant will be used, but we do not want a repetition of the ill-fated ground-nut scheme.

As far as water is concerned, it is obvious that as long as the farmer is at the mercy of the rainfall, he will be quite unable to predict success or failure in his crop. Irrigation schemes have proved the solution throughout the world, as well as in the Union. I always think it is tragic, when travelling through the Karroo, to see the little areas round railway stations, where there are boreholes, and where crop production is most successful, while the rest, although potentially very fertile, is a desert for lack of water. It is clear that if irrigation could be extended, enormous areas would be available for food production.

One could go on enumerating many other factors responsible for poor crop production—parasites, unequal distribution of mineral resources, and the type of agricultural worker. People working on the land should be well fed and healthy, but it too often happens that in the most backward countries, whose production is already inefficient, the workers are half starved, thus worsening the problem.

When the quantitative aspect of what happens to our food production is considered, several interesting points emerge. The limiting factor is the capacity of the soil to produce carbon compounds. On this basis the total crop production could theoretically support far more people than now live in the world. But about half is eaten by animals and only 3-5% of this is available again for human food. Only about 20% of the other half is at present used by us as food, and this makes no allowances for storms, droughts and other disasters, which always reduce this figure to a level where there is never enough.

In an interesting article entitled 'Science and Human Want', Clapp[5] goes, among other things, into the question of mechanization in farming practice. In the USA, in 1860 a farm produced enough food for 5 other people, in 1940 for 11 others, and in 1956 for 20 others. This great increase in production is mainly due to mechanization. Farming is now a big business in America, as shown by the fact that 80% of farm products come from 20% of the farms, and 1/3rd of the doubled farm production in the last 40 years is due to an increased use of mechanization. In the future, however, increases in production will be due less and less to mechanization, which seems to be reaching its peak. Thus we cannot expect much more increase in production from this source.

There are still two relatively untapped sources of food. One is the sea, and the other non-cultivated land. Between them they produce annually more than 150 thousand million tons of carbon compounds. As regards the sea, it is clear from our experience in South Africa that, provided it is wisely carried out, far more could be harvested from the sea than is done at present. For non-cultivated land, I am a little wary of the validity of such figures as those quoted above. Land must be used for grazing, since we shall always need animal food. Furthermore we need forests not only to provide fuel and building material, but also to protect the soil. One can instance New Zealand, where the indigenous bush was indiscriminately burnt by the early settlers to the great detriment of the soil.

For these reasons I do not see, except in completely undeveloped parts of the world, a great increase in the areas at present under cultivation. We must in the meantime improve the plants we have and the soil we cultivate.

Possible Solutions

Only about 1% of the 300,000 plant species so far described have ever been used for food, only 300 are now at all widely grown, and a bare dozen provide the world with 90% of its food supply. Presumably experience has taught our forbears that these dozen are the best for the purpose, but we know now that a wide possibility exists for the geneticist and plant breeder to produce plants with a better yield and greater robustness against weather and disease.

We seem to be very timid in experimenting with new food. Seaweed is known to be nutritious, in some areas it is still eaten,[8] and attempts have been made to develop its use in South Africa. An alga, chlorella, if fed with ammonium salts, will produce up to 500% of its original weight in protein. It can be grown in water at a rate of 27·5 tons per acre of surface—a far higher yield than that of soya beans, the most productive crop now grown. It remains to be seen if such a protein source is nutritionally useful.

As far as our soil is concerned, great advances have been made over recent years, especially in changing its chemical and biological properties to meet various conditions at critical periods to improve crop production. Even the humble gardener knows how to manipulate his soil to alter the colour of his hydrangeas. The carrying ability of agricultural soils has been increased to an amazing degree. In addition, the microbiology of the soil, which seems to have been largely neglected, is now becoming as complete a science as the microbiology of animals. The flora of the soil plays an important role in the decomposition of crop residues, in making available nitrogen and phosphorus, and in regulating the pH.

There is an aspect of this that has always interested me, viz. the apparent complete waste of drainage, which ought to be immediately available, with a rich content of nitrogen, phosphorus and other nutrients. I calculate that Johannesburg, with a population of 800,000, produces 25 tons of urea per day. An accountant accustomed to balancing credit and debit would be horrified to see such rich assets thrown away. I suppose that wiser heads than mine have gone into this matter, but it would appear on the face of it that a much more widespread use of sewage farms would give us a rich source of vegetables at a trifling cost. During the war farm animals were fed with urea as a partial source of nitrogen, and I see recently that it has been claimed that urea may furnish as much as 1/3rd of the protein needs of cattle, and that corn cobs and other roughage may be used with urea as a source of carbohydrate.

