THE PRINCIPLES OF NUTRITION FOR PRACTITIONERS AND STUDENTS

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with a Foreword by

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FOREWORD

In this work Professor Brockington has produced a simply written and readable book on the principles of nutrition—a subject which becomes more and more terrifying to the learner with each addition to the complex of vitamins.

The system of question and answer which has been adopted in the book will appeal to all students. The whole subject of vitamins is both efficiently and attractively presented, and gives not only a clear outline of the principles of nutrition but will certainly stimulate enthusiasm for this study which has, so often in the past, produced, if not terror, at least apprehension in the hearts of many.

The Introduction and Parts V and VII can undoubtedly be read and comprehended by many who are not qualified medically. Chapters XI and XII will prove of great use to those persons whose duties take them to work with the more primitive races of the world.

There is no doubt that this book will find its place on the bookshelf of many of us and help to fill the longstanding need for an attractive presentation of a most important part of preventive medicine which has been to many hitherto an almost closed book, and one only too often indeed set forth in a narrow and parochial manner.

Professor Brockington's longstanding study of nutritional problems has made him expert in knowledge, and his natural gift for writing clearly offers that knowledge to a wide public.

J. M. M.

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CHAPTER I

INTRODUCTION

How We came to Understand the Peculiar Importance of Food to Health

1. *Why is our knowledge about the relationship of food to health so recent?*

Although it must always have been obvious that the human being will starve and fall ill with too little food, it has been only in recent years that we have come to understand to what extent health depends upon what we eat. The reason for our failure to understand the relationship of health and disease to food is because the machinery by which the body processes are regulated is so very complicated. In consequence, the connection has for the most part required long periods of research and the use of laboratory methods, which have only recently been perfected. Only in one or two instances, for example, scurvy and beri-beri, has the relationship between food and health been sufficiently simple for acute observers (with none of these special weapons) to detect it.

2. *What early observations were made about the relationship of diet to scurvy?*

Scurvy is the most clear-cut example of a simple relationship between food and health, which was detected long ago. Scurvy has almost certainly been an endemic disease in northern countries since time immemorial; this has been due to a general lack of foods rich in vitamin C. In Great Britain it was sporadic until Elizabethan times. Our indigenous cultivated fruits (apples, pears,

plums and cherries) have never contained much vitamin C and the brassica family (cabbage, kale, cauliflower, Brussels sprouts, etc.) was not cultivated widely until much later. It was, in fact, the arrival of the potato which relieved us from this scourge. The source of this addition of a new staple food to our diet was not, as commonly supposed, the sweet potato which Sir Francis Drake brought back from the West Indies in 1580, but the common potato which arrived unobtrusively from Spain a few years later. The potato is a good source of vitamin C. Before this fortunate occurrence scurvy was a cause of much suffering on land, despite alternative sources of vitamin C in green leaves. If the disease was a danger to those who lived on land imagine its powers in the days of sailing ships during the long voyages when the diet could not possibly contain any fresh food. It was long known as the calamity of sailors and was more to be feared than the wind and the waves. Scurvy has settled many a sea battle more decisively than the guns of the enemy and brought to nought many a voyage of discovery.

3. *Who were Jacques Cartier; James Lind; Takaki; and Eijkman?*

Jacques Cartier, a French navigator, seeking to find new worlds, sailed to Newfoundland in 1535; of his 120 crew 103 developed scurvy and 25 of them died. It is recorded that in these dire straits he was relieved by kindly Indians, who showed him how to make an infusion of "pine needle" as a specific remedy against scurvy. This observation, however, went almost unobserved, and it was two centuries later before James Lind, in his "Treatise on the Scurvy," published in 1753, said: "Fresh fruit and vegetables are alone effectual to preserve the body from this malady." His description of how he

conducted a controlled experiment in one of His Majesty's ships is given in the following words :—

" On the 20th of May, 1747," he said, " I took 12 patients in the scurvy, on board the *Salisbury* at sea. These cases were as similar as I could have them. They all in general had putrid gums, the spots and lassitude with weakness at the knees. They lay together in one place being a proper apartment for the sick in the forehold. . . ."

