

Diseases of Faulty Nutrition

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Transactions of the Far Eastern Association of Tropical Medicine, England, 1927

MORE than 2,000 years ago Hippocrates wrote as follows:

'... it appears to me necessary to every physician to be skilled in nature, and to strive to know, if he would wish to perform his duties, what man is in relation to the articles of food and drink, and to his other occupations, and what are the effects of each of them to every one.

'Whoever does not know what effect these things produce upon a man, cannot know the consequences which result from them.

'Whoever pays no attention to these things, or paying attention, does not comprehend them, how can he understand the diseases which befall a man? For, by every one of these things a man is affected and changed this way and that, and the whole of his life is subjected to them, whether in health, convalescence, or disease. Nothing else, then, can be more important or more necessary to know than these things.'

It is strange that, although these words were written so long ago, it is only within the last quarter of a century that we have begun to pay attention to 'what man is in relation to the articles of food and drink', to 'know what effect these things produce upon a man', and, 'to understand the diseases which befall a man' in consequence of them.

In the time at my disposal I can do no more than give a very brief outline of the present state of knowledge of the nutritional or, as I prefer to call them, the malnutritional diseases. I shall not, therefore, concern myself with morbid states which result from the ingestion of food in insufficient quantity, nor with those which may be associated with over-eating, but will confine myself to ailments whose genesis is directly or indirectly dependent upon the improper quality and or the improper balance of food ingested in sufficient quantity.

Since the functions of food are to rebuild the living tissues, to supply energy and to preserve a proper medium in which the biochemical processes of the body can take place, it follows that derangements of nutrition -- and, therefore, of health -- must result if the food ingested fails adequately to subserve these functions. Then the architecture of the living tissues becomes imperfect; transformation of energy in the body becomes deranged; and, metabolic processes become disordered, with the consequent production of abnormal or, it may be, of toxic metabolites. The failure of food to subserve these functions may be brought about in a number of ways; but the one which chiefly concerns us here is the insufficient provision in the diet of one or other or all of three of its essential constituents: suitable protein, inorganic salts and vitamins. Foods which are

unsatisfactory in these regards give rise to sub-optimal, or to subnormal states of health, or even to actual disease, the character and the severity of which depend upon the nature and degree of the food faults and the length of time the organism has been subjected to their influence.

The first effect of such unsatisfactory foods to which reference must be made is the *low standard of physical efficiency* which they induce both in man and his domestic animals. In no country in the world is this more clearly manifested than in India where malnutrition is so widespread and where food habits are so much controlled by custom and prejudice. No one who has traveled far in India can have failed to notice the great differences in physique of different Indian races. The poor physique, the lack of vigour and of powers of endurance of certain southern and eastern races provide a remarkable contrast to the fine physique and hardiness of certain stalwart races of the north: these differences are in the main attributable to differences in biological value of their national diets. The low standard of physical efficiency of man's domestic animals in certain parts of India is common knowledge: it has the same malnutritional basis, and the gravity of its influence on the well-being of the people can hardly be over-estimated.

In addition to lowering the standard of physical efficiency (a matter of vast economic importance to India) food which is faulty with respect either to suitable protein, to mineral elements, to vitamins or to all three gives rise to many *minor manifestations of ill health*, without, it may be, the production of any morbid state to which we can attach a diagnostic label. It inevitably leads to some deviation from the normal histological structure, and to a corresponding reduction in functional efficiency, of one or other of the various organs and tissues of the body: the nervous, the osseous, the muscular, the endocrine, the gastro-intestinal, the respiratory and the circulatory systems. It leads also to some deviation of the body fluids from their normal constitution; the blood, the lymph, the digestive juices, the secretions, the excretions, even the tears, are all altered in one way or another, each alteration contributing to, or being indicative of, impaired well-being.

It is to be recognized, whether we be dealing with animals under experimental conditions or with man in his free state, that it is the gross evidences of malnutrition which force themselves upon our attention, which are recognized clinically, and for which alone our system of nomenclature provides appropriate labels. The lesser manifestations of malnutrition often escape our observation altogether, although they 'affect the health of individuals to a degree most important to themselves' (Hopkins, 1906).

If we closely observe animals subsisting on faulty food -- even though the fault be not so great as to cause such wreckage of health as *scurvy*, *beri-beri*, *pellagra*, *ricketts* or *keratomalacia* -- we notice many signs of impaired well-being which have their counterpart in human subjects similarly situated with respect to the quality and balance of their food. Thus, we may notice sub-normal or, as I prefer to say, sub-optimal states of growth or of unbalanced growth; or we may find that the animals' 'condition' is not so good as it might be, that their coats lack lustre, or that they are dull-eyed and devoid of the beauty of the well-nourished animal; we may notice, also, that their excreta are not

wholly normal, that they age prematurely, that their fertility is impaired, that they have but poor success in rearing their young, that their offspring when reared are very prone to disease and that the mortality amongst them is high. We may find, too, that they are apprehensive and timid, peevish, or it may be ill-natured, and that they resent handling which the well-nourished animal rarely does: all of which is unmistakable evidence of an unstable nervous system. Yet such animals may be suffering from no nameable disease though they are obviously not well.