The use of fertilizers has undoubtedly done as much as mechanization to increase crop yields. The experiments at the Morrow Plots at the University of Illinois are illustrative of the value of fertilizers. These plots had been put under maize every year since 1876 without the addition of any plant food. In 1955, full fertilization treatment brought up the yield to the same value as that of rotation plots which had been fertilized every year since 1904. As an onlooker on such procedures, it does seem to me that this aspect of modern agricultural practice is reducing the soil to the level of a vehicle like water in hydroponics—to hold up the plant and act as a sponge to absorb water and the various chemicals poured on to it but, other than this passive role, to have no value. With such intensive methods, the nutrients originally in the soil have presumably long since gone. While this appears inevitable with our modern methods and way of life, heaven help us if the supply of fertilizers fails!

Apart from the use of fertilizers, a number of plant protectors and stimulants are coming into use. Some seem to play a role like antibiotics in animal husbandry. Such substances as gibberellin, various hormones and other organic compounds are being more frequently used. Food preservation and transport, too, have made great advances, and it is possible to eat almost anything nowadays, whether it is in season or not. Unfortunately the cost of these articles puts them outside the pocket of many classes of people and frozen foods rank as luxury items. On a wider scale, however, surpluses of food can now be preserved and need not be wasted. One would hope that such surpluses would mean a more equitable distribution of food throughout the world, but so far this has happened only to a small degree. Lord Boyd-Orr once said that he was convinced that free gifts of food to Germany in the early 1930s from nations able to afford them might have averted the Nazi domination.

The supplementation of foods has been one way in which the diet of the under-privileged has been improved. In some countries this procedure has gone quite mad and a lot of waste has resulted. The cotton-wool which passes for bread in America is doubtless packed with good things, but who wants to eat it? In South Africa a courageous start was made with the addition of various nutrients to bread. However, it is unfortunate that no attempt, as far as I know, was made to find out what was lacking in the diet of the population before the additions were made. Nor have I seen any figures indicating that eating this bread has improved or in any way affected the health of the population, and especially that of the less privileged section. If indeed this information is not available, a valuable natural experiment has been allowed to fall by default, and it would appear difficult for nutritionists to justify the considerable expenditure which must have been involved. I do not think that enrichment of foods is more than a temporary expedient in solving this question. It implies a permanent source of the nutrient added, and also enforces on the population as a whole extra nutrients which many of them may not need.

I feel that no reference to these problems would be complete without mentioning sources of energy and their possible application. I am thinking of cheaper manufacture of fertilizers, possibly the conversion of sea water into fresh water and its transport to distant areas, cheaper power for use on farms, and factories for processing food. Coal and petroleum products have been exploited by us to as full an extent as will ever be achieved, and they will in the end be exhausted, but the new possibilities released by nuclear power, if they are as promising as they sound, and if we do not let the misuse of them destroy us, should solve many of our problems. But by the time this consummation has arrived we shall be living in the completely artificial world from which there is now no escape—an artificial soil, enriched by artificial fertilizers, pepped-up plants, controlled water supply, and energy from a source which can only be described as 'unnatural'. A breakdown in any of these—and they all seem to me to be unreliable to some extent—would mean a catastrophic disaster which would wipe out the majority of mankind. Life on the moon might seem no more hazardous, and possibly one solution will be space immigration!

One final point before I leave this aspect. Even if we can produce enough food to feed everybody properly, some economical readjustment must take place whereby everybody can buy or be supplied with what he needs.

DIET AND HEALTH

Before blithely planning that everyone should have enough to eat, we must consider very carefully what this should be. I suppose we consider that the Western form of diet is the best, and presumably wish to elevate the under-privileged elsewhere to a diet of that type. However it is becoming abundantly clear that the Western type of diet is killing off more and more people from coronary heart disease, and also that it is very bad for the teeth. I do not need to discuss coronary arterial disease here, but I should like to draw attention to some war-time studies which from the nutritional point of view are interesting and apparently show that these two processes are reversible.