He went on to say that all had a common diet. Two he ordered a quart of cyder a day ; two others 25 drops of elixir vitriol three times a day ; two others $\frac{1}{2}$ pint of sea water daily; two others a pill of various medicaments; two others had 2 teaspoonfuls of vinegar three times a day; the remaining two had two oranges and one lemon every day. He then says " The consequence was that the most sudden and visible good effects were perceived from the use of the oranges and lemons; one . . . being at the end of six days fit for duty . . . the other . . . was appointed nurse to the rest of the sick. I shall here only observe that the result of all my experiments was that oranges and lemons were the most effectual remedies for this distemper at sea. I am apt to think oranges preferable to lemons, though both given together will be found most serviceable." Shortly after this (from 1795) scurvy was prevented in the British Navy by the regular administration of lime juice to the sailors.

4. *What early observations were made about the relationship of diet to beri-beri?*

The second example is that of the disease called beri-beri ; paralysis and œdema are its main signs. As we know now the disease is due to a diet with an almost total lack of vitamin B_1, or aneurin. It has long been prevalent in Eastern countries and as in the case of scurvy the danger of its occurrence increased at sea. Many years

before the discovery of vitamins Takaki, Director of the Medical Department of the Japanese Navy, suspected that the disease had some connection with food. As a result of experiments in 1882 he was able to abolish the disease from the Japanese Navy by making changes in the diet, which he did not fully understand but which were, mainly by chance, sufficient to introduce a modicum of the vitamin aneurin involved.

5. *What are rice polishings and what is their significance ?*

In 1897 Eijkman, a Dutch physician, medical officer of a prison in Java, discovered that the disease was associated with polished rice ; that is, rice which has been machine milled and the outer layers thereby removed. He noted that not only the inmates of the prison where he worked had beri-beri but that the pigeons who fed off the same rice in the prison yard developed paralysis. He administered the discarded rice polishings to both pigeons and prisoners ; the disease disappeared in both types of gaol bird.

6. *What, broadly, was the extent of our knowledge about the importance of food to health at the turn of the century ?*

With these two exceptions, and the less definite example of rickets, at the end of last century we believed that the chief, if not indeed the only purpose of food was to provide the body with energy for work and warmth, and material for growth and repair. The Encyclopædia Britannica of 1911 defines food as that which " when taken into the body may be utilized for the formation of body tissue and the production of energy." We knew then that food could be divided into PROTEIN, FAT and CARBOHYDRATES, but we ignored the possibility that there might be other substances essential to life and health—MINERALS and VITAMINS, and we did not know that protein itself con-

tained some parts which could be missing with dire consequences.

7. *What was the significance of the experiments made in 1906 by Sir Frederick Gowland Hopkins?*

In 1906 Sir Frederick Gowland Hopkins fed rats on an artificial mixture containing highly purified protein, carbohydrate, water and mineral salts. As a result of this experiment he made the following statement, remarkable for its wisdom and for its prophecy :—

"No animal can live upon a mixture of pure protein, fat and carbohydrate—the field is almost unexplored, only it is certain that there are many minor factors in all diets of which the body takes account. In diseases such as rickets and scurvy we have had for long years knowledge of a dietetic factor but the real errors in the diet are to this day obscure. They are certainly of a kind which comprises minimal qualitative factors."

His experiment showed that a group of rats living on the purified mixture soon stopped growing. A second series of rats living on the same diet with the addition of a trace of fresh milk (itself insignificant in quantity) gained weight, if not normally, at least in marked contrast with the first group. On the eighteenth day the diets were reversed with the result that the first group of rats now began to grow and the second group ceased to grow. Sir Frederick concluded that milk contains what he called an "*Accessory food substance.*" He connected this new knowledge with the previous general observations on beri-beri and scurvy. We know now that the factor concerned in Sir Frederick Gowland Hopkins' experiment on rats was fat soluble vitamin A, present in infinitesimal quantities in the milk. We know that it is one of many accessory food factors, of which several dozen are recognized as vitamins or minerals. The amount which the body needs of the special food substances is so small that

it is not at first easy to see how they could jointly have such an important effect.