Similar symptoms of sub-normal health are common enough in human beings; but since they may conform to no stereotyped disease, have no 'microbe' nor any 'toxin' associated with them, nor be accounted for by any laboratory tests which we apply to them, we are apt to find nothing wrong with sufferers from them and to mistake their malnutritional meaning. Obsessed by the idea of the microbe, the protozoa, or the invisible virus as all-important excitants of disease, subservient to laboratory methods of diagnosis, and hidebound by our system of nomenclature, we often forget the most fundamental of all rules for the physician, that the right kind of food is the most important single factor in the promotion of health and the wrong kind of food the most important single factor in the promotion of disease. I emphasize these minor manifestations of malnutrition because they represent the beginnings of disease, and their recognition is, to my way of thinking, vastly more important than that of the wreckages of health, which even the man in the street can see, though his name for them may be less sonorous than our own.

Next in importance to the *physical inefficiency* and the minor *manifestations of ill health* induced by faulty food come those gross states of morbidity that are due to specific food faults: the list of these increases year by year. I shall do no more than mention them, leaving you to link each with its own food fault. They are: *keratomalacia*, *night blindness*, *dental caries*, *polyneuritis*, *beri-beri*, *pellagra*, *scurvy*, *ricketts*, *osteoporosis*, *slow healing of fractures*, *sterility*, *stone-in-the-bladder*, *anaemias*, some types of *goitre*, *alimentary dystrophy*, *gastric atony and dilatation*, *diarrhoea*, *constipation*, *intestinal stasis*, *colitis*, *unhealthy skin*, *disordered action of the adrenal glands*, and *vesical irritability*. The results of animal experimentation have been generally accepted as demonstrating the aetiological relation of specific food faults to some of these maladies in man, while their prevention in human beings by correction of the food faults has afforded incontrovertible evidence of the truth of this relationship. But in regard to others the knowledge that they have a similar aetiology has been slow to diffuse, and, therefore, slow to be put in practice, though it has been arrived at by the same means. Nevertheless, it will ultimately be made clear in man himself that certain disorders of the gastro-intestinal tract are as readily preventable by a perfectly constituted diet as are scurvy, ricketts or beri-beri.

The morbid states which are known to result from faulty nutrition in man's domestic animals are: imperfect growth; slow development; tendency for stock to decrease in size; deterioration of imported stock and of their offspring; high mortality; low birth-rate, sterility; reduced carrying capacity; poor physique as draught animals; low milk yield; poor quality of milk; poor coats; non-parasitic skin diseases; abnormal craving for bones, earth or faeces; emaciation; pernicious anaemia; one type of goitre; cretinism; 'hairless

disease'; *lamziekte*; rickets; osteomalacia; 'poor bone'; fragile bones; swelling of joints, stiffness of hind quarters and lameness (*styfsickete*); pining in sheep; poor egg-production in fowls and infertility of eggs.

These manifestations of malnutrition in man's domestic animals are attributed by veterinary scientists to deficiency in the food of essential mineral elements, and with good reason. But some of them, such as low birth-rate, sterility, rickets, non-parasitic skin diseases, some types of goitre, cretinism and pernicious anaemia, can be produced by other means in laboratory animals: deficiency of certain vitamins causing some, and infectious agencies others. It would seem, therefore, that a deficiency either of certain vitamins or of certain salts may bring about the same or, apparently the same, morbid result, and that in regard to these and other essential constituents of food we have still much to learn, as Hippocrates puts it, of 'the effects of each of them to every one'. However this may be, it is clear that the relation of malnutrition to disease-production has many aspects, and that progress in its comprehension depends on the closest co-operation between students of human, of animal, and of plant nutrition.

The mention of *lamziekte* in cattle, introduces us to a novel sequence of events in disease-production. This condition is due to a pathogenic agent -- the *Parabotulinus bovis* -- which has its habitat in decaying bones. The primary cause of the disease is, however, a deficiency of phosphorus in the food of cattle which induces in them so great a craving for this element that, to satisfy it, they eat the bones in which the pathogenic agent resides, thereby becoming infected. It may be that in this observation there lies a general principle which has an application to mankind.

