Food, Health, Vitamins

BEING A NEW EDITION
OF FOOD AND HEALTH

BY

R. H. A. PLIMMER, D.Sc. (Lond.)
Professor of Chemistry in the University of London
at St. Thomas's Hospital Medical School

AND

VIOLET G. PLIMMER

WITH COLOURED FRONTISPIECE
AND DIAGRAMS IN THE TEXT

NEW EDITION

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PREFACE TO THIRD EDITION

SINCE the last edition of our book, *Food and Health*, there has been so much new research work on the subject of vitamins that in this present edition the text has had to be largely rewritten and extended. The alterations do not mean that the earlier work was inaccurate. but merely that further knowledge of vitamins has nece. ıted some alteration in the general ideas. Some doubtful theories have become certainties, and some apparent disagreements have been reconciled.

Although from the scientific point of view many difficulties have been cleared up, yet to the layman the subject may appear more confusing and intricate. The old fat-soluble vitamin A and water-soluble vitamin B have each been found to consist of two vitamins. The chemical side of the subject has advanced so far that scepticism of the existence of vitamins now simply denotes ignorance.

From the practical point of view the subject has not changed so greatly. The good vitamin foods still remain the good vitamin foods. The chart and diagrams have been altered to represent more exactly the newer knowledge. An extra chapter has been added dealing with special diets, as we have frequently been asked about these points.

Objection has sometimes been made to our reference to certain proprietary foods. These foods are in constant use in scientific investigations. Their mention by name has been absolutely necessary so that readers can procure them without continual reference to us for information.

A change has been made in the title : partly to make it clear that the subject-matter deals mainly with the question of the supply of vitamins in the food ; and partly because we seem to have struck upon a hackneyed title which has been used both previously and subsequently to our choice of it for the first edition.

R. H. A. P.
February, 1928. V. G. P.

PREFACE

THIS small book is an attempt to explain concisely the principles which should guide the selection of food and to point out which foods should be eaten and why others should be avoided. It has developed out of several other short accounts which we have written and in response to a demand for a shorter version of our book on *Vitamins and the Choice of Food*, which gives the history of the discovery of the vitamins and the experimental work in greater detail. The subject matter was arranged for a series of lectures promoted by Miss Olga Nethersole, R.R.C., Founder and Honorary Organiser of the People's League of Health, and a desire was expressed for their publication.

Scientific and technical terms cannot be entirely avoided, but they are very few in number and are not too difficult for the general reader. Complaints have been made in the daily press that such words as *vitamin* or *protein* are too complicated and that scientific people cannot express themselves in simple language. The complaint should really be on the other side, that the public and the press do not trouble to learn a few special terms relating to food, though they pick up without effort a large number of technical terms dealing with wireless, motor cars, athletics and dress.

The diagram of " A Square Meal " was first published in the pamphlet, *What we should eat and why*, written for the People's League of Health. The idea was developed and used in an article in *The Practitioner*, January, 1925, to demonstrate the errors in the common everyday diet. These diagrams are again made use of here in a slightly different form.

R. H. A. P.
March, 1925. V. G. P.

Messrs. Longmans & Co. are indebted to the proprietors of *The Practitioner* for their courtesy in allowing these diagrams to be re-drawn for this book.

CHAPTER I

CIVILISATION AND THE CHANGES IT HAS MADE IN OUR FOOD

FOOD has gradually undergone great changes since those primitive days when man subsisted precariously like a wild animal upon fruits, seeds and roots, varied occasionally by a lucky find of honey or eggs, or by the trapping of fish and small animals. As his ingenuity and skill in making weapons developed, he was able to kill larger animals. At first all food was eaten raw, but later, he learned how to make fire to warm himself and discovered that some foods, if cooked, were more palatable and digestible. With the help of simple tools he began to till the ground and sowed the seeds of his favourite food plants. Man was thus no longer dependent upon chance but could lay up stores of grain until the next seed-time. Instead of relying upon the uncertainty of hunting for his supply of meat, he tamed and bred animals and birds to provide meat, milk and eggs. When his crops had exhausted the land, he removed with his flocks and herds to cultivate another part.

In this way man's food supply became more assured, but in Northern climates, such as our own, the winter was a difficult time, especially after a bad harvest. There was not enough pasture for the flocks during the cold months, so that the number of beasts had to be limited and only a few of the best stock were kept for breeding purposes. In the autumn most of the animals were killed and their flesh was salted or smoked and dried for winter use. The people did

not thrive upon their salted and dried rations and there was much scurvy in the Middle Ages, especially in London, and it was sometimes called "the London disease." The nobility and Lords of the Manor had their dovecots and game preserves to provide themselves with fresh animal food during the winter.

As our sailing ships made longer voyages, occasional raids and exploratory expeditions gave place to regular over-seas trade, which led to changes in the home food supply. New customs were introduced from abroad. Foodstuffs grown in warmer climates were imported and foreign plants were brought home and successfully cultivated. The custom of eating green salads was introduced by Catherine of Aragon, wife of Henry VIII. She had to import a Dutch gardener, as salad-growing was an unknown art in this country and up to the present day green salads have never been as popular here as they are on the Continent.

It is the common belief that Sir Walter Raleigh brought home the potato plant in Elizabethan times, but it was some centuries before potatoes were extensively used for human food. They were looked upon as pig food and were only eaten by people who were destitute.

The cultivation of oranges was introduced into the Mediterranean countries by the Portuguese in the sixteenth century. This attractive fruit was soon after brought to England and made a valuable addition to the monotonous winter fare.

The planting of root crops, such as the turnip, dates in this country from the middle of the seventeenth century. This was an important innovation, as large numbers of animals could now be fed through the winter on turnips and hay and it was no longer necessary to kill off most of the animals in the autumn. More livestock was kept and consequently more meat was eaten.

From the middle of the seventeenth to the middle of the

nineteenth century, it may be said that the quality of the food in this country was at its best. Agriculture had so far advanced that there was a good supply of home-grown food, pleasantly varied by the importation from abroad of spices, nuts and fruits like the orange and lemon. Most of the food eaten was fresh and free from the baneful influences imposed later by our mechanical, chemical age. The perfect spacing and freedom from decay in the teeth of our ancestors of this period testify to the satisfactory nature of their food and is in marked contrast with the teeth of the present generation which are overcrowded and begin to decay very quickly.

The nineteenth century saw great changes in the kind of foodstuffs used in most parts of the world. These changes took place so gradually and insidiously that elderly people seem quite unaware of the alteration in the food which has taken place during their lifetime. They cannot understand the present agitation about our food and say, "We never worried about vitamins when we were young and we did very well without them." They do not realise that they did so well because they were fed upon relatively natural foodstuffs which had not had their vital elements removed, or destroyed by commercial processes. Babies were not then reared on bottles; they were suckled by their mother, or a wet nurse.

Not so very long ago sugar was a rare luxury kept under lock and key in the tea caddy. At the end of the eighteenth century the manufacture of beet sugar was begun in Germany and the industry developed rapidly and lowered the price of sugar. Its consumption has increased enormously and is still increasing in all civilised countries. The Americans, with their love of candy, are the largest sugar eaters in the world. Incidentally, cancer and diabetes, two scourges of civilisation, have increased proportionately to the sugar consumption.

The sugar factory was the thin end of the wedge. Pre-

viously food and factories had had nothing to do with each other, but now many artificial processes are interposed between man and the plants and animals from which his food is derived. A modern provision shop is filled with packets and tins branded by a factory. *We do not know what has been added to or taken away from our food.* Mummified preparations are vividly dyed to simulate the green freshness of plants, the red or yellow of fruit juices, the golden colour of butter and eggs.

Cereal foods have suffered most severely since the introduction of machine-milling about 1870. Formerly the staple cereal of the East, rice, was pounded by hand and in this country our wheat was coarsely stone-ground at the local mill and only part of its bran removed. Wellington's soldiers were famous for their fine figures and good looks, yet the food they ate would be scorned nowadays. They received one pound of wheat per day. They ate the whole grain as it was issued, or if time allowed they pounded it up and made a coarse bread. They were allowed a few ounces of wholemeal flour weekly. During the Peninsular War they were dependent for their meat supply upon any goats they might chance to catch in the mountains. What a contrast to the white flour and tinned meat and vegetable ration of modern armies on active service !

The modern machine-mill with its steel rollers removes all the bran and germ from the grain, so that we eat only the innutritious core of the seeds of wheat, rice, barley and maize. Owing to a difference in the structure of the seeds, rye and oatmeal suffer less damage.

During the nineteenth century our population increased greatly and following the invention of machinery we became a manufacturing people living in towns instead of an agricultural people producing its own food. At the beginning of the century the corn was home-grown, at the end of the century most of the corn and other foodstuffs came from

abroad. Many changes in the nature of our food have arisen from the impracticability of importing perishable materials from the other side of the world. White cereals and sugar travel well, and fruits are carried without risk of going bad, if bottled, canned, dried or preserved as jam. For the same reason, meat, fish, vegetables and milk are canned, or dried. Some foodstuffs are preserved by chemicals, others come over in cold storage. These chilled foodstuffs more closely resemble the fresh material in nutritive value, if they are not kept indefinitely in cold store.

Towards the end of the last century uneasiness was caused by the discovery of bacteria and the manner in which infectious diseases were carried. We felt ourselves exposed on all sides to the attack of malevolent germs and parasites. The most easy entrance of bacteria into the body was obviously with our food, and we were cautioned against eating any raw foods, such as oysters, salad or fruit. The whiteness of our cereal foods received an added glamour as whiteness typified cleanliness and freedom from germs. Brown cereals were looked upon with suspicion. The pasteurisation of the milk supply in towns lowered the infant death rate from summer diarrhœa and the sterilisation of foodstuffs at first sight appeared to be a means of escape from many illnesses.

During the last twenty-five years the subject of food and nutrition has been most carefully investigated, not only by the bacteriologist, but particularly by the physiologist and bio-chemist. Formerly it was chiefly a matter of opinion which foods were good and nourishing and which were indigestible or harmful. No exact data were available. The choice of food was, and still is, governed mainly by convenience and individual tastes.

The subject of nutrition is now a science based upon ascertained facts and measurements. The knowledge gained by scientific research is available for general use and although it is by no means complete, yet enough facts are known to

afford a reliable guide to the choice of proper food. Feeding experiments have shown that in man and animals, the perfect growth of the body and its resistance to disease depend more largely upon food than on any other hygienic factor. A well-nourished body is a good protection against infection by germs, or by larger parasites like intestinal worms. The sterilisation of foodstuffs has been found to destroy a great deal of their nutritive value.

Civilised man has no instinct for choosing the right kind of food ; his likes and dislikes are not a reliable guide amongst the overwhelming abundance of artificial products which are offered to him. If we want to find races with splendid physique and health, we must look in those out-of-the-way corners of the world where geographical isolation or religious restrictions have caused the natives to adhere to the primitive diet of their forefathers—wholemeal flour, seeds, fruits and vegetables, often eaten raw with a good deal of milk and butter and little or no meat. On this diet they are healthy and live to an active old age. They do not suffer from the diseases of civilisation—constipation, indigestion, gastric and duodenal ulcers, gall stones, appendicitis, colitis, rheumatism, cancer and diabetes—although they live under very insanitary conditions and may be exposed to damp and extremes of heat or cold. European settlers amongst these natives are much better housed and washed, but suffer from the diseases enumerated above and die with tragic frequency from cancer. Doctors, who have worked for many years in such districts, have concluded that the good condition of the natives and the diseased state of the Europeans can only be explained by the difference in their food. The Europeans are not content with the native food grown locally, but import white cereals, tinned foods and sugar. If the natives adopt the same diet as the Europeans, they suffer from the same diseases and no longer have perfect teeth.

Nowadays our cattle, sheep and poultry are fed upon

sophisticated food-stuffs and it has been proved that the nutritive value of the milk and fat from these animals is nothing like as good as that from animals at grass or allowed free range. Even our fields receive artificial manures and it may well be that the grass and corn raised on chemical manures will prove to be less nourishing than those from naturally manured fields. An investigation by Col. R. McCarrison, I.M.S., in this connection showed the superiority of " natural " over " artificial " manures in influencing the nutritive and vitamin B value of food grains.

Machines and chemicals have brought us into a dangerous position as regards our food supply, but as we now realise our predicament it should not be a difficult matter to rectify our mistakes.

CHAPTER II

FOOD : ITS PURPOSE AND NATURE

FOOD has two distinct purposes. The greater part is burned up to keep the body warm and give it energy for movement, and never becomes part of the living tissues. It is burned like the coal in the fire of the steam engine. The harder the work, the more fuel or food is wanted. The foodstuffs which are burned up to give warmth and strength for work are called *the fuel foods*. The fuel foods are all kinds of fat, starch and sugar. Only a small quantity of the food enters into the intimate structure of the body to replace worn-out body substance and to provide new material for the growth of the young child or animal. Meat, fish, eggs, cheese or milk are the essential body-building foods.

The amount and kind of food required varies according to age and occupation. The growing child needs a larger proportion of building material than the grown man. A man engaged in hard manual work requires more fuel than the sedentary clerk. A woman whose time is spent on heavy housework, or on athletic games, wants plenty of fuel foods. The expectant, or nursing, mother has especial need for body building material. The healthy child with its ceaseless activity and steady growth demands a generous supply of both fuel and building materials.

Exposure to cold involves loss of body heat and more fuel must be burned to replace the loss. An elderly invalid needs little food, bedclothes and hot bottles prevent loss of heat and not much energy is spent on movement.

Physiologists by means of the apparatus called a calorimeter have measured exactly the output of energy and loss of heat by a man, woman or child at rest and under different conditions of work and temperature, and can calculate exactly the amount of fuel food required. This information is of the utmost value for estimating the quantity of food which must be provided for the feeding of large numbers of people, as for an army or navy, or rationing a nation. In ordinary life the appetite is a fairly reliable guide to the quantity of fuel food required, and the more muscular work or the colder the weather, the larger is the appetite.

The appetite is no guide to the right kind of food to eat, and as man has no natural instinct to help him, food cannot be correctly chosen without special knowledge. Reliable information of the value of various foodstuffs is now available and the selection of food should no longer be left to convenience and the random guidance of individual tastes. In this over-civilised country it is so much easier to eat the wrong kind of food. A certain amount of pertinacity and effort are necessary to secure really nourishing foods.

A complete diet contains six classes of substances which are essential for life :—

(1) *Carbohydrate.* This word stands for every kind of starch and sugar. One inclusive term saves the continual repetition of a whole string of names of the foods of this class.

The flour of wheat, rye, maize (cornflour), oatmeal, barley meal, barley, rice, sago, tapioca, arrowroot, custard powders, patent breakfast cereals, sugar, treacle, syrup, honey, jam are mainly composed of carbohydrate.

Potatoes and bananas consist largely of starch. Fruits and many vegetables contain sugar.

During digestion starch is converted into sugar. All carbohydrates are therefore of the same value in nutrition.

(2) *Fat.* This term includes all edible oils and fats, such as meat fat, dripping, lard, bacon fat, butter, margarine,

olive oil, cotton seed oil, cod liver oil, nut butters.

(3) *Protein.* This term includes the lean of all kinds of meat: beef, mutton, veal, pork, chicken, game and also fish. It forms an important part of cheese, milk and eggs. The use of the term *protein* again saves the frequent repetition of a number of names. Protein is the chief body-building material, and differs from carbohydrate and fat in that it contains nitrogen.

(4) *Mineral Salts.* By this term is generally understood table salt, or the daily dose of some aperient salts. Chemically speaking both these are salts, but the term has a wider meaning and includes the mineral material in the foods. Salts are the ash which remains on burning food or coal; they are the unburnable part of the fuel. The ash of the coal fire is just so much waste material, but the ash of our food contains mineral salts which are essential for life. They dissolve in the fluids of our body and play a vital part in regulating the work of different organs. If certain of these salts are absent from the food, the heart will cease to beat. The red colour of the blood cannot be formed without iron salts, nor the secretion of the thyroid gland without salts containing iodine. Lime salts and phosphates are required for the hardening of bones and teeth.

All these mineral salts will be provided if the diet is well mixed, that is, contains a variety of foodstuffs. The heating, tinning, bottling or ageing of foodstuffs does not harm the salts, but they are removed from our food in the milling of grain to make white flour and white rice. A diet consisting largely of these white cereal foods will not provide all the necessary mineral salts.

(5) *Water.* Most of our foodstuffs contain water. In this country there is seldom any shortage of drinking water. The amount taken is according to individual taste. From four to six pints of water, including other fluids, should be taken daily to flush the body and wash away waste material

which otherwise will accumulate and poison the system. Sufferers from rheumatism go to " watering " places where the chief part of the treatment consists in drinking very large quantities of saline water. The cure may be attributed as much to the cleansing action of water upon the tissues, as to any special value of the dissolved salts. Another advantage of copious water drinking is that it lowers the blood pressure which in many middle-aged and elderly people is too high.