Biörck[7] has given an analysis of the incidence of arteriosclerotic heart disease in Scandinavia before, during and after World War II. Owing to enemy occupation, or to rationing, the consumption of fat fell very considerably in Norway and Denmark. It was also reduced in Finland and to a lesser degree in Sweden. This was accompanied by a reduction in the total death rate in Finland, Sweden and Norway, but not in Denmark. Denmark usually exports butter and eggs in large amounts and, since this was no longer possible, the consumption of eggs and much more so of butter increased considerably. The inference was drawn that the change in food habits was one of the factors responsible for the fall in death rate, and evidence from other sources supports the concept that the reduction in fat intake was responsible. One fact that Biörck points out was the intimate connection between the fat consumption decrease and the decline in mortality from arteriosclerosis, there being practically no time lag. With the end of the war the diet 'improved' both in calories and fat content, and the death rate immediately rose again in Norway, Sweden and Denmark. In Sweden the percentage of fat per total calories rose from 33·5 in 1948 to 36·6 in 1953.

The other condition which improved greatly during the occupation was dental caries. During the war it was found that the incidence of caries in occupied countries fell considerably, though the interpretation of this apparently simple finding has varied considerably. Bransby and Knowles[8] investigated the teeth of children in the Channel Islands just after the German occupation and 2 years later. When the islands were liberated it was found that 51% of the children in the age-group 3—7 were caries-free. A similar group had been taken to England before the German occupation and of these only 11% were free of dental decay. Two years after liberation the teeth in the Channel Islands had deteriorated considerably, while those of the corresponding children in England had not changed to any great extent. After the liberation the chief changes in the diet were: more protein and vitaminized fat; considerable increase in consumption of sugar, jam and sweets; more puddings and made-up dishes; and an increased intake of all nutrients, including vitamins A and D, and of calcium.

The same decrease in caries was found in Norway, but here a dental campaign against the use of excessive carbohydrate, and other dietary reforms, had been in action since 1938. As a result a fall in the caries rate began in that year. This was accelerated during the occupation, when the sugar consumption fell from 87 to 30 g. per day per person and sweets were unobtainable. Collett,[9] who reported these findings, said that the relationship of caries to food was quite plain, and quoted Göethe: 'It irritates people that truth is so simple'.

In this connection, Sognnaes[10] made an analysis of the timing. The reduction in caries had a definite time lag after the change in diet. He attributed the improvement, not to a change in the oral environment, but to an indirect favourable effect on the development of the teeth. He has produced much other evidence in favour of the thesis that factors operating on the teeth during their development affect their caries resistance.

I have mentioned these two rather different pathologies to show that there is no doubt that a poor diet is not all bad. If we are going indiscriminately to improve the diet of the Bantu here, to bring it into line with our own, shall we then subject them to the danger of cardiovascular disease, from which they are now infrequent sufferers?[11] We already know at the Dental Hospital that the urbanized Bantu has caries which approaches that of the White man in severity.

Here is a tremendous responsibility for nutritionists of the future. Any improvement of the world food supply must avoid the tragic example of the Western world, where we seem to be killing ourselves off with eating. About the only consoling fact is that these conditions appear to be readily checked and are reversible.

The Value and the Use of Dietary Standards

I cannot but feel that a lot of our trouble about these problems is our ignorance of dietary standards—how these should be determined and how applied. We cannot estimate a world requirement for food unless our standards are accurate. The experimental method of putting animals on to diets 'adequate' in all respects but one, and then altering the intake of the item under investigation is obviously open to question. In the first place we are not sure of the adequacy of the diet, and secondly, as is well known, the requirement of one nutrient is often tied up with the dietary level of another, as for example, calcium and phosphorus, vitamin B_1 and carbohydrate.

Having served on a committee dealing with dietary standards, I now have much less respect for the figures so authoritatively set out by the official bodies of North America and Europe. During our deliberations, we wrote to some of these people asking for further information on points not clear to us, and found to our surprise that these points were also not clear to them. We felt that the functions of a table of dietary standards could be laid down at most as follows: 'The standards proposed . . . should be regarded as adequate for the maintenance of health without allowing for a safety margin for ill health, or for great individual differences in absorption and metabolism.' Furthermore it is obvious that while *every* constituent of the diet has a proper level of intake, those listed are only the ones which may be in short supply, such as vitamins, some minerals, protein, etc., the purpose of the table being to ensure that enough of them are provided. There must be standards for the intake of carbohydrate, sodium, potassium, chloride, and so on, but there is usually no danger of shortage of these. For fat, on the other hand, I think the time has come for nutrition councils to be more specific. Unlike the other items listed, here is an example of the danger of over-consumption, and not only the amount but the type of fat should be prescribed. Our Nutrition Council suggested the intake of 20–30% of total calories and the addition of essential fatty acids. This is not at all helpful to the person actually drawing up a diet; the absolute amount of fat to be consumed at various calorie levels, and also the kinds of fat that should or should not be eaten ought to be listed.