This brings me to one of the most important means by which disease is brought about both in man and animals by faulty nutrition: namely, by increasing their susceptibility to infectious agents. During the past two-and-a-half years (1925-7) 2,463 rats, living in my laboratories under conditions of perfect hygiene, have been fed on various faulty foods, while the daily average of control or well-fed stock rats was 865. The mortality in the ill-fed animals (excluding those that were killed on the conclusion of experiments) was 31.4 per cent, while in the well-fed animals it was less than 1 per cent; the chief causes of death being *lung diseases*, pneumonia or broncho-pneumonia and *acute gastrointestinal disease*.

In the course of my own work I have seen dysentery arise in ill-fed monkeys while well-fed monkeys living in the same animal room escaped; and I have seen ill-fed pigeons become infected with *Bacillus suipestifer* and with the invisible virus of *epithelioma contagiosum*, while well-fed birds living in their immediate vicinity escaped these infections. Other workers have had like experiences; the bacillus of mouse typhoid kills, on injection, over 90 per cent of ill-fed mice while it kills less than 10 per cent of well-fed mice; the ill-fed mice are likewise less resistant to *B. pestis cavide* and to *botulinus* toxins. Birds are rendered susceptible to infection by anthrax when fed on food deficient in vitamin B and rats to *septic broncho-pneumonia* when fed on food deficient in vitamin A; guinea-pigs, when fed on food deficient in vitamin C, die more readily from *tuberculosis*, new-born calves deprived of colostrum develop *interstitial nephritis* due to

B. coli infection; swine suffer from *tuberculosis*, which can be eradicated from the herds by well-balanced vitamin-rich food; stock animals develop *sarcosporidia* from the same malnutritional cause.

Man himself provides many examples of a like kind: I need but mention two: In Northern Melanesia, the native diet has been shown to be deficient in suitable protein, mineral elements and vitamins and the poor physique of the natives and their high death-rate from *respiratory* and *intestinal diseases* has been correlated with these deficiencies in the food; outbreaks of broncho-pneumonia in children have been definitely traced to the inadequate ingestion of fat-soluble A, and have been caused to disappear by the adequate provision of this vitamin. This list of infectious diseases, to which animals and man are rendered highly susceptible by faulty food, is comprehensive enough including, as it does, infections by such diverse organisms as protozoa, bacilli and invisible viruses. There is good reason, therefore, for the assumption that such death-dealing diseases as tuberculosis, leprosy, cholera, dysentery, plague and malaria have often in this country (India) a malnutritional element in their genesis and course.

Within recent years 'the spectacular results which have attended the experimental study of vitamins have overshadowed much else in nutrition both in the minds of the profession and the public' (Mendel, 1923). It may not be inappropriate, therefore, to refer to a class of disease which results under experimental conditions in animals from the lack of balance of various components of the food, each component in itself good. One example of the kind is afforded by the *hyperplastic goitre* which may result from an excess in the food of so homely a substance as butter. The excess of butter, or of unsaturated fatty acid, causes thyroid hyperplasia by reason of the relative deficiency of iodine brought about by this excess; similarly, *enlargements of the thyroid gland* of the colloid type may be induced by an excess of lime; they are preventable by increasing the iodine ingested proportionately to this excess.

Another example of much the same sort is that of *stone-in-the-bladder* which is brought about in rats by ill-balanced diets containing much oatmeal, or whole-wheat flour. To avoid 'stone' the excess of these cereals must be compensated for by the consumption of appropriate amounts of milk. Those most excellent foods, oatmeal and whole-wheat flour -- the staple articles of diet of such vigorous races as the Scots and the Sikhs -- may likewise prove harmful, by causing disturbance in the normal processes of calcification, when, *but only when*, the diets containing them are poor in vitamin D.

These cereals are not in themselves complete foods; a fact of which the races using them as staple articles of diet are not wholly in ignorance: the Sikh does not attempt to subsist on *atta* (whole-wheat flour) alone, nor the Scot on oatmeal. Any ill effect which these two foods may exercise is due to the failure suitably to combine them with other food materials which compensate for their defects. They are not to be condemned nor to be displaced from their prominent place in the dietaries of mankind for this reason. As well might we condemn the perfectly good fuel, petrol, for the over-heating of the engines of our cars when we fail to supply them with sufficient oil, as condemn the excellent wheat and oats when we fail to consume with them sufficient quantities of milk or other

vitamin-rich foods, which are required by the human machine for its smooth and efficient running.

The same kind of misunderstanding surrounds the controversy which periodically rages over the relative values of white bread and bread made from whole-wheat flour. Both are excellent foods though neither is a complete food; and since man requires a certain amount of suitable protein, of mineral salts and of vitamins as well as of carbohydrates, the superiority of the one bread over the other, as the staple article of diet, lies in the extent to which it excels as a source of these essentials. Seeing, therefore, that white bread is notably more deficient in suitable protein, in vitamins (A, B and E) and in certain essential salts than bread made from whole-wheat flour or, indeed, than any other single food entering into the dietaries of western peoples (with the exception of sugars, starches, and fats which are marketed in the pure state) (McCollum), it is by this much the poorer foundation upon which to build a well-balanced diet. Those who can afford to build upon it, and who possess the requisite knowledge to build wisely, have little need to fear nutritional ailments, though their building is improvident, while those who cannot -- and there are millions of such -- are in grave danger of disease. Next, then, in importance to the quality of the various ingredients of our food is their right combination.