(6) *Vitamins.*[1] This term is now frequently used in advertisements of patent food preparations and is therefore not unfamiliar. As the name implies vitamins are chemical substances of vital importance. At least five vitamins have been clearly distinguished and there appear to be others. For simplicity the vitamins are called A, B, C, D and so on. If any one of them is absent from the food for three or four months, death is the result. One vitamin cannot be substituted for another in the same way as one carbohydrate can be replaced by another, or one fat by another. Oatmeal can be used instead of rice, olive oil instead of lard and in the case of proteins, cheese can replace meat, but each vitamin must be considered individually.

Each vitamin is present in very small quantities in different foods and thus they are difficult for the chemist to extract. The comparative vitamin value of the various foods can only be ascertained by means of feeding experiments on animals, or in the case of human beings by practical experience.

The expression " vegetable salts " is often wrongly used and really refers to vitamins and not to salts. From the chemical point of view salts are all of the same character, whether they are vegetable salts or mineral salts. Vitamins are not mineral salts because they are destroyed by processes which leave the mineral salts unharmed. Vitamins are not vegetable salts because the concentrated preparations of the

[1] The word is derived from *vita* = life, and should be pronounced *vy-ta-min* and not *vitta-mine.*

vitamins, which have been prepared, do not possess any of the characters of a true vegetable salt. The vitamins and the salts are present in the same part of the animal or plant and may be removed together as in the milling of grain, or in the cooking of vegetables, hence the confusion.

The heating, ageing and drying of foods has a harmful effect upon some of the vitamins and they are destroyed by certain chemicals (see p. 106). These processes do not affect the vegetable salts.

One of the most important facts about vitamins is that they cannot be made in the human body and must therefore be supplied in the food. They are produced in plants and vitamins found in animals have come from the plant food. Vegetarians have one advantage over meat-eaters, that they get their vitamins direct from the plants.

Very few foodstuffs contain all the vitamins ; some are particularly rich in vitamin A or D, while others supply B_1, B_2, or C.

Vitamin A is generally found in all the animal fats, except lard, and in green vegetables.

Vitamin B or B_1 is found chiefly in the seeds of plants, and in the eggs and internal organs of animals.

Vitamin PP or B_2 is in meat and is found together with vitamin B_1 in yeast, wheat germ and some other foods.

Vitamin C is in fresh fruits and vegetables.

Vitamin D usually occurs associated with vitamin A in most animal fats.

The chemical substance ergosterol taken in the food can be converted into vitamin D in the body by the action of ultra-violet light.

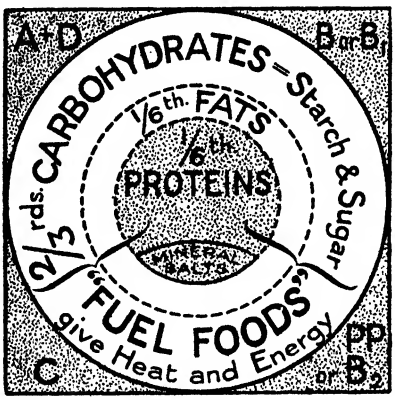
Vitamin E, like vitamins A and D, also occurs in fats, but is present in some vegetable oils which do not contain these other two vitamins.

Each vitamin, its distribution and properties will be considered in separate chapters.

Under modern conditions of life the vitamins may be unintentionally omitted from the diet, or consumed in insufficient amounts. It is our purpose to show how this may happen and how it may be avoided.

For practical purposes the easiest way in which to represent a complete diet is in the form of a diagram which we have called " A Square Meal." It is illustrated in fig. 1 and in the middle of the frontispiece.

FIG. 1



" A SQUARE MEAL "

The large circle represents the bulk of the food, the fuel foods, which consist of carbohydrate (starches and sugars) with a moderate quantity of fat. To a considerable extent the proportion of fat to carbohydrate can be varied without ill-effect, but too high a proportion of fat may upset the digestion.

The ordinary proportion is two-thirds carbohydrate to one-sixth fat, *dry* weight. Dry weights and the quantities of protein, fat and carbohydrate in foods are given on page 114.

Protein is essentially building material, but also serves as fuel. The proportion of protein should be about one-sixth of the diet, *dry* weight.

The mineral salts are also included in the central part of the diagram.

The shaded parts of the diagram represent those food constituents which serve some special purpose in the life of the animal. The white parts represent the two constituents which are used purely as fuel.

To make a "square meal" four corners must be added. In the diagram the corners are marked respectively A + D, B or B_1, PP or B_2, and C, showing how they must be filled by the vitamins to make a complete daily diet. For easy remembrance we may think of the A + D corner as coloured yellow, because the fats containing these vitamins are generally yellow. The B or B_1 corner is coloured brown to represent the wholemeal cereals which are brown. The C corner is coloured green, like the growing plant, which gives us fresh fruits and vegetables. The corner PP or B_2 is red, because this essential is found in the lean of meat.

In the frontispiece the diagram of the square meal is set within a large square subdivided into four sections so it can be seen at a glance which articles of food must be provided to fill each corner. If the corners are suitably filled and the appetite satisfied with these good foods, the diet will be well balanced.

Many foodstuffs in common use do not contain vitamins. Lists of these poor foods are shown at the sides of the square. They are placed for comparison outside the main square in line with the foods which contain the different vitamins. The food constituents of any meal can be checked against this standard diagram (frontispiece) to see how closely each meal, or the day's food as a whole, approaches to "squareness." Consider a simple meal of bread and butter, meat and some green salad. The bread supplies carbohydrate

(=starch), the butter supplies fat, the meat gives protein, and mineral salts are contained in the bread, meat and salad. If enough of these foods be eaten to satisfy a normal appetite, fuel for warmth and energy will be provided and also building material for growth and repair. The circle is thus properly filled.

To test the "squareness," each corner must be considered in turn. A + D are supplied by the butter, meat fat and green salad. The salad also supplies C. B will not be provided in sufficient amount and the meal will not be square unless the bread is wholemeal, as none of the other three foodstuffs supply this vitamin. The lean of the meat provides PP or B_2.

Wholemeal bread, butter, meat and green salad thus constitute a satisfactory diet. If a meal is really "square," it may safely be taken day after day. Variety is pleasant and the meal can be varied in an infinite number of ways without upsetting its "squareness" by changing one B food for another B food, one C food for another C food, and meat can be replaced by fish, cheese or eggs. If attention is paid to the corners, and the quantities provided satisfy the appetite, the diet will be found to be satisfactory, provided that there is a reasonable proportion between the amounts of butter, bread and meat.

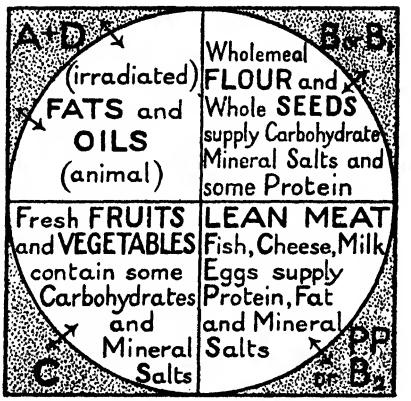
Some foodstuffs appear on the lists in more than one corner. Milk is in its natural state a "square meal" for the infant, but for the adult needs to be supplemented by foods from each corner.

Eggs are in the yellow, brown and red corners, and with the addition of potato from the green corner make a satisfactory "square meal."

Another simple way of classifying foods is to think of them as belonging to one or other of the four following groups :—

(1) Fats and oils, as typified by butter.
(2) Cereals, as represented by bread.
(3) Lean Meat and its alternatives, fish, cheese or egg.
(4) Fresh Fruits and Vegetables.

FIG. 2



The four Main groups of Foodstuffs and the essentials which they supply.

Fig. 2 represents the "Square Meal" in this form and shows what each group contributes to the diet as a whole.

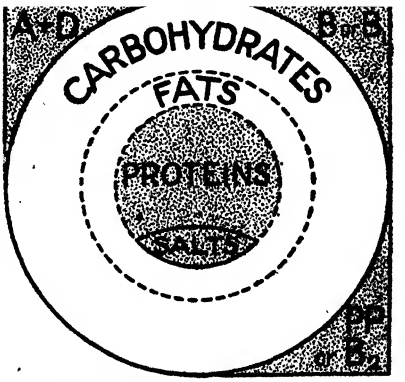
CHAPTER III

VITAMIN C AND SCURVY: THE NEED FOR FRESH FRUITS AND VEGETABLES

THE need for fresh fruits and vegetables was realised centuries before scientists discovered vitamins. If fresh fruits and vegetables are omitted from the diet, the dreadful disease scurvy follows. The protective substance in these fresh fruits is now known as vitamin C, this name having been given to bring it into line with vitamins B and A. It is easy to remember the connection C and SCurvy, B and Beri-Beri. In scurvy the C corner of our Square Meal is missing as in Fig. 3.

In former days scurvy was prevalent in this country during cold winters. Sailors on long voyages suffered severely from it. Consequently it was believed to be caused by exposure to cold and wet. There were thousands of deaths from this disease every year. The heavy mortality from scurvy nearly prevented the completion of Vasco

FIG. 3.



A diet without vitamin C leads to SCURVY.

da Gama's voyage of discovery in 1498 round the Cape of Good Hope ; he lost 100 out of 160 men from scurvy. In some of our wars in the past more men died from scurvy than from wounds, and even during the last war there were cases of the disease amongst our troops and particularly amongst the Indian troops in Mesopotamia.

Scurvy, though rare nowadays in Western Europe, is still common in Northern Russia. Scurvy is not uncommon amongst bottle-fed infants.

Popularly and wrongly believed to be a skin disease, scurvy is really a disease of the whole system, as will be made clear by an account of the chief symptoms. The complexion becomes pale and sallow. There are acute pains in the joints. Swellings in the limbs are caused by bleeding under the flesh. A general weakness of the walls of the blood-vessels is also shown by nose bleeding, the appearance of purple spots and marks like bruises on the skin, bleeding of the gums and other symptoms. The breath is most offensive and the teeth are buried by spongy swellings. The teeth become loose and fall out and the bones may fracture spontaneously. Unless the progress of the disease is checked, it ends fatally.

A timely change of diet works the most remarkable cure even in apparently hopeless cases, as illustrated by the following account taken from Lind's treatise on scurvy (1757).

"A sailor in the Greenland ships was so over-run and disabled with scurvy, that his companions put him into a boat and sent him on shore, leaving him there to perish without the least expectation of recovery. The poor wretch had quite lost the use of his limbs; he could only crawl about the ground. This he found covered with a plant which he, continually grazing like a beast of the field, plucked up with his teeth. In a short time he was by this means perfectly recovered, and upon his returning home it was found to be the herb 'scurvy grass.'"

Equally dramatic are the cures effected by orange juice in infants suffering severely from scurvy.

In the eighteenth century several valuable books were written dealing with this disease. The medical name for scurvy is *scorbutus* and the fruits and vegetables which cure the disease are called *antiscorbutics*. The most famous English work on scurvy was by Lind. He tried to convince his own generation by making the first exact experiments upon the curative value of different reputed antiscorbutics. He tested all the best-known remedies upon men who were suffering from scurvy and found that by far the most active was orange or lemon juice. Either of these caused rapid improvement. Lind in his day found that traditional beliefs were as difficult to combat as we find them now, for he wrote :

" Some persons cannot be brought to believe that a disease so fatal and dreadful can be prevented or cured by such easy means. They would have more faith in some elaborate composition, dignified by the title of an antiscorbutic golden elixir, or the like.

" Facts are sufficient to convince the unprejudiced.

" It is no easy matter to root out old prejudices or to overturn opinions which have acquired an establishment by time, custom and great authorities."

Captain Cook made use of the information gained by Lind and was successful in maintaining good health and freedom from scurvy on his long voyages of discovery.

Lind knew one other very important fact about the prevention of scurvy and that was the uselessness of dried vegetables as a substitute for fresh ones. Since his day, however, there have been some flagrant examples of ignorance of this fact. In the American Civil War dried vegetables were plentifully provided and did not prevent scurvy. Dried vegetables have been repeatedly tried in the British Navy and found useless, yet in spite of all this evidence the

British public during the recent war were asked to send dried vegetables to our fleets and prisoners of war.

One other fact in the history of scurvy must be remembered. Scurvy was eliminated from our Navy by the issue in 1795 of 1 oz. of lemon juice per man per day. A ration of $\frac{2}{3}$ oz. per day had previously failed to prevent scurvy. The fruit used at this time was the ordinary lemon, but the juice was called "lime" juice, hence the reputed value of lime juice as an antiscorbutic. Towards the middle of the nineteenth century, instead of the Mediterranean lemon the Navy used the juice of the West Indian lime, that is the real lime, and it proved a failure as an antiscorbutic. Lime juice has been tried in various arctic expeditions and has never been a success.

The value of fresh fruits and vegetables as part of the diet was pointed out again and again by distinguished medical men during the nineteenth century, but even now it is not sufficiently realised that dried fruits and vegetables cannot take the place of fresh ones.

Captain Cook noticed symptoms of scurvy in goats and sheep after they had been several months on board ship. Pigs also suffer from scurvy, but it is remarkable that certain animals, such as rats, cats, and birds do not get this disease even when their food contains no antiscorbutic. Some recent work has shown that the livers of rats and birds contain vitamin C, although their food has not contained this vitamin. These animals must therefore have the special faculty of making vitamin C from some other substance in the food, possibly from vitamin B.

Our recent knowledge of the cause and prevention of scurvy dates from 1907–1912, during which period two Norwegian experimenters, Holst and Frölich, were studying the cause of outbreaks of so-called "ship beri-beri" in Norwegian sailing ships. This disease turned out to be a combination of scurvy and beri-beri. The value of their

observations was at first overlooked and it was only during the stress of the War, when scurvy broke out amongst our troops, that their work was appreciated.

Further investigations on the same lines were carried out by Dr. Harriette Chick and her colleagues at the Lister Institute in order to find out the most efficient antiscorbutic for Army use.

Holst and Frölich had discovered that the guinea-pig if kept upon a diet of oats, or bread, and bran and water, died in about twenty-one days showing symptoms like those of scurvy in man. If fresh vegetables were included in the diet, the guinea-pigs grew and lived quite normally and showed no signs of the disease.

The guinea-pig proved to be a very useful animal for the purpose of testing the antiscorbutic value of different fruits and vegetables and making a standard of comparison. The antiscorbutic value of a number of fruits and vegetables, together with the effect upon them of cooking, drying, ageing and of various chemicals has now been examined, using the guinea-pig, or occasionally the monkey, as the test animal. We now know the least or *minimal* daily quantity of many fruits and vegetables which is required to prevent scurvy. These values, together with the calculated figures for man's requirements, are put together in the tables on page 22.

The figures for man have been calculated from the guinea-pig figures by using the old observation in the Navy that 1 oz. of lemon juice daily prevented scurvy in the men, while $\frac{2}{3}$ oz. was insufficient. Man's requirements are therefore twenty times as great as those of the guinea-pig. According to Hess the infant requires ten times as much as the guinea-pig, that is, half as much as the adult.