8. *What is the relationship of food to the regulation of body processes ?*

From these small beginnings much has followed. The study of food in relation to disease during the past forty years has revealed the existence of a whole series of diseases whose cause had for long past baffled the best brains of the medical and scientific world. But it has done much more than teach us that a bad diet is a cause of disease. We have learnt that such diseases represent extreme forms of dietary deficiencies and that diet means more to man than the mere prevention of disease ; it is now certain that perfect health is still not necessarily present in the absence of such frank diseases. Perfect health, in so far as it depends upon food, can be achieved only when a good mixed diet, well stocked with all the " accessory food factors," is man's daily portion.

9. *For what three main purposes does the body need food ?*

Thus, with the knowledge that has been gained by many years of intensive research on humans and animals, in the laboratory and in the field, by generations of workers in different branches of science, we now have a fair insight into the chemical, biochemical and physiological processes which take place in the body as a result of the food we eat. Broadly, food is needed for three purposes—(1) for growth and repair ; (2) for energy and heat ; and (3) for the regulation of vital processes.

10. *What are the protective foods ?*

The protective foods are those which contain appreciable amounts of the vitamins and minerals—the accessory food substances in Sir Frederick Gowland Hopkins' terminology which protect us against deficiency diseases.

It is not unusual to extend the term also to include the foods which are necessary for growth and repair, thus leaving outside the scope of the term " protective foods " only that class of foodstuff whose function is limited to the production of energy and heat.

11. *What are Nutrients and " Essential Nutrients " ?*

Food, whether it is protective in the sense of being needed for the maintenance of health and the production of good growth and repair, or solely concerned with the production of energy and heat, is a mixture of chemical substances. These chemical substances are often called nutrients because they nourish ; they fall into five main groups—proteins, carbohydrates, fats, mineral elements and vitamins. Those parts or elements in them which are, or contain, the accessory food substances, and therefore upon which the virtue of the protective food rests are called " essential nutrients " because they are in the last resort essential to life or health or both.

CHAPTER II

HOW HEALTH DEPENDS UPON MINUTE AMOUNTS OF SPECIAL SUBSTANCES

(1)

The Regulation of Vital Processes by Vitamins A and D

1. *Why are these two vitamins considered together and named A and D ?*

The two vitamins are grouped together and spoken of almost as twins mainly because they are fat soluble and

occur together in certain vital foods. They are quite distinct in function and structure. Vitamin A is Axerophthol and vitamin D is Calciferol, these being the names given by chemists to the pure substances once they were isolated. It would be much more sensible to use the correct names now that there is no longer doubt as to their chemical composition. The fact that we do not abandon the original designation of vitamins A and D is simply that we are familiar with them. When we could do no more than guess at the existence of some substances with profound effects in minute amounts it was convenient to use the letters of the alphabet. As new discoveries were made new letters were added. Axerophthol happened to be the first vitamin to be detected in a specific foodstuff (Gowland Hopkins, 1906) and hence it received the first letter of the alphabet.

2. *What is the importance of vitamin A to health?*

Vitamin A is essential to growth. You will recall the early experiment with rats in which Sir Frederick Gowland Hopkins showed that the rate of growth depended upon the addition of minute amounts of milk to an otherwise purified diet. Sir Frederick Gowland Hopkins did not realize at the time of his experiment that the missing factor was vitamin A. Vitamin A is also essential to the health of the conjunctiva and cornea of the eye. When vitamin A is almost completely absent from the diet these tissues become dry and thickened (keratomalacia); ultimately blindness (xerophthalmia) can result. These unfortunate happenings are, of course, very rare, but they are most likely to occur in breast-fed babies whose mothers do not get enough vitamin A. A third function of vitamin A is to nourish that part of the retina which is responsible for vision at night; a diet deficient in vitamin A results in night blindness. All the above is well estab-

lished fact ; what follows is more in the nature of conjecture. At one time vitamin A was thought to prevent infection of all sorts. For this reason it was once referred to as the anti-infective vitamin. This has definitely been disproved, but much still supports the view that it is essential for the health of mucous membranes. If this is correct then mucous membranes, in an absence of sufficient vitamin A, tend to dry up, as we have seen earlier the conjunctiva may also ; one result of this is thought to be that these surface linings more easily fall prey to bacterial infection resulting in respiratory diseases, ear and sinus infections, and infections of the alimentary canal.