The first tables to be officially issued were put out by the League of Nations in 1935. Since then the Food and Nutrition Board of the National Research Council of the USA, the Committee on Nutrition of the BMA, the Dutch Nutrition Council, the Canadian Council on Nutrition, and our own National Nutrition Council, have put out tables. I do not wish to comment on all these findings; they are not strictly comparable, because the underlying philosophies are not the same, but in general they do not differ a great deal.

Calculations about the future of the world food supply depend in large measure on our dietary standards, and it behoves us to study these critically to ensure that our calculations are all right. Seeing that the laws of thermodynamics are also supposed to apply in physiology we can, I think, assume that the calorie levels listed are correct. These figures are amenable to accurate appraisal, and the effects of excess or deficit are immediately seen. Protein standards seem to be undergoing a change. The report of the FAO committee,[12] though now 3 years old, shows that much constructive thought has been given to the matter. A reference protein (of high biological value) is used as the basis. This puts the matter on a far more quantitative basis than the old pious hope that of the total protein intake 'at least 1/3rd should be of animal origin'. It now appears that our protein requirements were set too high and that some reductions can be made, going back to the standpoint of Chittenden half a century ago. In addition, the important practical aspect of protein mixtures, to give a final satisfactory amino-acid balance, has been stressed. This is a particularly vital point in feeding natives in countries like Africa, where the diet is primitive or unsatisfactory. If our protein requirements have in fact been estimated at too high a figure, this is reassuring for the future, since, as I see it, a world protein shortage is likely to be the most acute problem of the future.

Fat is the most expensive of all foodstuffs. If we can encourage people to eat less fat, so much the better. In fact, from our wartime data, a world shortage of fat in the future would appear to be desirable.

The vitamin recommendations, with the exception of ascorbic acid, are probably of the right order, though recently the American Food and Drug Administration[13] have proposed a daily requirement of 10 mg. of niacin and 1 mg. of riboflavin, a reduction in both cases from previous recommendations. In this connection I should like to emphasize the fine work of Horwitt and his colleagues,[14] who have studied the effects of vitamin deficiencies and of various levels of intakes directly on humans. Their figures for riboflavin and niacin requirements, based on long-term and painstaking experiments, are of the same order as those found in official tables. They are still undecided whether vitamin E plays any role in the economy of the adult.

I should like to mention two other nutrients which figure in nutrition tables. One is ascorbic acid. After the classical work of Fox and Dangerfield in 1940,[15] who showed that Natives on the mines could remain in perfect health on small intakes of this vitamin, and the confirmation of their findings by Bartley *et al.*,[16] it is incredible to me that the National Research Council of the USA still recommend such high figures. The same applies to calcium; the recommendation for this element was at one time 1 g. per day for adults. Hegsted *et al.*,[17] Walker[18] and I[19] have all stressed that in adults the calcium requirement is far lower than this, though I do not go so far as to say there is no requirement—there must be one, however small it is. Probably the only people who need calcium in any amount are children and lactating women. The full-term foetus contains about 25 g. of calcium, and thus is not much of a drain on the mother's reserves. For full lactation over 9 months, the mother must produce about 80 g. of calcium, or about 8% of her skeletal reserves, and in spite of extra calcium in the diet she often prefers to use her bone calcium. For children I recommended some years ago[20] that Terroine's method,[12] based on body analysis, should be employed instead of the hit-and-miss metabolic balance methods now current. Calculations based on the available figures of body analysis of children show that their calcium requirement is a good deal less than supposed. Thus here, too, we find that the estimated requirements on which many of our calculations for the future are based are too high. This is a reassuring thought and shows that in this respect the future may not be so gloomy as at first thought.

Assessment of Nutritional Status

If we are going to improve the world's diet, we must have some method whereby we can assess nutritional status and observe if our dietary changes have caused any improvement. The clinical evaluation of nutritional status is difficult. Even the rationale of the figures of the Metropolitan Life Insurance Co. of New York for heights and weights does not appear very clear, and I know of no evidence for their being accepted as gospel truth, save the fact that they are statistically built up upon the findings from a large number of apparently normal people.

In the evaluation of bodily composition it is important to have a basis from which to work. This information is being gradually acquired from the analysis of corpses and will form a valuable standard from which to argue.