TABLE 1

The Vitamin C Value of Fruits

Minimum Daily Quantity to Protect from Scurvy

	Guinea-Pig		Man	
	Weight in grams	ounces	grams	ounces
Lemon, fresh juice	1.5	$\frac{1}{20}$	30	1
Orange, fresh juice	1.5	$\frac{1}{20}$	30	1
Tomato, fresh juice	2.0	$\frac{1}{15}$	40	$1\frac{1}{2}$
Pineapple, fresh juice	2.5	$\frac{1}{12}$	50	$1\frac{3}{4}$
Pineapple, pulp	9.0	$\frac{3}{10}$	180	6
Peach juice	3.0	$\frac{1}{10}$	60	2
Peach pulp	6.0	$\frac{1}{5}$	120	4
Lime, fresh juice	5.0	$\frac{1}{6}$	100	$3\frac{1}{2}$
Strawberry	3.0	$\frac{1}{10}$	60	2
Apple	10.0	$\frac{1}{3}$	200	$6\frac{2}{3}$
Banana	10.0	$\frac{1}{3}$	200	$6\frac{2}{3}$
Grapes . . more than	20.0	$\frac{2}{3}$	400	$13\frac{1}{3}$

TABLE 2

The Vitamin C Value of Vegetables

Minimum Daily Quantity to Protect from Scurvy

	Guinea-Pig		Man	
	Weight in grams	ounces	grams	ounces
Spinach	1.0	$\frac{1}{30}$	20	$\frac{2}{3}$
Cabbage	1.5	$\frac{1}{20}$	30	1
Green Peas	2.0	$\frac{1}{15}$	40	$1\frac{1}{3}$
Swede Turnip	2.5	$\frac{1}{12}$	50	$1\frac{2}{3}$
Runner Beans	5.0	$\frac{1}{6}$	100	$3\frac{1}{3}$
Potato, less than	10.0	$\frac{1}{3}$	200	$6\frac{2}{3}$
Carrot, young less than	10.0	$\frac{1}{3}$	200	$6\frac{2}{3}$
Carrot, old, less than	35.0	1	700	20
Vegetable Marrow, young	12.5	$\frac{5}{12}$	250	$8\frac{1}{3}$
Vegetable Marrow, old	37.5	$1\frac{1}{3}$	750	27
Sweet Potato	13.2	$\frac{1}{2}$	260	10
Beetroot . more than	20.0	$\frac{2}{3}$	400	$13\frac{1}{3}$
White Turnip . less than	50.0	$1\frac{2}{3}$	1000	$33\frac{1}{3}$

TABLE 3

EFFECT OF COOKING AND PRESERVING UPON THE VITAMIN C VALUE OF FRUITS AND VEGETABLES

Minimum Daily Quantity to Protect from Scurvy

	Weight in grams	*Guinea-Pig* ounces	*Man* grams	*Man* ounces
Cabbage, raw	1.5	$\frac{1}{20}$	30	1
cooked 20 mins.				
cooked 1 hr.	15.0.	$\frac{1}{2}$	300	10
cooked with soda	No antiscorbutic value			
canned, less than	7.5	$\frac{1}{4}$	150	3–5
Potato, raw, less than	10.0	$\frac{1}{3}$	200	$6\frac{2}{3}$
cooked 15 mins.	10.0	$\frac{1}{3}$	200	$6\frac{2}{3}$
cooked 1 hr., more than	15.0	$\frac{1}{2}$	300	10
Milk, fresh raw, variable	100.0	$3\frac{1}{2}$	2000	70 = $3\frac{1}{2}$ pts.
boiled 3 mins.	100.0	$3\frac{1}{2}$	2000	70
dried or condensed[1]	100.0	$3\frac{1}{2}$	2000	70
Orange, raw juice	1.5	$\frac{1}{20}$	30	1
boiled 1 hr.	3.0	$\frac{1}{10}$	60	2
marmalade	No antiscorbutic value			
canned	1.5	$\frac{1}{20}$	30	1
Tomato, raw juice	2.0	$\frac{1}{15}$	40	$1\frac{1}{2}$
boiled 5 mins.	5.0	$\frac{1}{6}$	100	$3\frac{1}{3}$
boiled 1 hr.	10.0	$\frac{1}{3}$	200	$6\frac{2}{3}$
canned juice	8.5	—	—	—
„ „ after 4 yrs.	10.0	$\frac{1}{3}$	200	$6\frac{2}{3}$
Lime, raw juice	5.0	$\frac{1}{6}$	100	$3\frac{1}{3}$
preserved juice	No antiscorbutic value			
Apple, raw	10.0	$\frac{1}{3}$	200	$6\frac{2}{3}$
baked or as sauce	No antiscorbutic value			
canned, old process	No antiscorbutic value			
canned, improved „	10.0	$\frac{1}{3}$	200	$6\frac{2}{3}$
Peas, green raw	2.0	$\frac{1}{15}$	40	$1\frac{1}{3}$
boiled 20 mins.	5.0	$\frac{1}{6}$	100	$3\frac{1}{3}$
canned & reheated	3.0	$\frac{1}{10}$	60	2
dried	No antiscorbutic value			
dried & sprouted, less than	5.0	$\frac{1}{6}$	100	$3\frac{1}{3}$
dried, sprouted & boiled 20 mins.	20.0	$\frac{2}{3}$	400	$13\frac{1}{3}$
Dried fruits[2]	—	—	—	—

[1] Sweetened condensed milk prepared at a low temperature and *in vacuo* is equal in antiscorbutic value to fresh milk; unsweetened condensed milk is frequently heated to a higher temperature, and so loses about half its Vitamin C.

[2] With possible exception of dried peaches which may have a slight value.

Only after a consideration of these tables can it be realised how much of each fresh fruit or vegetable must be eaten to fill the C corner of the "Square Meal." Several of the fruits stand out pre-eminently—the orange, lemon and raw tomato. Other raw fruits, such as the apple and banana, are very poor in comparison. If no other antiscorbutic food is eaten, the figures show that at least two apples, or two bananas, must be taken daily. The most disappointing of the fruits is the grape. The fresh lime has some antiscorbutic value, but is not nearly as good as the lemon and it failed to prevent scurvy in the Navy and in arctic expeditions, because it was given in too small quantities.

Raw cabbage and spinach are very good and in the same class must be included lettuce, watercress, and other green salads.

It is very curious that there is so much difference amongst the root vegetables; swede is good and turnip and beetroot poor; carrot and potato are intermediate.

Other differences in fruits and vegetables can be easily made out from a study of the Tables.

Table 3 gives the results of the experiments which were made to test the effect of cooking upon the vegetables. In every instance the cooking has a harmful effect upon this vitamin, the longer the cooking the greater the damage. Boiling for a short period is less harmful than slow cooking at a lower temperature. Cooking after the hay-box fashion and stewing are the worst ways of treating vegetables. Twice cooking destroys all the vitamin C, hence mashed and fried potatoes, made from left over boiled ones, are valueless as a source of this vitamin.

A common practice is to add soda or bicarbonate to vegetables during cooking to retain their green colour. Soda and other alkalies are fatal to this vitamin. There is no need to add soda, as vegetables cooked for a short period, not more than twenty minutes, keep their green colour, have more

flavour and also retain much more of this vitamin than those cooked for longer periods.

Oranges, tomatoes and lemons are more resistant to heat than green vegetables (see Table 3). Hot water used in making lemonade is not harmful to the vitamin. Jam, which is made by the prolonged boiling of fruit, does not contain vitamin C. The process of making marmalade has been found to destroy the antiscorbutic value of oranges.

On account of the sensitiveness of this vitamin to the ordinary household methods of cooking, canned fruits and vegetables have usually been regarded as valueless as a source of vitamin C. There is, however, evidence that canned fruits and vegetables, if prepared with certain precautions, are equivalent in vitamin C value to the fresh material. The destructive agent has proved to be, not the actual degree of heat, but the chemical process of oxidation, which takes place more rapidly at higher temperatures. It is oxidation, or combination with the oxygen of the air, which causes the tarnishing or rusting of metals. One effect of oxidation on apples is shown by a brown discolouration of the peeled fruit. Apples canned in the ordinary way were found to lose all their vitamin C, but if first specially treated to check the brown discolouration, subsequent canning in the absence of air does not appreciably destroy vitamin C. During the modern process of canning, fruit and vegetables have the air actually sucked out of their tissues. The re-heating of such canned fruits and vegetables, on account of the absence of air in the material, does not involve loss of vitamin C. In fact, canned fruits and vegetables, even after re-heating before serving, are in many cases superior in antiscorbutic value to fresh fruit and vegetables stewed or boiled at home.

The method of canning is not always the same, and it is safer not to assume that all brands of tinned fruits and vegetables have exactly the same value, one kind of tinned tomatoes may be better than another. The supply of

vitamin C, if derived solely from canned fruits, should not be cut down to the minimum.

These observations explain why slow cooking at a relatively low temperature is more injurious than rapid cooking at a higher temperature. Boiling expels the oxygen quickly from the food material, but in simmering the oxygen is only driven off slowly and remains a long time in contact with the vitamin at a temperature sufficiently high to ensure rapid oxidation.

Many more tests of the vitamin C values of fruits and vegetables, both fresh and canned, are still needed. Strawberries, gooseberries, rhubarb and onions are known to have considerable antiscorbutic value, but the minimum protective doses have not yet been determined.

The ageing of fruits and vegetables has been shown to reduce their antiscorbutic value. New potatoes, young carrots and freshly picked apples contain more vitamin C than those which have been stored some months. It is again oxidation which slowly destroys vitamin C during storage. Canned tomatoes suffered little loss even after three years' storage because the oxygen had been removed. Nevertheless it is advisable that all canned and dried foodstuffs should be stamped with the date of manufacture.

Various kinds of fruit juice have been dried by a process similar to that used commercially for drying milk and have been found to retain some antiscorbutic value. Orange juice included in the preparation of dried milk has been found to increase the amount of vitamin C with advantage to the infants fed on this mixture as compared with plain dried milk.

There is now a special commercial preparation[1] of concentrated orange juice which has been carefully tested and found to possess the full antiscorbutic value of the fresh fruit. This preparation is especially suitable for use on board ship, as in

[1] California Fruit Growers Exchange, London, S.W. 1.

Polar expeditions, or for giving very concentrated doses of vitamin C.

Ordinary dried seeds have no antiscorbutic value, but seeds become a very valuable source of vitamin C when they are germinated. This is quite easy to do. Dried peas are the most suitable seed. It is best to use those sold by the pound. The ones in packets do not germinate well, possibly because they have been in contact with the little bag of alkaline salt which is sold with them, and some varieties appear to have been tinted a bright green. The whole unsplit peas are soaked for twenty-four hours in water, transferred to a damp cloth and kept warm and moist and exposed to air until they begin to sprout in about three or four days. The warmer the room the sooner they begin to grow. Sprouted peas, with roots about one inch long, need much less cooking and have much more flavour than the dry peas. Germinated seeds have often proved a splendid remedy for scurvy and are most useful for armies abroad or in winter.

Fresh meat contains little vitamin C. It is effective only when huge amounts are eaten such as the Eskimo is capable of doing. It is reported that scurvy has been prevented in Africa, and also during the War in Mesopotamia, by the consumption of fairly large amounts of meat.

The potency of milk as an antiscorbutic has been much exaggerated. Its value is shown by the figure in Table 3, and depends to a large extent upon whether it is summer or winter milk. It has been proved both here and in America that the milk of cows at grass has much more vitamin C than the milk of cows fed on oil cake and hay in the winter (see also under vitamin A, p. 49). Protection is not efficient unless the adult gets 3½ pints of raw milk daily. For the infant milk is a sufficient antiscorbutic, only if it is undiluted and not spoiled by wrong treatment. Its antiscorbutic value depends very largely upon the handling

and heating which it has undergone. Many cases of infantile scurvy have been traced to pasteurisation at the dairy followed by boiling the milk in the home. Dried and condensed milks have been tested and found to have about the same value as fresh milk.

The treatment of milk with sodium citrate, or sodium bicarbonate, to make it more digestible destroys vitamin C and is another cause of infantile scurvy.

Bottle-fed infants are the only section of the community who are in danger of getting definite scurvy. The care taken to protect their milk from harmful germs and to make it easily digestible by adding sodium citrate, leads to the destruction of the antiscorbutic vitamin. Scurvy in children is called Barlow's disease, or sometimes by the inaccurate name scurvy-rickets : inaccurate because scurvy is quite distinct from rickets. Cases of acute infantile scurvy are rare, but many slighter cases pass unrecognised and recover gradually as the diet becomes more varied. The symptoms in mild cases may be nothing more definite than pallor, loss of appetite, fretfulness and failure to gain in weight. Purple marks on the gums during teething indicate a rather more advanced state of scurvy. Swellings in the legs and knees are often mistaken for rheumatism. The child with scurvy cries on being handled, but in rickets there is no tenderness.

Grape juice is a very poor antiscorbutic and in the small quantities in which it is given to infants is quite useless. A daily dose of orange juice speedily restores health, As a preventive it is advisable to give every bottle-fed child a small amount of orange juice daily, beginning with one teaspoonful and gradually increasing the amount.

It will be seen from the above information that there should be no difficulty in selecting foods to fill the C corner of the " Square Meal " and at the same time to vary the diet pleasantly. It is only necessary to bear in mind that fruits differ in value and that vitamin C may be destroyed by wrong treatment.

CHAPTER IV

VITAMIN B OR B_1* AND BERI-BERI : THE NEED FOR WHOLE CEREALS

SOME of the most interesting and significant facts in nutrition have come to light in the study of the disease beri-beri. This disease occurs mainly amongst the rice-eating peoples of the East, but it has also developed in Australia, the United States, Europe and many other parts of the world. It is not confined to the tropics, nor to rice-eaters. There are many examples of the occurrence of beri-beri amongst eaters of white bread.

Dr. Little recorded outbreaks of beri-beri in Labrador and Newfoundland. There were no cases of beri-beri in these countries in the old days when wholemeal flour was in general use, but after white flour became the chief food during the winter months beri-beri appeared every spring. He described how a ship laden with wholemeal flour was stranded upon the Newfoundland coast. In order to refloat her a quantity of the flour was removed and was consumed by the inhabitants of the district, and for more than a year after no more cases of beri-beri were reported.

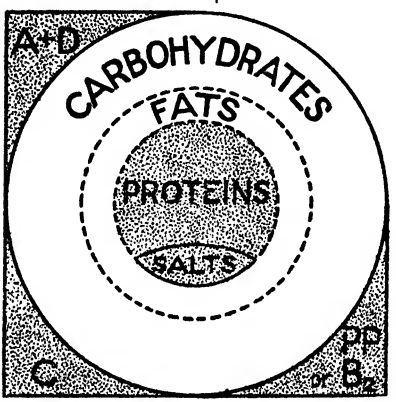
The story told by Holst of an old sea-captain affords another instance of beri-beri on a diet of white wheaten flour. In 1894 it was made compulsory to supply Norwegian sailors with white flour with the idea of making their life at sea more pleasant. Rye flour had previously been used. The captain objected to the new regulations and for his own use took rye flour. The crew, fed on white flour, fell

*For explanation of vitamin B, see pages 35, 47.

ill with beri-beri and were cured by biscuits made from the captain's private supply of rye flour.

Beri-beri has also been observed amongst the eaters of manioc, or tapioca, in Brazil. All kinds of white cereal foods are concerned in the causation of beri-beri.

FIG. 4.



A diet without vitamin B leads to BERI-BERI.

The diet producing beri-beri is represented by the "Square Meal" with the B or B_1 corner missing as shown in fig. 4.

Closer attention was given to the cause and prevention of beri-beri after the outbreaks of this disease among our troops in the Dardanelles and Mesopotamia during the War. The British troops fed on white bread suffered severely, but the Indian troops on "atta" and "dahl," that is, wholemeal flour and the chick-pea, did not have the disease. The freedom from beri-beri during the later days of the siege of Kut was traced to the consumption of the Indian wholemeal flour by the British troops after all their own white flour had been used up.

The disease beri-beri is characterised by severe nervous and heart symptoms and by digestive troubles. The latter, though mentioned last, really appear first and are the most important, as they seem to form the basis of the ultimate nervous troubles. Poisons absorbed from the diseased digestive tract may be the cause of the final paralysis of the limbs. In some cases there is also much œdema, that is, the limbs are swollen and distended with fluid as in dropsy.

Like scurvy, the disease is fatal unless arrested by a timely change in the food.

The establishment of large machine mills for preparing white rice led to an enormous increase of beri-beri, but only gradually was the connection between beri-beri and the food supply realised.

The sailors of the Japanese Navy suffered greatly from beri-beri and a special investigation of its origin was made by Takaki, Medical Inspector-General of the Japanese Navy. He concluded that the freedom from beri-beri amongst the European navies was connected with a higher protein diet and persuaded the Japanese naval authorities to make a change in the men's food.

Before this change 32 per cent of the men suffered from beri-beri, but after the introduction of the new rationing in 1884, the disease was practically stamped out. Three years after the change there was not a single case, although the personnel of the Navy had meanwhile been doubled. The most remarkable effect of this diet is shown by the report of sickness from beri-beri during the Russo-Japanese War. There were 200,000 cases in the Army, but none in the Navy. It is instructive to consider the difference in the food of the two Services, as shown by the rations they received during the Siege of Port Arthur :—

Japanese Navy.	*Japanese Army.*
1 lb. of Meat.	5 ozs. of Meat.
20 ozs. of Rice.	30 ozs. of Rice.
10 ozs. of Whole Barley.	

At first sight it would appear that Takaki was right in attributing the cause of the disease to lack of meat. Experience from other countries, however, did not confirm the theory that meat was the preventive agent of beri-beri. It is now known that it was the whole barley which was the preventive in this case. The quantity of barley in the diet amounts to one-third of the dry weight.

The first real insight into the cause of the disease was given by the observations of Eijkman in 1897. Eijkman noticed that some fowls kept at a prison in Java, at which he was chief medical officer, fell ill and suffered from a peculiar form of paralysis which he called polyneuritis. No micro-organism could be found that might be the cause of the disease. Eijkman discovered that the birds were fed upon rice left over from the prison food and he made experiments upon the feeding of birds with various kinds of rice. Some of the birds were fed on the whole grain, some on half-peeled rice and some on white rice. Only those fed on white rice suffered from the disease. These birds were cured by being given the whole grain, or by the half-peeled rice. The disease was produced by feeding with any sort of white rice : fresh, old, raw or cooked, and it could be cured by adding the rice bran to the white rice.

Not only white rice, but also sago or tapioca as the sole food, caused the disease amongst birds.

Eijkman, with the help of a colleague, Vorderman, put the result of the bird experiments to a practical test in the gaols of Java, containing altogether about a quarter of a million prisoners. The inmates of some prisons were given white rice and in others they were given half-peeled rice.

In the prisons receiving white rice 1 in 39 of the inmates developed beri-beri.

In the prisons receiving half-peeled rice, only 1 in 10,000 of the inmates developed beri-beri.

Another very valuable piece of work upon this subject was done by Fraser and Stanton in the Malay States. They confirmed Eijkman's results and made a further advance by showing that the preventive substance in the whole rice grain, or the rice bran, could be extracted with alcohol. They thus proved that the cause of the disease was the

absence from the food of some chemical substance essential for life.