3. *What is the importance of vitamin D to health ?*

Vitamin D has the power of controlling the deposition of calcium and phosphorus in the tissues ; it is essential to the growth of bones and its absence results in rickets. It is also essential to the maintenance of normal bone structure. As you will recall all tissues are being broken down and built up afresh continuously and thus the adult can be adversely affected by lack of vitamin D just as can be the child ; a shortage of vitamin D in the adult leads to softening of the bones, called Osteomalacia—this is likely to occur during pregnancy. Lady Mellanby has shown that lack of vitamin D is associated with badly formed teeth.

4. *What are the sources of the two vitamins ?*

Vitamin A is found in animal fat (but not lard or vegetable fats) and also in the green and yellow pigments of plants. The yellow pigment is carotene ; when animals, including fishes, ingest carotene they turn it into vitamin A and store the vitamin in the liver and body fats. Liver is very rich in vitamin A, particularly cod's liver ; the older the fish the richer is the store of vitamin A in the

liver. Cod liver and halibut liver extracts are the best supplementary sources of this vitamin.

Vitamin A, or its precursor carotene, is found mainly in milk, cream, butter, egg yolk, liver, green vegetables, and carrots. Variations in vitamin A content occur in the seasons ; the vitamin content of milk, butter and eggs is lowest in the winter and highest in summer and autumn.

Vitamin D is also found in animal fat but, unlike its brother vitamin A, it is not found in plants. Indeed vitamin D is one of the least distributed of the accessory food factors. It is found in cream, butter, egg yolk and liver. The best liver is again that of cod or halibut. Halibut oil contains twelve times as much as cod liver. The amount varies with the season of the year in just the same manner as for vitamin A. Vitamin D differs in another essential from vitamin A, mainly by being manufactured in the skin by the action of ultra-violet light from the sun's rays. The skin contains a fatty substance known as 7 Dehydrocholesterol, which is of a chemical composition little different from vitamin D ; when ultra-violet light falls upon it, 7 dehydrocholesterol becomes natural vitamin D. Not only can the human skin be fortified with vitamin D by the simple action of the sun's rays but also other foodstuffs, in fact, anything containing the fat cholesterol. Thus, the vitamin D content of milk can be increased by exposing it to the ultra-violet lamp.

5. *What is the history of the discovery of vitamins A and D ?*

Night blindness was spoken about in the writings of Hippocrates long before the Christian era, and it was known that it could be cured by eating liver. But the next step was not taken until Sir Frederick Gowland

Hopkins' experiment in 1906 and this only took us as far as some fat soluble substance present in minute amounts in milk which was needed for growth. It was soon shown to be present in butter, cod-liver oil, but not in olive oil or vegetable fats (such as are used for making margarine). Then in 1919 Dr. Steenbock of Wisconsin, U.S.A., discovered that carrots, yellow maize and a number of other plant products contained vitamin A or something like it ; it was seen that the yellower they were the more active they were and their activity turned out to be due to the yellow pigment.

Rickets has also been known from the earliest times to be prevented and cured by sunlight ; for a number of years some relationship between rickets and cod-liver oil was also suspected ; for example, cod-liver oil is mentioned in the Archives of the Manchester Infirmary in 1789. But again we awaited the year 1918 for the next great step forward when Sir Edward Mellanby, working with puppies, found a fat soluble vitamin capable of preventing rickets, in butter, egg yolk and cod-liver oil. This was at first confused with vitamin A since the two vitamins occurred so closely together. However, the following year, another worker, Huldschinsky managed to cure rickety children by exposing them to a Quartz mercury vapour lamp. This showed that ultra-violet light could bring about the same result, and violent controversy began between the two schools of thought. In 1920 Dr. Harriette Chick and her colleagues from the Lister Institute, London, confirmed the fact that the rickety children in starving Vienna could be cured by either cod-liver oil or exposure to sunlight or ultra-violet rays ; she found also that less cod-liver oil was needed if sunlight was also available ; cod-liver oil could prevent or cure rickets even in the absence of sunlight but sunlight was not able to effect a complete cure