In living people, however, indirect methods have to be employed, based upon dilution methods and metabolic data. This subject has been recently reviewed.[22] The assessment of muscle mass can be made from estimations of urinary creatinine, but these figures are not so interesting from the nutritional point of view as those of body fat and water content, since these latter constituents are most easily changed by diet. The methods for evaluating fat and water values must take into account genetic and other factors, since to compare a skinny person with one naturally well covered, without such considerations, would be valueless. One of the most important influences to consider is the endocrine one. For one person a weight of 150 lb. may be normal, for another of the same height it might represent long-standing malnutrition.

Physical anthropologists have gone into the question of body build and have endeavoured to draw up formulae for the proportions of skeleton, muscle, fat, etc. We all know of the 'somatype' classification of Sheldon,[23] but to what extent these various 'morphs' are produced by nutrition is undecided. It seems, however, that nutrition must play a big part, since endomorphs are fat types and ectomorphs are usually skinny. Brozek and Keys,[24] in their well-known starvation studies, found a strong correlation between somatype rating and body density. They consider it possible that this may have eliminated the virtue of the system as providing a permanent (constitutional) index, but the somatype rating may be used instead as a measure of nutritional status.

Experimental work has produced much interesting information. The standard used is the lean body mass, which appears both in animals and man to have a quite uniform composition, with a specific gravity (SG) of 1·100. Thus it should be possible to estimate the amount of body fat from the amount of body water as well as from the SG.

One would have thought that the direct determination of the SG would have been the easiest and most accurate, since we know the SG of the fat-free body. However, the complicated apparatus needed would preclude its use by all but the best-equipped clinics. In addition, errors creep in from the air in the respiratory passages and the lungs, and from any gas in the intestines. In animals the air trapped in their fur introduces a further error. A gas-dilution method has been described which theoretically should be perfect, but the apparatus is very expensive and needs trained technicians to operate it.

However, indirect methods for estimating body composition can be used. As one example of how this can be done one can quote McCance and Widdowson:[25] who measured the extracellular space by the thiocyanate method, corrected for water in the red cells, determined total body water by the urea technique, and calculated the cell mass and fat of the body. The differences between total body water and the volume of extracellular fluid was considered to be cell water, the cells being 67% water by weight. The fat-free body contained 7·5% minerals by weight. The fat was then calculated as the body weight minus the weights of extracellular fluid, cell mass and minerals. Using this method McCance and Widdowson studied various people, including undernourished German prisoners of war. In the latter it was found that while they were of normal weight for their height, part of the weight that would have been interpreted as fat was water. The extracellular fluid volumes are also very high in undernourished children.

An ingenious and simple method for fat assessment, developed by the Minneapolis school, is the measurement of skin folds by special calipers. This method is obviously not particularly accurate, but it has proved useful when working with large groups, where a technique like that of McCance and Widdowson could not be applied.

It would be most helpful if we could have a formula to work out the SG from such parameters as height and weight. Cowgill[26] has produced such a formula, based on weight and height measurements. On applying it to a number of different people it seemed to give results of the right order. As an extreme example, the famous fat man, Daniel Lambert, who weighed 739 lb., had a SG of 0·950, the SG of human fat being 0·92. Newborn babies had calculated fat contents of 12-16%, which agreed well with actual analyses. The data for children varied from specific gravities of 1·10 for tall boys and 1·108 for abnormally thin boys to 1·066 for fat boys. The formula was applied to the prisoners investigated by McCance and Widdowson, and had the limitation of over-estimating the fat in these individuals. As stated above, part of the weight regained was water, not fat. Cowgill comments that it would be interesting to know how long the period of rehabilitation must be in order to restore not only the person's weight, but also the body composition which that weight represented.

We are thus developing useful and accurate methods for the determination of the nutritional status. If we are going to improve the diets of peoples in the future, it is only by methods such as these that we can determine if we have succeeded or not.

THE FUTURE

It may appear that I have given a very gloomy prognosis for the future of world nutrition—a rapidly expanding world population, a far too slow development in food production, and a general lowering of standards to ensure our survival.

The answer is an 'artificial' type of life, dependent on many factors which are themselves unreliable. But are we not there now? When the electricity fails in my house, we cannot cook, food deteriorates in the refrigerator, and we have no light, no heat and no radio—what more artificial than that? In nutrition we shall have to rely on fertilizers, mechanized production, irrigation schemes, atomic power; because of the way we have chosen to evolve, such developments are inevitable.

But we can at least exploit the resources which have lain fallow in the world since man began to live in it. All these facilities were there but they were not used. I think the future is one of challenge and promise. We know the problem and we know the answers. With the potentialities that we possess and the techniques now available, it is our responsibility to utilize them to the utmost of our ability and knowledge.

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