Eijkman and his colleagues tested various foods for their protective action against beri-beri and were able to divide foods into two main classes, those containing the protective substance and those not containing it. They were :—

Foods Containing Anti-Beri-Beri Substance.	Foods *NOT* Containing Anti-Beri-Beri Substance.
Rice Bran.	White Rice.
Half-peeled Rice.	Tapioca.
Potato.	Sago.
Barley, whole grain.	Peeled Barley (=Pearl).
Beans, dried.	Sterilised Foods.
Rye Flour.	White Flour.
Milk.	
Yeast.	

Amongst those foods not containing the preventive substance may be noticed sterilised foods, or in other words, canned foods made at high temperatures and under pressure. This was contrary to the belief then current that beri-beri was due to an infection.

Many unsuccessful attempts were next made to isolate the actual preventive substance from the bran of rice and from other foods. Very concentrated extracts can easily be prepared and it appears that the active substance has been isolated and analysed by Jansen and Donath in the Dutch East Indies (1927). The substance is so potent that ½ to 1 mg. (1 mg. =.000035 oz.) a day is enough for a man receiving 500 gm. (=18 oz.) of rice ; that is, it is effective in the proportion of 1 part of the anti-beri-beri substance in 500,000 parts of food.

The anti-beri-beri substance, sometimes called the antineuritic substance because it relieves the symptoms of polyneuritis, seems to be the same as vitamin B.

The discovery of vitamin B came from quite independent work upon the feeding of animals. It was believed that animals could exist upon the three main food materials, protein, carbohydrate, and fat, together with mineral salts and water. Sir F. Gowland Hopkins showed that this was impossible and that besides these known food constituents something else was necessary. The unknown he called an *accessory food factor*. He found that a small quantity of milk, or of an extract of fresh animal tissue, added to the pure foods every day supplied all that was necessary for the growth of rats.

At the same time very extensive researches were being carried out in America by Osborne and Mendel and they also found that the purified protein, fat and carbohydrate of an artificial diet, together with suitable mineral salts, were not adequate for the growth and life of animals. The addition of milk was necessary. Their further experiments, as well as those of McCollum and Davis, showed that the milk contained *two* unknown accessory food factors. One was found in the cream and called the *fat-soluble* and the other in the water and called the *water-soluble* factor. For convenience they were called A and B respectively. Each of these unknowns is essential for life. The name *vitamin* was coined for the substance in rice bran. As it was found that the foods which can replace the watery part of milk were the same as those which can prevent beri-beri, the essential substances were believed to be identical. So the anti-beri-beri substance is now called vitamin B.

The examination of foodstuffs for the presence of the anti-beri-beri substance or vitamin B has been carried out mainly in this country at the Lister Institute by Cooper and later by Chick and Hume, and then by Plimmer and his colleagues.

The following table gives the chief foods containing vitamin B, and at the same time shows those which do not contain the vitamin B.

Foods Containing Vitamin B	Foods *NOT* Containing Vitamin B
Wholemeal Flour.	White Flour.
Whole Barley.	Pearl Barley.
Whole or Half-peeled Rice.	White Rice.
Oatmeal. Rye. Wheat Germ.	Sago.
Nuts. Peas. Beans. Lentils.	Tapioca.
Eggs. Milk. Liver.	
Yeast.	Canned Meats, Fish.

By comparing these lists with those of Eijkman on page 33 it is seen that the two series are almost identical, consequently it was believed that the anti-beri-beri substance and vitamin B were the same thing.

Most of the foods containing vitamin B, especially yeast and wheat germ, have been found to contain another vitamin which prevents the disease, pellagra (see chapter V), but does not prevent beri-beri. To distinguish the two vitamins the Medical Research Committee has called the anti-beri-beri vitamin B_1 and the pellagra-preventing vitamin B_2. The distinction between the two vitamins has been demonstrated by the discovery that the anti-beri-beri substance, B_1, is destroyed by heating under pressure to a high temperature with alkali, but that B_2, the pellagra-preventing substance, survives this treatment. Further the distribution of the two vitamins is not exactly the same. In some foods, for example meat, there is more B_2 than B_1, and in other foods, such as lentils and peas, there is more B_1 than B_2. As the anti-beri-beri substance has for so long been taken as identical with vitamin B, it seems likely that the term vitamin B will continue to be used to denote the anti-beri-beri substance and vitamin B_2 to denote the pellagra-preventing substance. McCollum prefers to retain the name vitamin B and to call the anti-pellagra substance vitamin F.

Chick and Hume and Cooper were mainly concerned with finding out the best foods for the prevention of beri-beri, and tried to determine the smallest quantity of the different foods which would prevent polyneuritis (=beri-beri) in pigeons. They also tested the various foods for their curative action upon pigeons suffering from polyneuritis. The preventive values are the more reliable guide. Their data have been collected in Table 4.

TABLE 4

Quantities of Foods Preventing Beri-Beri.

FOR ADULT PIGEONS

	per day	*per cent*
Lentils	3.0 g.m.	18
Barley, whole	3.7	22
Egg, yolk	3.0	18
Liver, Ox	3.0	18
Heart, Ox	5.0	30
Brain, Ox	6.0	36
Muscle, Ox=Beef	20.0	50
Milk, more than	35.0	—
Wheat Germ	1.5	4.5
Yeast Extract	1.0	3.0

The preventive quantities were expressed by Chick and Hume as the amount required each day. For comparison with the other Tables 5 and 6 these figures have also been given in Table 4 as the percentage consumed.

Some data have also been determined by American workers who used rats as the test animal. The few values available are collected in Table 5.

TABLE 5

PERCENTAGE OF VITAMIN B REQUIRED

	For Rats	*per cent*
Carrot		15
Swede		15
Dried Cabbage		15
Dried Spinach		10
Orange Juice[1] (10 cc. per day)		50

The work of Chick and Hume gave the impression that the amount of vitamin B required could be reckoned as a certain quantity per day. There was no connection with the American data.

With this idea that a small daily quantity of vitamin B was all that was necessary, Plimmer and Rosedale made experiments on the vitamin B requirements of growing chicks to see exactly how much was needed, using a basal diet without vitamin B and supplementing with a standard source of vitamin B. Keeping this standard quantity per day fixed and increasing the total amount of food as the growing chicks required more, it was observed that the chicks suffered from polyneuritis. It was only possible to rear the chicks by keeping the supply of vitamin B in a constant proportion to the total food. The need for a proportional amount of vitamin B was also proved in the case of adult pigeons.

The balance of food by vitamin B thus appears to be essential. Further work has since been done upon these lines and it has clearly been shown that all the constituents of the diet, protein, fat and carbohydrate must be balanced by vitamin B : that is, the supply of this vitamin must be proportional to the total fuel value of the diet.

The question of balance can be made more clear by the following illustration. Birds fed upon a certain quantity of white rice and a certain quantity of yeast, say x white rice

[1] Willimott, 1928.

and Y yeast remain quite well. On doubling the amount of rice and leaving the yeast the same, that is 2X rice + Y yeast, the birds develop beri-beri. Other experiments show that fat also must be balanced by vitamin B. That is X fat + Y yeast are balanced and the birds are well, but 2X fat + Y yeast are not balanced and cause illness which is cured by giving 2Y yeast. Thus, if X is increased to 2X, then Y must be increased to 2Y. In the same way if the protein in the food is increased from X to 2X, then the yeast must be increased from Y to 2Y. This relationship can be expressed as :—

$$\frac{\text{vitamin B}}{\text{total food}} = \text{a constant.}$$

This ratio expresses the fact that the more food is eaten the more vitamin B is required to keep the constant. Suppose that vitamin B is 1 and the total food is 10 ; if the total food is increased to 20, the vitamin B must be increased to 2, or the constant would be one half of what it was, that is, it would cease to be a constant.

The experiments have also shown that young birds and rats need a higher percentage of vitamin B than adults. The suggestion has consequently been made that vitamin B is an essential part of the body tissue, possibly a part of the cell nucleus. As in the case of protein, the adult may require the vitamin to make good wear and tear : the young animal requires it for wear and tear and for growth of new cells.

For practical purposes it is not enough to know that certain foods contain vitamin B, we want to know how much there is in ordinary foods and how much should be eaten to balance the white flour and sugar in the diet. For this purpose Plimmer and his colleagues have tested a large number of foods, using white flour and fish meal as the basis of the diet. They found out the smallest percentage quantity of each food which will maintain the birds for periods varying from six months to a year when the test food is the sole source of vitamin B in the diet.

TABLE 6

Percentage Quantities of Foods Required to Prevent Beri-Beri

For Pigeons[1]

	per cent
Dried Yeast	4
Wheat Germ	6
Marmite	10
Baker's Yeast	12
Peanuts, Hazel Nuts	20
Dried Peas, Soya Beans, Lentils	30
Bran, Middlings	30
Almonds, Dried Chestnuts, Haricot Beans	40
Whole Wheat, Rye, Barley, Millet, Dari	40
Egg Yolk	50
Maize, Oatmeal	50
Leek, Parsnip	60
Cabbage, Kale, Orange	70
Potato, Artichoke	80

Other Vegetables : Beetroot, Carrot, Swede, Turnip; Brussel Sprouts, Cauliflower, Celery, Lettuce; Runner Beans, Spinach; *Fruits :* Apples, Apricots, Currants (red), Gooseberries, Plums, Strawberries, Tomatoes, Bananas, Ground Coconut	Contain only traces of vitamin B.

These figures show the percentage of the various foodstuffs which must be added to white flour (or other white cereal) to prevent the onset of beri-beri. The best foods

[1] These figures may need slight alterations as the experiments are still in progress by Plimmer and colleagues.

are those with the *lowest* percentage number. The figures mean that 40 per cent of wholemeal flour supplies enough vitamin B to compensate for the addition of 60 per cent of white flour, or any white cereal, or sugar, or other food not containing vitamin B. In the case of oatmeal 50 per cent of such a food can be added. By a little calculation it is possible to determine how much of a mixture of any of these foods must be taken to supply enough vitamin B to balance the total food.

In most cases very large amounts of the foods containing vitamin B are required as they contain little of the vitamin. There are only two foodstuffs which can be considered as very rich in vitamin B. These are wheat germ and yeast extract. Six per cent of wheat germ, or 10 per cent of yeast extract is required to compensate for a diet consisting mainly of white cereals, sugar, meat and fats. Wheat germ is now sold under the name of "Bemax." The high vitamin content of germ, bran and middlings show how essential it is that they should not be separated from flour in the milling. The whole of the grain should be used for human food, whether it is wheat, rye, barley, or maize which is the staple cereal. The other valuable vitamin B food, yeast extract, is well known under the name of "Marmite."

In order to supplement adequately a diet which consists chiefly of foods lacking in vitamin B, the amount of marmite required is about 1 to 2 oz. a day ; or if wheat germ (bemax) is the supplement ½ to 1 oz. is required.

Vegetables have also been tested on pigeons and have been found to be very variable. Leeks, cabbage, kale, parsnips are fair. Potatoes and artichokes are less good. Only traces are present in other vegetables and fruits (see Table 6).

From the above data it must be concluded that the vitamin B in plants is concentrated chiefly in the seeds, and is found in some roots and tubers ; that is, wherever there is a reserve

of food material, and not usually in the leaves as in the case of vitamins A and C.

The paralysis characteristic of beri-beri is generally considered to be the only important diagnostic symptom and because this paralysis is very rare in this country, it is concluded that there is plenty of vitamin B in the ordinary mixed diet. The earlier manifestations of beri-beri are quite overlooked. Colonel McCarrison, I.M.S.,[1] in his book on *Deficiency Diseases*, lays greatest stress upon the order of appearance of the symptoms :—

> First of all there is a loss of appetite, or there is a depraved appetite, that is, a craving for unnatural food—animals eat their excreta or feathers.
>
> Indigestion.
>
> Bouts of diarrhœa may alternate with constipation.
>
> Colitis, that is inflammation of the colon or large bowel.
>
> The general condition is very poor; there is loss of weight, weakness, headache, anæmia, unhealthy skin, sub-normal temperature, heart trouble.

The observations by Plimmer, Rosedale and Raymond upon birds on diets containing too little vitamin B lead to the same conclusion as that of McCarrison that the attention should be focussed upon the earlier signs of the disease and not upon the paralysis. On a diet containing a *shortage* (not *absence*) of vitamin B, birds show the above signs of ill-health, and die without showing paralysis, but showing stagnation of the food in the gut (constipation or stasis) and appendicitis.

The abnormality of the heart was also a fairly constant feature. The birds were overladen with fat, especially round the internal organs.

The effect of too little vitamin B in the food of rats has

[1] Director Deficiency Diseases Inquiry, Indian Research Fund Association, Pasteur Institute, Coonoor, India.

been especially studied by Dr. M. J. Rowlands. He found that the constipation and stasis is caused by an actual degeneration of the muscular coats of the bowel. The weakened walls of the stomach and bowel sag out of their normal position and are unable to contract strongly enough to keep the contents moving onwards at the normal rate. X-ray examination showed that this deficient diet caused great distension and dropping of the stomach. On supplementing the diet with "Bemax" (wheat germ) the stomach regained its proper position and size and the bowel passed on its contents at the normal rate. The resistance to infection of the rats on this deficient diet was tested and found to be much lower than normal. Microbes passed through the degenerated intestinal walls and were able to infect tissues in other parts of the body. On a complete diet microbes could gain no entry through the bowel walls.

A variety of chronic diseases may thus start with constipation and a lowered resistance to infection. Dr. Rowlands has evidence that chronic rheumatoid arthritis owes its origin to the entry of bacillus coli into the tissues through the degenerated wall of the intestine consequent upon a long-continued slight shortage of vitamin B in the ordinary diet.

The experimental work upon the quantity of vitamin B that is required has been mainly carried out with pigeons. A comparison with the rat was made by Plimmer and his colleagues, who found that the requirements of the rat were about half those of the pigeon. It is possible that man's percentage requirement is less than that of the pigeon and more like that of the rat. It is safer in the absence of definite knowledge on this point to base the quantity for man on the higher figure rather than to underestimate. An excess of this vitamin has not been observed to do any harm.

CHAPTER V

THE QUALITY OF PROTEIN. THE DISEASE PELLAGRA AND VITAMIN PP OR B_2

THE bodies of animals consist chiefly of the nitrogenous substance called protein, which cannot be formed in the body from any other food constituent, but only from protein. The foods which contain the best protein are animal products, such as the lean of meat, fish, cheese, milk and eggs. Plant tissues contain some protein; dried peas, beans and lentils contain as much protein as lean beef. The adult needs only small quantities of protein for the repair of the tissues, but the growing child needs relatively more as he has to form new body substance. Protein differs from the carbohydrate and fat of the food in containing the element nitrogen and also sulphur, and in many cases phosphorus as well.

Protein has a very complicated chemical structure and is built up of some twenty different kinds of units, in themselves elaborate chemical substances. Each kind of protein may be compared with a chain, containing beads of some twenty different colours. During digestion the chain is broken and the beads separated and they pass into the blood stream. Each tissue or organ of the body has, as it were, a special protein pattern and collects only the kinds of beads which it wants to assemble this pattern. Animal proteins contain the beads in the most suitable proportions. Beads which do not fit into the patterns, or any excess of beads, are burned up as fuel. The Eskimos use protein and fat as their fuel

food instead of carbohydrate, but in the milder climate of this country, or in the tropics, the use of protein as a fuel food is attended with certain dangers and is also a very expensive source of fuel.

Plant proteins contain the same kinds of beads as animal proteins, but in quite different proportions. Some kinds are present in excess and others may be very scarce or absent. In order to get enough of the kinds of beads which are scarce in plant proteins, an enormous amount of bulky vegetable food must be eaten, and there is a great waste of the commoner kinds of beads, which are present in much larger quantities than are needed. Sheep and cows have extra stomachs adapted for working up this mass of material, so they can select the beads they require and reject the others. By eating meat, or other animal protein, all the units or beads are supplied in suitable proportions for man. "Complete" proteins are those which contain all the different kinds of beads. Most so-called "vegetarians" take milk, cheese or eggs which provide them with "complete" protein. The accepted standard for the quantity of protein is $\frac{1}{6}$ (dry weight) of the total food (see page 69), and this is subdivided into animal and vegetable protein. The quality of the protein depends on the proportion of animal protein. As every bead contains nitrogen, the nitrogen content of the food, commonly used to calculate the protein value, gives no indication as to whether the protein is "complete" or "incomplete," that is, whether or no it supplies all the essential beads. Proteins derived from cereals, especially those derived from maize, are of poor quality because they fail to supply enough of the rarer kinds of beads. The protein of peas and beans is of less value in nutrition than that of meat, fish or eggs. The protein beads in these pulses are not well proportioned though each kind is present.

In this country there is a liberal supply of animal protein, but in some parts of the world, such as certain districts in

Italy, Roumania and in the southern part of the United States, the peasants live on poor diets containing practically no flesh foods, milk or cheese. Large numbers of people in these areas have died from a peculiar disease called pellagra. This disease is characterised by digestive trouble, peculiar skin eruptions and mental symptoms generally ending in insanity. In the States this disease was increasing at an alarming rate and there were over 100,000 cases in the south in 1916 and many more in 1917, but after that the disease began to decline owing to the education of the people in better dietary habits.