Of all the constituents of food on which normal health is dependent, vitamins are the most remarkable. We know neither what they are nor yet how much of them we need, though knowing that normal metabolism is impossible without them. We are accustomed to think of them in such infinitesimal terms that we have come to believe that the amounts we need of them are almost imponderable. I do not know whether they are ponderable or not, nor whether science will ultimately succeed in encompassing them all within chemical formulae; but I do know that for optimum well-being we need much more of them than is generally supposed.

At all events, races like the Sikhs, whose physical development and vigour are equal to those of any race of mankind, and superior to many, consume these substances in large quantities as compared with races whose physique is poor. I find that for rats the well-balanced, vitamin-rich diet of the Sikhs is superior to any synthetic diet I can devise and to which vitamins in the form of yeast and cod-liver oil are added. I do not believe that human beings can have too much vitamins when they are taken in the form in which Nature provides them in well-balanced combinations of unsophisticated food materials. Some individuals appear to require more vitamins than others, size being an important factor in determining their requirements; some species of animals require more of a particular kind of vitamin than do others; more are required by the lactating than by the non-lactating animal and more for longevity than for a shorter life. The amount needed varies with the composition of the food, with its balance in other essentials and with its digestibility; more of one vitamin is required when the food is very rich in another as, for instance, more vitamin C when the food is rich in vitamin D; there is for optimum nutrition an ordered balance even amongst the vitamins themselves. In short, the amount of vitamins needed varies with the metabolic requirements of the individual; the attainment and maintenance of physical perfection, reproduction, lactation, heavy work, exposure to cold, infectious and debilitating diseases are all indications for their liberal

supply.

Before bringing this brief survey to an end I may, perhaps, refer to another aspect of the matter: the effect of vitamin-deficiency in increasing the susceptibility to certain poisons, which the work of Smith, McClosky and Hendrick has recently brought into prominence. It has been mentioned that deficiency of vitamin A increases the susceptibility of mice to *botulinus* toxin; it also increases their susceptibility to mercuric chloride. The same deficiency induces in rats an enormously increased susceptibility to morphine, to ergotoxine and, in lesser degree, to histamine. Deficiency of vitamin B likewise increases greatly the susceptibility of rats to ergotoxine and to pilocarpine. Stimulants of the central nervous system are all more toxic to rats receiving too little vitamin A than to well-fed animals.

Observations of this kind suggest forcibly that the ability of the tissues to detoxify certain poisons -- both bacterial and other -- is reduced by diets deficient in vitamins; while indicating that such diets increase the sensitivity of the nervous system and of its autonomic division to toxic agents. Not only may this be so, but the disturbances of metabolism which result from vitamin-insufficiency may themselves give rise to toxic metabolites which exercise specific effects on certain organs and tissues of the body. This I believe to be the case in beri-beri, about which malady we shall presently engage in argument. Most of us will probably agree that there is such a thing as a specific beri-beri-producing poison; though disagreeing as to whether it be produced in rice before this food is ingested, or in the intestine by some bacterial agent introduced with rice, or in the course of a disordered metabolism arising out of vitamin-insufficiency. Our disagreements will not greatly matter so long as we recognize the prime importance of a sufficiency of the anti-neuritic fraction of vitamin B in preventing beri-beri.

In looking through the pages I have just written, I find mention of a host of diseases and departures from health which make up an imposing array. But amongst them there are none that I have not myself seen to arise as the direct or the indirect result of faulty nutrition or which are not vouched for by investigators of repute. I know of no disease-producing agency which reaps so rich a harvest of ill health as this: though like others it has its limitations. Perfectly constituted food is not a panacea for all diseases, but it is an agent as potent in preventing a host of them as is the mosquito-net in preventing one or inoculation in preventing another; while it is no mean coadjutor even to these.

The newer knowledge of nutrition is, I am convinced, the greatest advance in medical science since the days of Lister, and the sustained success of our profession in its conquest of disease depends, in no small measure, on the extended study of this vitally important subject and on the application in practice of the results reached by that study. When physicians, medical officers of health and the lay public learn to apply the principles which the newer knowledge of nutrition has to impart, when they know what malnutrition means, when they look upon it as they now look upon sepsis and learn to avoid the one as much as they now avoid the other, then will this knowledge do for Medicine what asepsis has done for Surgery.