After this, the great floods in the Mississippi basin caused loss of livestock at a time when this cotton-growing area was already suffering a period of economic depression. Large numbers of people had to subsist upon a miserable diet of maize, fat pork and molasses, with the result that the incidence of pellagra again increased. The mortality from the disease in these States in 1927 is estimated to be twice as high as it was in 1924.

At first pellagra was thought to be caused by maize, since it was chiefly confined to maize-eating districts, and it was commonly believed to be infectious. However, Dr. J. Goldberger, making investigations on behalf of the United States Public Health Service, found that pellagra developed if the diet was for a long period poor in animal protein. It seemed possible that a diet containing protein chiefly derived from seeds, such as maize or wheat, might fail to supply all the necessary units, or beads, as we called them. In the Southern States where Goldberger carried out his investigations, there were no dairies or butchers' shops and very few people kept any cows, poultry or live-stock. The inhabitants worked in cotton plantations and lived almost entirely upon cereals, vegetables, syrup and fat bacon. The supply of vegetables was very scarce because cotton was practically the only crop grown.

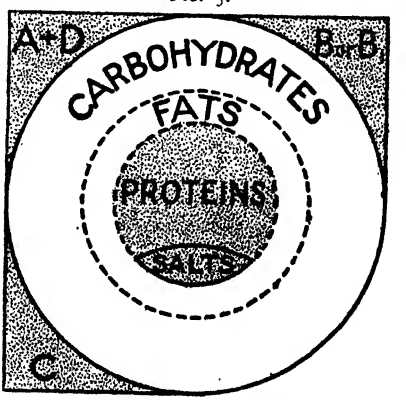
In its earlier stages pellagra could be cured by giving large amounts of animal protein. Patients too ill to take solid food were cured by a diet of milk and canned tomato juice.

In Egypt pellagra broke out at the end of the War in camps for Armenian refugees and for prisoners-of-war. The pellagra-producing diets were studied by Professor Wilson of Cairo, who considered that the diets contained too little animal protein, although the total amount of protein satisfied the accepted physiological standard and there was apparently no shortage of vitamins. The disease was cured by increasing the amount of animal protein.

The quality of the protein appeared to be the determining factor in the causation of pellagra. Wilson estimated that at least 40 grams (1½ oz.) *dry* weight of animal protein must be taken daily in order to prevent the appearance of pellagra.

The later work of Goldberger and his colleagues indicated that pellagra is not caused directly by a lack of animal protein, but by an insufficient supply of some special pellagra-preventing substance which he designated the PP factor, or vitamin. This PP factor occurs in the flesh and internal organs of animals, fish and eggs. It is present most abundantly in yeast and in lesser amounts in wheat germ. Dried peas, milk, whole wheat and tomatoes contain only small quantities of

FIG. 5.



A diet without vitamin PP leads to PELLAGRA

this substance, which is distinct from any of the other vitamins that these foods contain.

From the practical point of view if the diet contains enough animal protein foods, these will carry with them enough vitamin PP. Fig. 5 represents a pellagra-producing diet.

Vitamin PP, as will be noticed from the list of foods tested by Goldberger, is present in many foods which also contain vitamin B. In particular it is noticeable that yeast and wheat germ are rich in both B and PP. The most striking differences in their distribution are that meat is poor in B, but rich in PP, and that egg white has no vitamin B, but much vitamin PP. The distinction between the two vitamins is shown by the possibility of completely destroying B in yeast and not harming PP. Yeast can thus be deprived of its power of preventing beri-beri without diminishing its power to prevent pellagra.

Pellagra is analogous to the disease in dogs known as black tongue, or sore mouth, and by other names. Goldberger and his colleagues have made numerous tests showing the similarity between this disease in dogs and pellagra in man. Dogs fed on a pellagra-producing diet are cured by meat, yeast and other foods which are preventive and curative of pellagra.

The study of the PP factor is also made on rats as experimental animals. These experiments have demonstrated the difference between vitamin B and the PP substance in their reaction to heat.

The Medical Research Committee has decided to call the anti-beri-beri substance vitamin B_1 and the pellagra-preventing substance PP vitamin B_2 (see page 35).

CHAPTER VI

VITAMIN A AND THE EYE DISEASE, XEROPHTHALMIA

THE scientific work upon the feeding of animals (page 34) showed that milk contained two unknown substances, one in the cream called fat-soluble A and one in the watery part called water-soluble B.

The discovery of fat-soluble A in cream led to an examination of other fats for its presence. It became evident that fats could be sharply divided into two groups, the "good" fats containing A, and the "bad" fats not containing it. They are given in the following lists :—

Good Fats.	*Bad Fats.*
Butter or Cream.	Lard.
Cod Liver Oil.	Almond Oil.
Egg Fat.	Olive Oil.
Kidney Fat (Suet).	Cotton Seed Oil.

These fats can be grouped roughly into animal fats as "good" and vegetable fats as "bad." There is one exception —lard—partly due to the feeding of the pig and partly to the refining processes to which lard is subjected.

Though oils extracted from seeds contain so little vitamin A, the fats contained in other parts of the plant are not devoid of the vitamin. Green leaves contain comparatively large quantities of vitamin A. It is formed in the green parts of plants by the action of sunlight. The yellow leaves which

are not exposed to the sun do not contain vitamin A which is found in the green outer leaves of the cabbage and lettuce, but not in the heart.

Green plants are the primary source of vitamin A in the livers of cod and other fish. In the springtime there is a great growth in the Northern seas of green algæ, microscopic green plants. These form the food of minute floating animals which in turn are eaten by small fish and these again by larger fish, such as the cod. The vitamin A is transferred from the smaller to the larger fish during digestion and in some way becomes concentrated in the liver of the cod. It is easy to understand why cod liver oil is so valuable ; it contains the vitamin collected from an enormous quantity of plants. In the period preceding spawning there is also a concentration of the vitamin in both the hard and soft roe. Fish roe is thus an especially valuable food for children.

Green grasses have been proved to be the origin of vitamin A in milk. Experiments carried out both here and in America showed that the milk from grass-fed cows contained twice as much vitamin A as milk from stall-fed cows. In other words, summer milk, when the cows are at pasture, is of far better quality than the winter milk (cf. vitamin C, page 27).

It is thus clear that the amount of vitamin A in the milk depends upon the food of the animal. The amount of this vitamin in cow's milk is greatly increased if the cow is given cod liver oil in its food. These facts prove the importance of feeding a mother nursing her infant on food containing vitamin A. She must have food from the good list of fats or her milk will be as poor as that from a stall-fed cow.

The amount of cream in milk is no guide to its vitamin A value. Winter milk, poor in vitamin, may be more creamy than summer milk.

The dependence of the vitamin value of milk upon the food of the animal explains why pig fat contains practically

no vitamin A. Pigs are usually not fed upon green stuff. Pigs fed upon green stuff give a fat which contains vitamin A.

A comparison of the vitamin A value of fats has not been made in such detail as for the foods containing vitamins C and B. There are at present only a few figures available.

The presence of vitamin A in a foodstuff was recognised by the growth of the young animal. In the absence of vitamin A there was no growth. It has therefore often been called "the growth factor," but this designation is misleading as other defects in the diet will also interfere with growth.

The usual method of testing the vitamin A value of any foodstuff is to estimate the minimum quantity of it which will produce growth on a diet complete in every respect except for vitamin A. The values in the following table have been obtained in this way :—

Foodstuff.	*Quantity per Day for Rats.*	*Percentage of Total Food.*
Cod Liver Oil . . .	0.02 to 0.002 gm.	0.2 to 0.02
Cod Roe	0.2 g.m.	2
Butter	0.2 to 0.4 gm.	2 to 4
Whole Milk, fresh, condensed or dried	2 c.c.	20
Cabbage (green part) . .	1.5 gm.	15
Tomato, dried . . .	0.1 gm.	1
„ fresh would be	0.1 × 90	90

These figures show how rich cod liver oil is in comparison with butter and other good fats. Cod liver oil is estimated to contain about 250 times as much vitamin A as butter, but samples of cod liver oil vary considerably. The liver oils of salmon and halibut are often, according to Rosenheim, more than 100 times as rich in vitamin A as cod liver oil. Spinach has been found to contain approximately three times as much vitamin A as butter.

The effect of heat and of exposure to air upon this vitamin is of great practical importance. In the absence of air vitamin A is not destroyed by heat. Sterilised milk and canned meats contain it, as they are prepared in closed vessels. Dried and condensed milks are generally prepared in the absence of air and contain vitamin A. Dried eggs and preserved eggs prepared in the absence of air are also good. In the ordinary processes of cooking, animal fats are exposed to air as well as heat and will therefore lose some of their vitamin A.

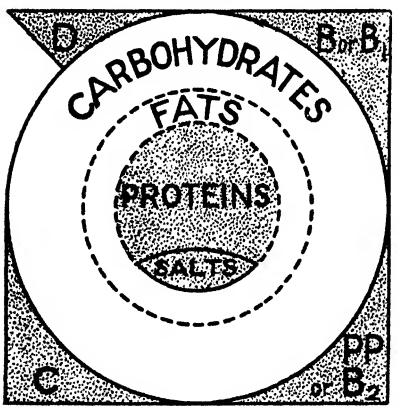
Margarine may be made from vegetable oils, fish oils or animal fats. The oils are hardened by commercial processes to make solid fat. Vegetable oils generally do not contain vitamin A, but this vitamin is present in fish oils and destroyed by the process of hardening. The animal fats vary according to the food of the animal, and the part of the body from which they are taken, and may or may not contain vitamin A. The liver oil of birds, fishes and herbivorous animals is much richer in vitamin A than fat from other parts of the body. Some varieties of margarine contain a mixture of hardened oils and animal fats and some may be pure animal fat. Consequently, margarine cannot be relied upon to contain vitamin A. On account of the need for vitamin A, and also of another fat-soluble vitamin D, in nutrition, manufacturers of margarine are now introducing special preparations into their margarine so that it should equal butter in vitamin value (see page 62). Butter is very variable in fat-soluble vitamin content. The margarines prepared with fat-soluble vitamins have been found on testing to be equal to good butters.

The presence of vitamin A in fats can be detected by means of a colour reaction with arsenic or antimony chloride in chloroform, devised by Rosenheim and Drummond. It is a valuable contribution to the work of isolating and identifying vitamin A. The intensity of the colour

varies with the amount of vitamin A in the fat, and can be measured in a special apparatus called a colorimeter. The vitamin values, estimated by the colorimeter are proving to be consistent with those obtained by feeding tests. It appears possible to substitute the colour test altogether for the tedious feeding experiments, which will make it easier to grade fats according to their vitamin A content.

If the amount of vitamin A in the diet is very small, or altogether lacking, as in Fig. 6, the health suffers. There are no distinctive symptoms as in scurvy or beri-beri, but children on diets poor in vitamin A lose weight and have an extraordinary low resistance to any infection. They are particularly liable to develop an inflammatory condition of the cornea of the eye, called xerophthalmia, which if unchecked leads to blindness. Local treatment of the eye has no effect, but the trouble is relieved in a few days by the addition of cod liver oil to the food. The sore eyes have occasionally been described amongst artificially fed infants in this country, but it is much more common in countries where nursing mothers practise long religious fasts. During the War there were many epidemics of this particular form of eye-disease, especially in Roumania, where the children had no milk at all. Other outbreaks have been reported in

Fig. 6.



A diet without vitamin A leads to FAILURE of GROWTH and lowered resistance to infections, especially of the eye and lung.

Denmark and Japan. In every case cod liver oil was found to cure the disease and prevent blindness, if taken in time before the cornea was perforated. Animals on experimental diets lacking this vitamin suffer from a similar eye disease. Catarrh and infections of the digestive tract and lungs are common amongst this type of badly fed child or animal, and death results, not from any definite deficiency disease, but from some severe infection.

Adults appear to require less vitamin A than the growing child, but it is essential that vitamin A should be present in the diet of the adult as a preventive of xerophthalmia and other troubles, especially lung diseases, due to a low resistance to infection. There is a form of "night-blindness" which has been observed, often in an epidemic form, among older children and adults upon deficient diets. This trouble can be cured within 12 to 24 hours by cod liver oil. It is also cured by eggs, carrots and other foods rich in vitamin A. "Night-blindness" is apparently merely an early stage of xerophthalmia before the cornea is very obviously affected.

CHAPTER VII

RICKETS, VITAMIN D AND ULTRA-VIOLET LIGHT

THE most obvious of the diseases due to badly chosen diet is rickets. Bow legs are a common deformity of children who have suffered from severe rickets. In slighter cases the bulging forehead may be noticed, but the majority of cases are too slight to be detected except by careful medical or X-ray examination.

Rickets is not entirely a disease of the bones, but affects the whole body. The muscles are flabby and the ligaments are soft and lax. The disordered state of the nervous system is shown by the frequent occurrence of convulsions in rickety children. Even in the early stages of the disease the vitality is lowered and these children are easily attacked by broncho-pneumonia or other infections. The number of these slight cases of rickets is not generally realised. Some years ago Lawson Dick stated that 80 per cent of the children in the L.C.C. schools were rickety. It would appear that slight rickets in childhood is the primary cause of the large number of men rejected as army recruits. In the London area the proportion rejected as physically unfit has been since the War as high as 82 per cent ; these figures were considered typical for the whole country. The percentage of those rejected corresponds with Lawson Dick's earlier estimate of the percentage of rickety children in London schools. General Sir Wilfred Beveridge stated that the chief cause of the men's rejection was malnutrition during

childhood. This does not necessarily mean that they had been underfed but that they had been fed on wrong kinds of food during their period of growth, and so on reaching manhood could only be classed as C3 individuals.

The report by Dr. Corry Mann[1] in 1922 was more encouraging. The number of cases of rickets in London was found to be diminishing. The decrease was ascribed to the good work done by the maternity and infant welfare centres, and by school nurses working in conjunction with the school medical officers. If this improvement were continued, Dr. Corry Mann prophesied that in ten year's time there should be few cases of rickets in London. Figures from Sir George Newman's official report (published 1927) show that about 50 per cent of the children examined, from various parts of England, were rickety.

Two main theories of the cause of rickets have been held for the last forty years.

The one believed it to be due to unhygienic conditions, such as lack of fresh air, exercise and sunlight ; the other ascribed it to some error, or combination of errors, in the diet.

The dietetic origin of rickets can now be correlated with the effect of light.

In considering the relation of rickets and diet it has become quite clear that three factors may be concerned in the production of the disease. These are :—

(1) Lime salts and phosphates.

(2) The fat-soluble vitamin D, or anti-rachitic vitamin, which is generally found in the same foods as vitamin A.

(3) Excess of carbohydrate, that is starch and sugar.

It is obvious that hard bones cannot be formed unless the hardening agents, lime salts and phosphates, are contained

[1] Medical Research Council Report No. 68. *Rickets. The Relative Importance of Environment and Diet as Factors of Causation : an Investigation in London,* by H. Corry Mann, O.B.E., M.D., 1922.

in the food in sufficient quantity. Further, they must be present in the food in proper proportions. Excess of lime salts or of phosphates, particularly of lime, in the diet interferes with the normal calcification of the bones. Vitamin D apparently controls the deposition of these mineral salts in the bones and teeth and compensates for any irregularity in the proportion of lime salts and phosphates. The necessary salts may be contained in the food in the right proportions, but cannot be utilised if there is too little of this vitamin.

A shortage of whole milk in the diet has been responsible for many cases of rickets. Milk supplies the growing child both with mineral salts and with the anti-rachitic vitamin.

Excess of carbohydrate added to the milk leads to a smaller consumption of milk and at the same time causes the diet to be short of vitamin B as well as of vitamins A and D.

The conclusions so briefly summarised here have come from the careful experimental study of each factor, carried out by many workers here and in other countries, together with the examination and tabulation of the history of the development of rickets in children in a very large number of cases.

The part played by a fat-soluble vitamin in the prevention of rickets has been ascertained by numerous experiments on several kinds of animals, chiefly on rats and dogs. The results though varying somewhat with the different animals yet confirm each other. The earliest experiments were made by Professor E. Mellanby on dogs. A series of puppies was given the same food :—

White Bread,
Skimmed Milk, or sometimes Lean Meat,
Vitamin B as Yeast,
Vitamin C as Orange Juice,

so that their basal diet was correct except for fat-soluble vitamins. This basal diet was given to all the dogs, but

they were divided into different groups to test the effect of adding different fats and oils.

Some of the fats added had no preventive action, while others prevented rickets. They can be arranged in two columns :—

Preventing Rickets	*NOT Preventing Rickets.*
Cod Liver Oil.	Linseed Oil.
Beef Suet.	Olive Oil.
Butter.	Cotton Seed Oil.
Egg Yolk.	Palm Kernel Oil.
	Rape Seed Oil.

Lard, Peanut Oil, Coconut Oil were intermediate between the two groups.

The fats preventing rickets correspond with the good fats for vitamin A (see page 48), hence it at first appeared probable that vitamin A was closely related, or identical, with the anti-rachitic substance in foods.

At the same time Mrs. Mellanby studied the effect of the different fats upon the formation of the dogs' teeth. In all cases the food was soft, so that the results obtained were entirely due to the chemical nature of the food and not to any variation in its hardness or softness. Puppies receiving cod liver oil had perfect teeth regularly spaced. Butter produced less perfect teeth and with linseed oil they were very imperfect.

These results pointed clearly to the effect of a vitamin in cod liver oil controlling the calcification of the bones and teeth.

The experiments were repeated later with similar results, but it was then observed that an excess of cereal foods had a bad effect.

Experiments on rats have in the main confirmed Mellanby's results on dogs. The work on rats was on a much more extensive scale and was also concerned with the proportion of lime salts to phosphates as well as of fat-soluble

vitamin in the food. If the proportion of lime to phosphate was not right, the vitamin ensured the deposition of the mineral salts in the bone. The evidence makes it clear that the anti-rachitic vitamin has some controlling action upon the calcification of bone.

Mellanby and other workers were doubtful as to whether the anti-rachitic vitamin was or was not identical with vitamin A. If two vitamins existed, they were extraordinarily similar in distribution and in physical properties. An experiment of McCollum and his co-workers was the first definite indication that cod liver oil contained two vitamins. They found that cod liver oil retained its anti-rachitic power even after vitamin A had been destroyed by heating and æration. The unknown substance controlling the calcification of bone was called vitamin D and the factor concerned with the rate of growth and the prevention of xerophthalmia (page 52) was still known as vitamin A.

Other clear evidence as to the existence of two fat-soluble vitamins came from experiments with green vegetables. Spinach, which is rich in vitamin A, is incapable of preventing rickets. Mellanby observed that certain vegetable oils which did not prevent xerophthalmia had a slight anti-rachitic action. The irregular effect of vegetable oils is explained by a variation in the relative quantities of vitamins A and D which they contain.

Another differentiation of these two vitamins has come from the discovery of the colour test peculiar to vitamin A (see page 51) and by the identification of vitamin D as activated ergosterol (see later, page 61).

The results of feeding experiments upon animals must be considered in conjunction with the clinical observations upon children in hospitals where the diet could be accurately measured and controlled. Investigations upon the causation of rickets in children were carried out in Vienna over a period of three years from 1919 to 1922 by Dr. Harriette Chick

and other representatives of the Medical Research Council and of the Lister Institute, who worked in co-operation with Professor Pirquet and his staff. As a consequence of war conditions practically every child in Central Europe was at that time more or less rickety. Professor Pirquet believed that rickets was an infectious disease like tuberculosis, attacking the badly nourished, but after three years' work with Dr. Chick and her colleagues, he was convinced that rickets was of dietetic origin. In large numbers of young infants maintained under exactly similar conditions of general hygiene, rickets developed only in those who received a diet poor in fat-soluble vitamins.

Dr. Corry Mann arrived at the same conclusions. He made a careful analysis of the dietetic errors in hundreds of cases of rickets in Bermondsey and Southwark and contrasted the rickets-producing diets with those received by healthy children living in the same districts under similar hygienic conditions. The healthy babies were decidedly better fed, getting more milk and animal fat and less carbohydrate. The majority of rickety children had been fed on excessive amounts of white cereals and sugar and little animal fat. Dr. Corry Mann considered that sunlight and other hygienic conditions were of minor importance, because the healthy and the rickety children lived under practically identical conditions except for a difference in the way they were fed.

The information derived from feeding experiments on animals, from observations on children in Viennese hospitals, and from the report of Corry Mann all suggested that a wrong diet was the primary cause of rickets and was contrary to the idea that unhygienic conditions, such as bad housing, lack of fresh air and exercise, were responsible for the disease. There were, however, many observations in support of this second supposition. Experiments on dogs by Findlay and Paton, and an enquiry made by Findlay and Ferguson into the relation of rickets and household condi-

tions in Glasgow suggested that, apart from diet, an unfavourable environment and confinement indoors were productive of rickets. These two divergent views were very difficult to reconcile, but they can now be co-ordinated by the discovery of the influence of ultra-violet light upon rickets.

Sunlight has always been suspected of playing an important part in the prevention and cure of rickets. Rickets is seldom seen in the tropics, but prevalent in temperature regions where there is a distinct seasonal variation in the number of cases. Many more cases appear after the winter than after the summer and most cases improve in the summer sunshine. The cure of rickets by exposure to sunlight was demonstrated by Hess and Unger (1921) in children and in animals and was confirmed by McCollum and others.

The effect of ultra-violet light from mercury vapour lamps as a curative agent in rickets was first tried by Huldschinsky (1920) with positive results. His work has been sufficiently confirmed in this country, America and elsewhere. The effect of sunlight and of ultra-violet light from the mercury vapour lamp upon rickets were tested in Vienna during the course of Dr. Chick's investigations. The curative action of either kind of light was certain unless the cases were very severe, and then cod liver oil had to be given to effect a cure. Babies fed upon a constant diet poor in the anti-rachitic vitamin developed rickets in the winter, but without change of diet were healed by exposure to the spring sunshine. Light could thus to a certain extent act as a substitute for vitamin D, but it could not relieve xerophthalmia by replacing vitamin A.

The effect of sunlight is due to the ultra-violet rays in it. The several forms of artificial-sunlight lamps supply these rays in a concentrated form and are used in hospitals and other institutions as a form of heliotherapy (=sun cure). The ultra-violet rays do not pass through ordinary glass windows. A special glass (vita-glass) is now made which allows the

ultra-violet rays to pass. Dust and smoke in the atmosphere absorb these rays. The use of vita-glass is only beneficial in a clear atmosphere.

The causation of rickets became narrowed down to two possibilities, lack of a specific vitamin in the food, or lack of the ultra-violet rays in sunshine. The action of light corrected the effect of an imperfect diet only if the defects were not too severe nor too long continued.

The subsequent experimental work has been to ascertain how the ultra-violet rays effect the cure of rickets. An accidental observation led to the solution of the problem. Rats on a rickets-producing diet did not get rickets, if their cages containing sawdust were exposed to ultra-violet light. Rats on the same diet and in similar cages with sawdust, but not irradiated, developed rickets. The healthy rats were seen to eat the irradiated sawdust. The preventive agent was therefore not the light itself, but something in the sawdust which had been activated by the light.

The next step was the irradiation of other kinds of food. Foods of various sorts known to possess no anti-rachitic vitamin were irradiated. In these foods the constituent which was activated by light was found to be the fat and not the protein or carbohydrate. Chemical examination of the fats led to the localisation of the active substance in the so-called "unsaponifiable" matter and finally to its association with the well-known chemical substance cholesterol. Examination of pure cholesterol led to the discovery, as an impurity in it, of very small quantities of an allied substance called ergosterol. It was the ergosterol which, on exposure to the ultra-violet rays, became changed into the active vitamin D, "radiostol." Ergosterol is the pro-vitamin or precursor of vitamin D.

The identification of ergosterol and its conversion into vitamin D was the first clear proof of a vitamin being a definite chemical substance belonging to a known class of compounds, the sterols. The beneficial effect of light

upon the body is due to the activation of previously inert ergosterol contained in the fat under the skin. The ergosterol must first be obtained from the food. Food may contain either ergosterol or activated ergosterol, which is the same as vitamin D. If the food contains neither ergosterol, nor vitamin D for a long period, so that the body is drained of its reserve of these substances, then ultra-violet light is powerless to prevent or cure rickets. The activation of ergosterol by light explains also the better quality of summer milk as compared with winter milk. Ergosterol consumed by the cow is activated under its skin in the summer sunshine : the vitamin D formed in the skin circulates throughout the body and is secreted in the milk.

Exercise, massage and fresh air play a part in the prevention of rickets by improving the circulation and assisting the distribution of vitamin D to various parts of the body.

The quantity of activated ergosterol (radiostol) that is required to prevent rickets in animals is extraordinarily minute. The amount $\frac{1}{10000}$ mg. a day is sufficient as a preventive or curative dose for baby rats. For children the quantity is from 2 to 4 mg. daily (.00007 to .00014 oz.).

A practical application of these scientific discoveries has already been made by the extraction of pure ergosterol, its activation by ultra-violet light to radiostol and administration directly in the form of pills or mixed with foods such as malt.

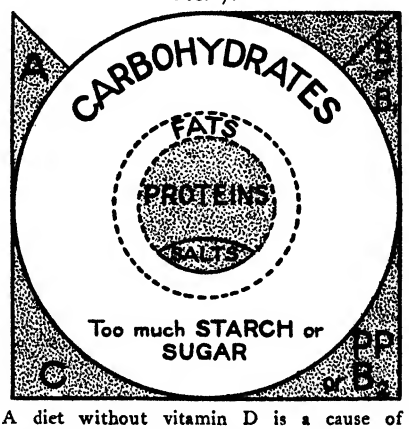
Many other practical applications are possible, such as the incorporation of activated ergosterol in margarines, which could then be standardised according to the quantity of added vitamin D. Ergosterol is a rare substance present in small quantities in certain fats and troublesome to isolate in a pure form. The introduction of vitamin D, and also of vitamin A, into margarine is, however, being carried out by various manufacturers by the use of the so-called "unsaponifiable" matter which can be prepared from cod liver oil and other oils rich in these vitamins.

Though the irradiation of dried milk has been found to improve its anti-rachitic value, the direct irradiation of foods does not appear to be a practical method, as they often become unpalatable after exposure to ultra-violet light and there is a danger of over-irradiating and destroying the active substance. Moreover, any vitamin A is destroyed by ultra-violet rays.

The prevention of rickets thus depends upon an adequate supply in the food of vitamin D, or alternatively, of a supply of ergosterol, which must be subsequently converted into vitamin D in the body by the action upon the skin of ultra-violet rays in sunlight or from a special lamp.

Lack of vitamin D is the real cause of rickets, but a constant feature of rickets-producing diets is an excess of carbohydrate. The carbohydrate is usually in the form of white cereals, malted foods, or sugar and the diet as a whole is therefore lacking in vitamin B. Dr. Corry Mann has particularly emphasised the need for cutting off this excess of carbohydrate as the first step in treatment, instead of still further overloading the diet with milk and cod liver oil. The typical rickets-producing diet is represented in Fig. 7 as lacking in vitamin D and containing an excess of sugar and starch.

FIG. 7.



A diet without vitamin D is a cause of RICKETS. Excess of starch or sugar and a shortage of vitamin B may be contributory factors.

Mellanby interpreted the bad influence of carbohydrates as due to the presence in cereals of a poisonous substance or anti-vitamin, the harmful effect

of these substances being neutralised by vitamin D. There has not as yet been any confirmation of this supposition. Mellanby condemned oatmeal as being particularly rich in this anti-vitamin, but considered that in the ordinary diet its bad effect is counteracted because it is eaten in the form of oatmeal and milk, or as oatcake and butter.

Not only children, but also adults suffer from the effects of too little vitamin D. In Central Europe when the supply of animal fats was very limited as a result of the War, there were outbreaks amongst adults of a curious bone disease ("hungermalacia" or osteoporosis). The sufferers had a peculiar waddling gait, the bones were painful to touch and sometimes fractured spontaneously, yet the disease was quite distinct from scurvy. X-ray examination revealed an alteration in the structure of the bones. Cod liver oil, butter or animal margarine were all helpful in curing the disease, though in severe cases nothing but cod liver oil was of benefit. The disease must therefore have been caused by the absence of one of the fat-soluble vitamins. As green vegetables, though rich in vitamin A, had little curative power, lack of vitamin D must have been the cause. This condition has never been reported in this country.

As sunlight has such a good effect in the treatment of tubercular bone and of lupus, it is possible that vitamin D may be responsible for maintaining resistance to infection by the tubercle bacillus.

Evidence is accumulating that "stone" (=phosphatic calculi) in the bladder is caused by a lack of vitamin D in the food. The function of this vitamin in compensating for a disproportion between the supply of lime salts and phosphates has already been mentioned. The prevalence of urinary calculi in rats on diets deficient in fat-soluble vitamins was mentioned by Mendel in 1920. Van Leersum of Amsterdam observed hundreds of experimental rats upon complete diets and diets lacking in fat-soluble vitamins. None of the rats

on complete diets developed stone, but it was exceedingly common, especially in the males, on the deficient diet. Quite independently McCarrison has noticed that "in rats stone in the bladder is brought about by an ill-balanced diet containing much oatmeal, whole wheat or white flour, and that to avoid stone the excess of these cereals must be compensated for by the consumption of appropriate amounts of milk. Those excellent foods, oatmeal and whole wheat, may prove harmful by causing disturbance in the normal diet, when, *but only when*, the diets containing them are poor in vitamin D." The prevalence of stone in the bladder in human beings on diets with a preponderance of cereals unbalanced by vitamin D makes it probable that, as in the case of rats, it is the shortage of this vitamin which is to blame.

The easy purchase of vitamin D (*irradiated ergosterol*) in various forms has made it possible to take large doses. Ill-effects from over-dosage with such preparations have been described, but there is no reason to anticipate harm if the prescribed quantity is not exceeded.

Excessive doses of irradiated ergosterol were found harmful to rats, but equivalent doses of ergosterol were harmless. It is thus preferable to have ergosterol in the diet and to secure its activation through the skin by exposure to sunlight, or ultra-violet light. Ergosterol is found in cod liver oil and various fats, but its real origin is in plants, chiefly fungi (mushrooms, etc.) and yeast. Fungi are not common articles of food. Yeast is used in making bread. More yeast could be put into bread, and yeast could be substituted for baking powder in scones and cakes.

The report (1929) of the Medical Research Council points out that a proper diet is better and cheaper than treatment with ultra-violet light, which had not proved as efficacious as expected. The reason may have been lack of ergosterol in the diet. The two factors, ergosterol and ultra-violet rays, as pointed out on page 62, are essential for the production of vitamin D.

CHAPTER VIII

VITAMIN E

RATS can be successfully reared at a normal rate on a synthetic diet of pure casein (milk protein), starch, lard, milk, mineral salts and yeast, that is on a diet containing all the known essentials for nutrition, but on such a diet there is little or no reproduction. Rats do not need vitamin C.

The sterility of the animals is not overcome by increasing the proportion of protein, or of yeast, nor by the addition of cod liver oil. A different salt mixture has no better effect.

The introduction of lettuce, or of dried leaves, or of whole wheat or oats, or egg yolk, or liver into the diet gave the stimulus for reproduction.

This fact was first announced by Evans and Bishop in 1922 and has been confirmed by other workers in America. Since all known factors were supplied in the synthetic diet which sufficed for growth, the conclusion was that another vitamin was necessary for reproduction. It is termed vitamin E.

Experiments have been repeatedly made to try and secure reproduction by altering proportions without any real success in the production of young. On these diets reproduction has been secured on adding wheat germ oil, or hardened cotton seed oil. Neither of these oils contains vitamins A and D which are present in cod liver oil. A third vitamin is thus present in some fats of different origin.

The examination of the fats for vitamin E has shown it

to be present in the unsaponifiable portion. Further examination of this material has shown that it is not in the part in which one finds vitamin D, but in that portion in which one would find vitamin A. The two are not apparently identical because vitamin A is easily destroyed by oxidation, whilst vitamin E is not so quickly destroyed. This fraction, not containing vitamin A, if added to the diet allows of reproduction in rats on the synthetic diet.

So far as the nutrition of man and animals is concerned, the ordinary mixed diet containing meat, eggs, green leaves and seeds supplies plenty of vitamin E. The addition of extra vitamin E to foods has been shown not to lead to any extra production of young. A well-balanced diet of all the essentials leads to good reproduction and upbringing of young.

It has also been observed that mother rats, though bearing young, are not always able to rear them from want of sufficient milk. Another vitamin was at one time supposed to be concerned in lactation. It has, however been found that extra vitamin B in the diet improves lactation. In fact, three to five times as much vitamin B is wanted by the mother at this period. There is thus no need to assume a special vitamin for lactation. Larger amounts of vitamin B are needed by pigeons for the hatching of their eggs and rearing of their young. Fat soluble vitamins A and D are also required for lactation and rearing in amounts above the normal.

CHAPTER IX

THE EVERYDAY DIET: ITS COMPOSITION AND COMMON ERRORS

HAVING learned how the diet must be composed we are in a position to examine the common everyday diet.

In considering the provision of the daily food, it is first essential to look into the total quantities of the different foodstuffs consumed and to have some standard to work by. Under ordinary conditions of life it is impracticable to determine the exact quantity of each kind of food which is eaten. No one would care to have his dinner with his plate as the scale pan of a balance, though the method might be instructive and in these days of lovely spring balances with glass pans, considerable amusement might be afforded for a time in calculating out how nearly individual appetite corresponded with the actual physiological requirements.

Measurement is the basis of all science. The eye and the judgment are easily deceived, but as soon as precise measurements are made one is dealing with facts and getting out of the realm of mere opinion.

The only method of ascertaining the average individual food consumption is from the daily household budget of quantities purchased and apportioning it according to the number of people. Even on this basis many allowances have to be made, since a pound of food purchased does not represent a pound of food eaten. Allowance must be made for the inedible waste, such as bone and skin in meat, shell of

eggs, outer leaves and peelings of vegetables and fruit. The allowance for such waste portions is difficult to estimate. Many tables have been compiled of the amount of waste matter in various foods. These are not much use to the ordinary householder, but are of great value to those who have to cater for large institutions, and for the Army and Navy. The usual allowance for waste is 10 per cent. An average standard of food consumption can be set up from the household food budgets which have been carefully studied in Germany, the United States, and in certain towns of this country, especially in York by Rowntree for his book *Poverty*. The average is :—

Protein.	*Fat.*	*Carbohydrate.*
3½ to 4½ oz.	2½ to 3½ oz.	14 to 18 oz. *dry* weight daily.
or	or	or
100 to 120 gm.	70 to 100 gm.	400 to 550 gm.

These statistical figures of the average diet actually consumed correspond very closely with those found by exact physiological measurements on individuals who have been used as experimental subjects in the apparatus called a calorimeter, by which every detail of intake and output of energy can be accurately measured.

From the above data certain valuable proportions can be calculated. Thus, taking the average protein as 4, fat as 3, and carbohydrate as 15, the total quantity is 22 ; so that protein is $\frac{4}{22}$, fat is $\frac{3}{22}$ and carbohydrate is $\frac{15}{22}$.

For simplification in making calculations these figures can be more conveniently expressed as :—

Protein $\frac{4}{24}$ or $\frac{1}{6}$; fat $\frac{4}{24}$ or $\frac{1}{6}$; and carbohydrate $\frac{16}{24}$ or $\frac{2}{3}$; that is, a typical diet consists of $\frac{1}{6}$ protein, $\frac{1}{8}$ fat and $\frac{2}{3}$ carbohydrate (dry weight) as represented in Fig. 1 (page 13).

It is not generally realised what a large proportion of the diet, $\frac{2}{3}$, consists of carbohydrate, which in these days is mainly white flour and sugar.

Some of the protein included in this proportion is plant protein derived from the vegetable food. Flour and other cereals contain about 10 per cent of protein. The amount of " complete " protein from animal foods like meat, fish or egg is about one half of the total protein. The protein ratio in the whole diet should be subdivided into $\frac{1}{12}$ plant protein and $\frac{1}{12}$ animal or " complete " protein.

Comparison of these figures should be made with those of the constituents of human and cow's milk.

	Protein.	*Fat.*	*Carbohydrate.*	*Total.*
Human Milk	2.0	3.5	6.5	12 parts solid matter
Cow's Milk .	3.4	3.7	4.9	12 „ „ „
i.e.:				
Human Milk	$\frac{1}{24}$	$\frac{7}{24}$	$\frac{13}{24}$ or approximately	$\frac{1}{8}$ $\frac{2}{8}$ $\frac{3}{8}$
Cow's Milk .	$\frac{7}{24}$	$\frac{7}{24}$	$\frac{10}{24}$	$\frac{1}{4}$ $\frac{1}{4}$ $\frac{1}{2}$

These ratios show that on changing from infant to adult food the proportion of fat is reduced from $\frac{1}{3}$ to $\frac{1}{6}$ and the carbohydrate increased from $\frac{1}{2}$ to $\frac{2}{3}$. The proportion of protein in human milk and in the adult diet is the same, but there is this important difference that the protein in milk is entirely animal protein, which means that the infant is really having a higher ratio of " complete " protein than the adult. On weaning, by overloading the diet with carbohydrate, the proportion of " complete " protein is generally reduced to a lower ratio than in the adult diet ; at the same time the proportion of fat is reduced too much. As already pointed out the overloading with carbohydrate is a contributory factor to the development of rickets in children (see page 56). During the whole period of growth the child's diet should approximate to the ratios found in milk, that is, it should contain at least as much animal protein, rather more fat and rather less carbohydrate than the adult diet.

Let us consider a specimen day's food for the adult, not

of ideal composition but such as might be consumed any day. The proportions of protein, fat and carbohydrate in the diet are quite simple to calculate if the table on page 114 is used. The foodstuffs are differentiated into animal and vegetable sections added up separately to make it clear what proportion of the protein is of animal origin and may therefor be considered as "complete."

AN AVERAGE DIET

		OZS. *DRY* WEIGHT		
		Protein.	*Fat.*	*Carbohydrate.*
½-pint Milk (10 ozs.)	gives	⅓	⅓	½
One Egg (2 ozs.)	,,	¼	⅓	—
Meat, Fish (4 ozs.)	,,	⅔	⅓	—
Meat-Fat, Butter	,,	—	1½	—
Cheese (2 ozs.)	,,	½	½	—
Total from Animal Foods		1¾	3	½
Bread (8 ozs.)	gives	½	—	4
Potatoes (10 ozs.)	,,	¼	—	2
Cereals, (Rice, Flour, Biscuits, Cake) (8 ozs.)	,,	¼	—	4
Sugar (2 ozs.)	,,	—	—	2
Vegetables, Fruit, Jam, etc.	,,	¼	—	1½
Total from Vegetable Foods		1¼	—	13½
GRAND TOTAL (Dry Weight)		3	3	14

All these figures are given on the moderate rather than the generous side. These amounts can easily be verified by taking the daily portions of these foodstuffs and weighing them. Some of the cheese can be replaced by more meat, fish or egg.

The quantities of protein, fat and carbohydrates add up to the total for the average figures compiled from statistics (page 69).

A diet on the above scale satisfies the physiological requirements of the average individual as regards *quantity* of food. The quantity as pointed out on page 8 is varied according to the amount of work or exercise and the degree of exposure to cold and so 18 ozs. or more of carbohydrate may be eaten.

The central circle of "the Square Meal" can be considered as filled by the average diet.

Quantity and Quality of Protein.

The specimen diet shows that the quantity and quality of the protein satisfies the daily requirement. In this country most people eat some meat, egg, cheese, fish or drink some milk and thus ensure a sufficient supply of "complete" protein. It is possible that the very poor do not get quite enough as animal protein is expensive. Some kinds of fish, tinned or corned beef and condensed skimmed milk are cheap and supply just as good quality protein as the more expensive cuts of fresh meat.

There is evidence that smaller daily quantities than 1¾ oz. (*dry* weight) of "complete" protein will suffice, as it did in Denmark during the War at a period when the effect of our blockade was being severely felt. Many years ago Chittenden maintained that the ordinary standard total quantity of protein could be reduced from 3½ to 2 ozs. without any ill effect for individuals of all types. More recently Hindhede has used even smaller quantities than those of Chittenden and kept people in perfect health.

In general one may hazard that the amount of "complete" protein consumed by adult Europeans is much larger than the actual physiological requirement. A large number of people now live permanently in hotels and in the better class

hotels the consumption of protein is very large. The average consumption of bread per person per day in a large London hotel has been given as only about 4 ozs., half the normal amount. It is quite usual to serve fish for breakfast followed by sausages or eggs and bacon ; fish and meat or poultry, and cheese are served at lunch and in a table d'hôte dinner three to four or more courses consist very largely of protein. In hotel and restaurant meals of this kind protein takes the place of carbohydrate as the chief fuel food. The consumption of protein in the ordinary household is on a less lavish scale.

The first error in our diet will thus be a too large consumption of meat. This surplus of meat not only upsets the balance of the day's food, but it leads to the overtaxing of the liver in its digestion and of the kidney in the excretion of its waste products. The total consumption of meat has increased greatly in this country during the last fifty years ; at the same time gout, which is attributed to excessive meat-eating, has decreased. Fifty to a hundred years ago excessive amounts of meat were eaten by the richer classes and it was a luxury amongst the working classes. The consumption of meat has become more evenly divided. At the present time the only people who are in danger of a serious shortage of " complete " protein are the very poor and a few people of eccentric dietetic habits.

Where the income is small and the expensive protein foods like meat, fish, cheese, can only be purchased sparingly, it is very necessary to remember that the growing children have first claim for this special body-building material. It is usually the men-folk, who, as chief wage earners, get these expensive foods and the children are given bread and jam or margarine. This is just the wrong way round. The bread and jam or margarine will supply a man with energy for hard manual labour but cannot help the child to grow. The nursing or expectant mother has also special needs for

protein so that as a rule the man ought to be considered *last* where the supply of protein foods is limited.

The Balance of Fat and Carbohydrate.

The function of fat is like that of carbohydrate to supply heat and energy. Within certain limits fats and carbohydrates can be used alternatively in the diet, but if there is too large a proportion of fat, then the fat is incompletely oxidised. Carbohydrate burns more quickly than fat and for the complete combustion of fat in the body carbohydrate must be burned along with it. Mixed with carbohydrate it is as if fat burns with a clear flame, but if there is too little carbohydrate it burns smokily. The half-burned products of fat are poisonous to the body and produce headache, sickness and even coma. This condition of *ketosis*, or acidosis, as it is called, occurs :—

(1) In starvation, a condition in which the reserve stores of fat in the body are burned in the absence of carbohydrate.

(2) In diabetes, a disease in which through failure of the pancreas, the body is unable to use any sugar and is to all intents and purposes suffering from carbohydrate starvation.

(3) In children or grown-ups eating too much fat in proportion to the amount of carbohydrate.

(4) In the pregnant woman ; the uterus draining the sugar rapidly from the blood may leave an insufficient amount available for the proper combustion of the fat.

In the specimen diet the proportion of fat and carbohydrate is suitable for ordinary conditions.

The Vitamins. Deficiency : Absence and Shortage.

As explained in the previous chapters, the four corners of the " Square Meal " represent the supply of vitamins in the different classes of foods. A full and adequate supply of each vitamin must be provided to make a " Square Meal." Absence of the vitamins leads to the definite deficiency diseases : scurvy, beri-beri, pellagra, rickets. It is necessary to distinguish between the *absence* or nearly complete absence,

represented in the diagrams by a missing corner, and the *shortage* or too little of a vitamin, represented diagramatically by half instead of a whole corner. For shortage of one or more vitamins the term "vitamin underfeeding" has been suggested.

Except in rare instances we do not suffer in this country from the definite deficiency diseases, that is from the absence of any one vitamin, but the health of the nation does suffer from the effects of a chronic slight shortage of one or more of the vitamins, in particular of vitamins B or B_1 and vitamins A + D. Such a condition of vitamin-underfeeding is inconsistent with health. Examination of each "corner" must be made separately to discover how the shortage is likely to arise. We have already seen that in the case of a long-continued slight shortage of vitamin B (pages 41, 42) the damage done to the digestive tract has gone too far to be repaired. In the same way people who have lived on a diet mainly composed of white bread and sugar for thirty or forty years cannot hope by a change of food to get their digestive tract to work normally. All that can be done is to give a certain measure of relief and to stave off worse consequences. It is the next generation who must be prevented from suffering in the same way.

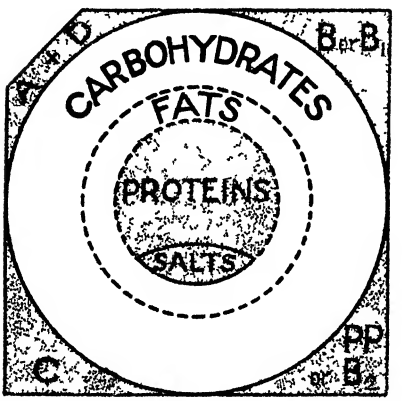
The A + D Corner.

Meat, fish, eggs and green vegetables contain these vitamins and provided that the adult eats these foods, he will get vitamins A + D in sufficient amounts and he can safely eat margarine instead of butter. The requirement of the adult for these two vitamins is less than that of the growing child, but the adult needs some vitamin A for the prevention of the eye disease, "xerophthalmia," and of other infective conditions; vitamin D is needed for the prevention of bone disease (osteoporosis) and of "stone" in the bladder (phosphatic calculi). There are indications that the amount of vitamin D in the food needs to be pro-

portional to the total food as in the case of vitamin B.

Though adults generally get enough of the fat-soluble vitamins A + D the position with children is different. Relatively the child needs more of these vitamins than the adult. The common error is overloading the child's diet with carbohydrates at the expense of all the other constituents of the food.

Fig 8.



Shortage of vitamins A and D leads to lowered resistance to infections, decayed teeth and rickets.

The shortage of fat-soluble vitamins, fig. 8, is not confined to the children of the poor. Many children are the victims of over-fussy mothers and nurses. A number of natural sources of these vitamins are forbidden: meat, as "too stimulating," so the child gets no meat fat; eggs as "too binding" are only given occasionally. All fatty foods are considered "too rich," so white fish is given instead of oily fishes. The fish is boiled or steamed instead of being egg and bread-crumbed and fried in dripping or butter, the way the child prefers it. Bacon fat, which is lacking in fat-soluble vitamins is held in high esteem in the nursery and generally administered daily. Butter and jam are not allowed on the same piece of bread and the child prefers jam. There seems a conspiracy to deprive the nursery child of the foods containing vitamins A + D. It fattens upon sweet and starchy food and is considered fine and well nourished. It is inactive and late in walking and does not work off its

fat by exercise. The flabbily fat type of child is proverbially "chesty." Like the experimental animals on the same kind of food, it is prone to lung infections. Remembering the special action of vitamin A in increasing resistance to infections, especially of the lung and eye, and of vitamin D in preventing rickets, it is advisable to give plenty of foods rich in fat-soluble vitamins to those of all ages. The value of cod liver oil in the treatment of lung diseases and of rickets has long been known. The great concentration of vitamins A + D in cod liver oil makes it possible to give an abundance of these vitamins without overloading the diet with fat and risking digestive disturbance. By giving too much cod liver oil the general balance of the diet by vitamin B may be disturbed. Large amounts of cod liver oil should not be given unless the supply of vitamin B is increased proportionately. This balance is particularly necessary in the case of children who do not easily digest fat. If extra vitamin B is given in the form of yeast extract, or wheat germ, the power of digesting and assimilating fat is improved and the children are able to take egg, or cod liver oil, which previously upset them.

Rickets is by no means uncommon in breast-fed children. In these cases it is the mother's diet which is at fault. She cannot produce good milk if her food is poor in fat-soluble vitamins and overloaded with carbohydrate. It is essential for the prevention of rickets that the nursing mother should choose fats which contain vitamins A + D and carbohydrates which supply vitamin B.

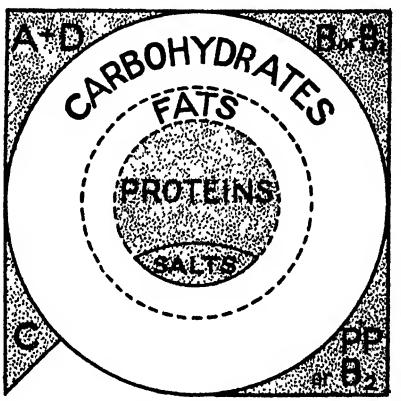
The C Corner.

In considering possible errors in connection with the C corner of the "Square Meal" it is necessary to check all the little amounts of the various fruits and vegetables in the day's food to see if the total is equivalent to 1 oz. of orange juice. This vitamin is generally contained in foodstuffs of low fuel value and consequently for economical reasons

is likely to be omitted. The typical diet (page 71) suggests 10 ozs. of potato and if this amount is taken there is little fear of scurvy even in the absence of other vegetables or fruit. The chances are that this amount of potato may not be consumed, or that it may be spoiled by over-cooking, and then in the absence of fruit or salad we are going on the road towards scurvy.

There is evidence that potato is the chief antiscorbutic food eaten by many people amongst the poorer classes. Some of them are quite content to have no fresh fruit or green vegetables and greatly prefer pickles or sauces as a relish with their meat. Scurvy invariably appears after a failure of the potato crop. In 1917 in Manchester, Newcastle and Glasgow outbreaks of scurvy followed the failure of the potato supply. Londoners are well provided for even in the winter months; cheap vegetables and oranges are always on sale in the street markets. In small country villages there is a great dearth of fresh vegetables in the winter and the scanty supply of homegrown potatoes is eked out carefully.

FIG. 5.



Shortage of vitamin C leads to vague ill-health, sallow complexion, fatigue, lowered resistance to infection.

In schools, institutions and boarding houses in which the catering is done as economically as possible, there is a tendency to omit fresh fruits and salads as they are considered unnecessary luxuries. A daily dish of stewed prunes or figs is believed to take the place of fresh fruits and beetroot

or pickles are served instead of green salad. Dried peas, beans or rice are sometimes served instead of green vegetables. The value of the green vegetables provided may be spoiled by overcooking, or the use of soda. A large number of people have thus only a slight margin of safety.

Professor Sir Gowland Hopkins traced a period of ill-health in a boys' preparatory school to a lack of fresh fruits and vegetables during the winter. Good health was restored by increasing the quantity of these fresh foods. The prevalence of influenza and other infectious diseases in the first three months of the year is well known. We malign our climate and put down all our ills to its vagaries, but the prevalence of infectious diseases in the early spring may be largely due to a small consumption of fresh fruits and vegetables. During the virulent influenza epidemic which followed the War, it was observed that allotment holders who were provided with plenty of fresh-cut green vegetables suffered less from the disease.

The food provided at the cheaper restaurants is nearly always very poor in vitamin C and indeed it is not always easy to select a " Square Meal " from the varied bill of fare. The food is sometimes cooked at a central kitchen and distributed to branch depots. It is re-heated and perhaps kept simmering for hours till all the vitamin C is destroyed. Appetising fresh fruits are not conspicuous articles at the cheaper restaurants. Fruit salad is a popular dish but is often made from dried fruits. " Home-made " lemonade sounds good, but on investigation may prove to be a sickly-sweet artificial concoction with a fragment of a slice of lemon on top to give local colour.

There are no particular warning signs of a shortage of vitamin C, so it is difficult to form any judgment when the danger point is approaching. Perhaps the earliest sign is a change in the complexion. The skin becomes sallow and muddy. There is a loss of vigour and of the sense of well-

being, fatigue is felt after slight exertion. Fleeting pains in the limbs and joints may be mistaken for rheumatism. Another sign is the lowered resistance to infection and the slow healing of any wound. During the War wounds were observed not to heal in men who were on the border-line of scurvy.

Everyone can make sure that some fresh fruit, or an ample helping of potatoes, or green salad, is eaten every day. At tea time, instead of jam it is better to serve tomato, cress or lettuce sandwiches. If the money that is spent on sweets were spent on fruit, how much healthier everyone would be. Oranges and lemons are so cheap and plentiful when home-grown antiscorbutics are scarce, that no one need be short of vitamin C at any season of the year.

Acid fruits are sometimes avoided for fear that they may cause "acidity." This fear is groundless as the acids in fruits are burned in the body leaving an alkaline ash which neutralises acids arising from the protein in the food. In the case of children getting nettlerash from eating certain fruits, it was observed that these fruits could be eaten with impunity after wholemeal bread and flour had been substituted for the white articles.

The PP or B_2 Corner.

Pellagra only occurs in this country under exceptional circumstances. The ordinary diet contains meat, fish, milk, eggs and cheese ; all these foods provide B_2, the pellagra-preventing vitamin.

There are only two classes of people who are likely to be short of this vitamin : those who cannot afford the foods just mentioned and subsist largely upon white bread, and secondly, those who have deliberately chosen an eccentric diet.

Amongst these two groups, the late Dr. Chas. Mercier reported cases of mental disease which were successfully treated by increasing the amount of meat in their food.

Mental disease is one of the most serious signs of pellagra, the deficiency disease which is caused by a lack of vitamin B_2.

The germ and bran of cereals also supply vitamin B_2, and it is essential that those who have through poverty to rely on bread as their mainstay should eat wholemeal and not white bread. Vegetarians who abstain from a number of animal foods rich in vitamin B_2 as a rule eat wholemeal bread and also peas, beans and lentils which provide a considerable amount of this vitamin. Tomatoes and other fruits and vegetables contain small quantities of the vitamin.

The B or B_1 Corner.

The remaining corner, B, though taken last, is not the least important. There are two essential considerations about vitamin B. *The one* is that the amount in the food must bear a constant relation to the quantity of food eaten. The more food eaten the more vitamin B is required. The amount cannot be satisfactorily expressed in terms of a daily dose : it is a question of balance. *The other* is that the ordinary foods contain very small amounts of vitamin B. The only two foods really rich in it are wheat germ and yeast extract. The comparative vitamin B values of foodstuffs is shown in Table 6 (page 39), which gives the percentage amounts which must be present to balance a diet of white flour and other foods poor in this vitamin.

The question is whether the foods ordinarily eaten that have vitamin B contain enough to balance the foods which have none. *The answer* is decidedly NO.

In our typical day's diet, milk, eggs, potatoes and cheese contain some vitamin B. Butter, meat, white bread, biscuits, other cereals and sugar do not contain appreciable amounts of it. Milk and cheese together contain enough vitamin B to balance their own fuel value but have no excess. The egg yolks have enough to balance the egg whites and perhaps some over to balance the butter and other fat ; the

potatoes will balance the small allowance of sugar. The white flour in the bread, biscuits, puddings, etc., and other white cereals will be unbalanced. If more than 2 ozs. of sugar be eaten, which is very likely, in the form of chocolates, sweets and cakes ; or if more butter or meat be taken, the condition of underbalance will be worse. The B corner is not filled by the average diet. Unless large quantities of eggs, pulses, nuts, liver and other foods with a high vitamin B value are eaten, which is not generally done, the carbohydrate in the white flour, bread, cereals and sugar is not compensated for.

In this connection the diet which failed to prevent beriberi amongst our troops in the Dardanelles should be studied.

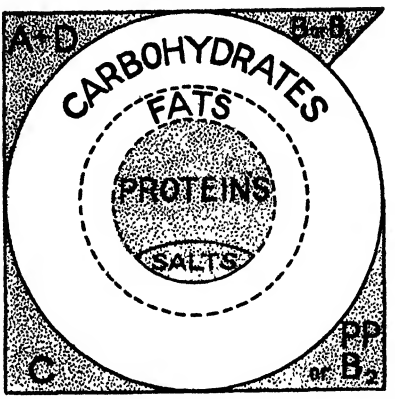
The daily allowance for each man was as follows :—

	lbs.	*ozs.*	
White Bread	2	0	2 lbs. 8 ozs. of foods which do not contain vitamin B.
Rice	0	4	
Sugar	0	2	
Margarine or Butter	0	2	
Meat or Bacon	0	6	8 ozs. of foods balanced by their own vitamin B.
Cheese	0	2	
Peas, Beans or Lentils	0	0 to 4	2 to 6 ozs. of foods rich in vitamin B.
Potatoes or fresh Vegetables	0	2	

This diet is not unlike that of the working classes at home except for the absence of eggs and a shortage of potatoes and other vegetables. It is therefore probable that it is eggs and potatoes which are the chief safeguards in this country against the appearance of the paralysis seen in advanced beri-beri. In winter, when eggs are dear and scarce, potatoes are the one redeeming feature in the diet of the poorer classes for vitamin B as well as for vitamin C. The majority

of the people are living on the kind of diet which in experimental animals just prevents the appearance of paralysis typical of advanced beri-beri, or which delays the appearance of these symptoms for a very long time. Before the advanced signs of beri-beri develop in these animals, they first suffer from constipation and may die from colitis or appendicitis. Constipation, appendicitis and colitis are common everyday ailments which we try and avoid or relieve with pills. It has even been asserted that cancer comes from a primary condition of indigestion and constipation and J. Ellis Barker, in his book *Cancer*, has amassed a vast amount of evidence in support of this view. The statistics show that cancer and diabetes are increasing all the world over and so is the consumption of starch and white sugar. It would appear that it is the starch and sugar diet with its shortage of vitamin B which is responsible for the preliminary troubles which may culminate in cancer or diabetes. Yet we put up beet sugar factories in this country assisted by the Government ! We ought to eat the whole sugar cane or the whole beet, but not the extracted sugar. We need the residues which are discarded.

FIG. 10.



Shortage of vitamin B leads to chronic disease of the heart, digestive tract and endocrine glands.

The question of an adequate and ample supply of vitamin B in the diet is a fundamental one where white flour or other white cereal is the staple food, made worse by the addition

of large amounts of sugar. The statement so often made that white bread eaters get plenty of vitamin B from the rest of their mixed diet is not justified by facts. The chief natural supply of this vitamin is from the seeds of plants, and if the germ and bran are removed from our staple cereals by the milling, the vitamin B is removed, and its loss can only be compensated for by the addition of some specially concentrated vitamin B food such as yeast extract (Marmite) or wheat germ (Bemax).

It has been claimed that as yeast is so rich in vitamin B, the addition of yeast in making bread, supplies enough of this vitamin and that it is therefore unnecessary to eat wholemeal bread. This claim is wrong. Feeding experiments show that in order to compensate for the absence of vitamin B from white flour it would have to be mixed with 12 per cent of baker's yeast instead of the usual 2 per cent or less. White bread does not therefore carry any appreciable amount of vitamin B and requires to be supplemented by one or other of the foodstuffs especially rich in it.

Fruits and vegetables are usually considered to be rich in vitamin B, but the figures given in the Tables 5 and 6 (pages 37 and 39) do not confirm this belief. The fruits tested had no value. The mistaken idea of the value of vegetables has probably arisen from the figures in Table 5 for rats. The values given in this table are for *dried* cabbage and spinach and must be multiplied by 90 to allow for the water which is present in the fresh material. Whether in the wet or dry state no human being eats these enormous quantities of vegetables.

Although potatoes in comparison with yeast and eggs are poor in vitamin B, they must be considered as a valuable source of this vitamin because they generally form a large proportion of the ordinary diet in this country. Potatoes might with advantage be used in still larger quantities and

take the place of white bread, as they supply both vitamins B and C in which white bread is lacking.

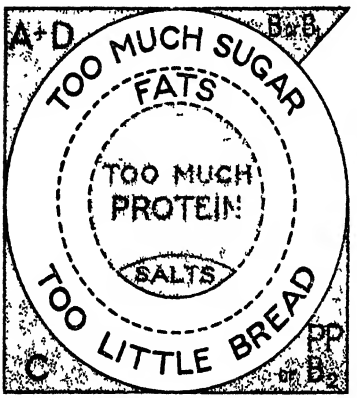
Indirectly there is other evidence that the majority of white bread eaters are short of vitamin B. Those who have tried the effect of regularly taking extra wheat germ or yeast extract have been astonished at the feeling of improved health and energy which they have experienced. They no longer have to take medicines to relieve constipation: chronic ailments, not previously suspected to be due to diet, have disappeared : especially have disorders of the heart and digestive system responded to treatment with additional vitamin B. Cases of chronic rheumatoid arthritis have benefited by taking wheat germ in conjunction with other treatment.

The general improvement in health occasioned by taking additional vitamin B points clearly to the inadequacy of the ordinary diet. If wholemeal flour were substituted for white flour and the amount of sugar reduced, there would be no shortage of vitamin B in the diet of the people as a whole.

A Combination of Errors.

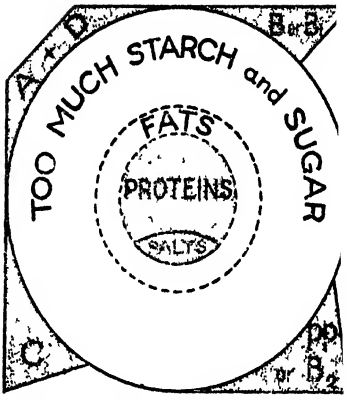
In many cases there is a shortage not only of one, but of several vitamins, and combined with this general vitamin underfeeding there may be a lack of proportion as regards the supply of protein, fat, carbohydrate and mineral salts. The most common errors in the ordinary diet can be illustrated by means of modifications in the " Square Meal " diagram, by chipping the corners and by altering the relative sizes of the circles.

FIG 11.



The diet of the RICHER CLASSES contains too much sugar, meat and fish, and too little vitamin B

FIG. 12.



The diet of the POORER CLASSES contains too much starch and sugar and too little of the vitamins, especially of A + D and B

In the case of the poorer classes there may be a shortage of all the vitamins and an excess of flour and sugar. In the food of the very poor there may be a shortage of protein also. In the diet of the richer classes there is generally an excess of protein, fat and sugar unbalanced by vitamin B, but vitamin C is well provided.

Comparing Fig. 12 with Fig. 7 (page 63) it is seen that the poor man's diet resembles the rickets-producing diet. Figs. 7, 11 and 12 all have one feature in common, a shortage of vitamin B.

No two people have precisely the same diet, and as many of these diets may be unsatisfactory in diverse ways the signs of ill-health which they will eventually produce are many and varied. Since diseases as unlike each other as pernicious anæmia and certain forms of goitre may both be alleviated by appropriate diets, it would appear that they owe their origin to abnormalities of diet.

It is not enough just to provide good food. It is necessary to see that it is fairly divided and actually eaten. From time to time cases of pellagra, beri-beri and scurvy have cropped up in institutions in which the diet was well planned. Investigation traced the occurrence of the disease to individual fads and the habitual refusal of certain articles of food.

A Shortage of Vitamins and Lowered Resistance to Infection. In addition to a number of diseases directly traceable to the lack of some essential vitamin in the food, mention has also been made of the part played by the various vitamins in keeping up the resistance of the body to infections by micro-organisms. For instance, the absence of vitamin A in the food leads most certainly in the majority of cases to xerophthalmia, an inflammatory condition of the cornea caused by the lowered resistance of that tissue to infection. No antiseptic local treatment will cure the disease, the only remedy is to give vitamin A in the food, and this acts with magical speed. The fat-soluble vitamins A + D both assist in maintaining the resistance to infections of the lung such as broncho-pneumonia and consumption. Whooping cough, measles and bronchitis are far more likely to end fatally in children who are rickety. Rickety puppies are more easily affected by distemper, broncho-pneumonia and mange than puppies on a complete diet. Dogs fed on wholemeal bread are said to be immune from dog-hysteria, a disease which attacks those fed upon white cereals.

Lack of vitamin C was found during the War to delay the healing of wounds and increase the risk of septicæmia. Boils were prevalent among troops on deficient diets, and in this connection it may be remembered that yeast which is rich in several vitamins is an old-fashioned cure for boils.

Pellagrins, the sufferers from lack of vitamin B_2, have

a very low resistance and often die from some infective condition before the actual pellagra is far advanced.

In the case of man and animals it has been observed that ulcers and inflammatory conditions of the digestive tract, dysentery, and infection by worms are much more common in those on deficient diets.

Collecting data from a very large number of experimental animals (1252 pigeons, 2463 rats) McCarrison has produced very convincing evidence of the protective power of a complete diet. The following figures give the relative mortality :—

Ill-Fed.	*Well-Fed. All under perfect hygienic conditions.*
31.4	1.0 per cent mortality of rats.
13.5	0.63 per cent mortality of rats from lung diseases.
3.3	0.09 per cent mortality of rats from acute gastro-intestinal troubles.
5.8	0.06 per cent mortality of pigeons from heart disease (chiefly pericarditis).
90.0	less than 10 per cent mortality of mice injected with mouse typhoid.

McCarrison observed that true dysentery arose in ill-fed monkeys while well-fed ones in the same room escaped. Ill-fed pigeons became infected with bacillus suipestifer and with epithelioma contagiosum while well-fed birds escaped. Birds, normally immune to anthrax by reason of their high blood temperature, became susceptible to anthrax infection on a diet deficient in vitamin B, very likely as the result of the fall in body temperature which this vitamin deficiency may cause. He found guinea-pigs on diets poor in vitamin C to be less resistant to tuberculosis. Calves on deficient diets develop chronic interstitial nephritis due to B. coli infection. McCarrison confirms the early experience of M. J. Rowlands that tuberculosis can be eliminated from herds of swine, animals very prone to this infection, by giving them a well-balanced diet of vitamin-rich food. Another impor-

tant observation was that on vitamin-poor diets animals were less resistant to poisons. The ability of the tissues to render harmless certain poisons, both bacterial and others, is reduced by diets deficient in vitamins.

Man provides many examples of a similar kind and Col. McCarrison quotes two instances. In Northern Melanesia the native diet is poor in suitable protein, mineral salts and vitamins. Correlated with these food deficiencies is the poor physique of the natives and a high mortality from diseases of the lungs and of the digestive tract. Outbreaks of broncho-pneumonia in children occur on diets deficient in vitamin A and disappear when this vitamin is given. In the opinion of McCarrison tuberculosis, leprosy, cholera, dysentery, plague and malaria in India have often a malnutritional element in their genesis and course.

If there were no other specific ill-effects attributable to the vitamins surely their power of increasing the resistance of the body to infections and to certain poisons would alone be a sufficient justification for the claim that the inclusion of an adequate supply of all the vitamins in the diet of man and of live-stock is a primary factor in preventive medicine and one which is as yet insufficiently applied. Just as no surgeon willingly operates except under aseptic conditions, so in the future no physician will attempt treatment until his patients are placed on " complete " diets.

General Summary.

Civilisation has made it too easy to get wrong foods of all kinds and difficult to get the foods we ought to eat. Natural foodstuffs form but a small part of the present-day diet, because they have for convenience been replaced by less perishable foods. As we walk down any street of shops we are continually being tempted by displays of groceries, sweets and cakes. Whole shop-fronts are dressed artistically with the foods we should not eat.

The figures of the Board of Trade show that the imports of sugar have increased enormously per head of the population, thirty times as much sugar is used per head now as compared with a hundred years ago. Sugar, in its concentrated form, is not a natural food. At one time honey in very limited quantities was the only sweetening agent available. Sugar forms no part of the diet of the Indian hill tribe of the state of Hunza, whom Colonel McCarrison describes as living on natural foods and having the perfection of health and physique.

A very varied and " tasty " diet may contain little or none of the vitamins, providing only fuel and protein. On the other hand, very monotonous diets may contain all the essentials, such as milk and potatoes, upon which the Irish peasant thrived and produced children free from rickets. During the war the Danish people had to exist upon very plain fare which yet supplied everything necessary. Meat was unobtainable except by the very wealthy, and the rest of the people lived upon

Bread, made of Whole Rye, Wheat Bran and Barley.
Barley Porridge. Milk, in considerable quantities.
Butter. Greens. Potatoes.

A terrible outcry would arise if the British working man were given such plain fare, yet it is physiologically an excellent diet. During the period of its consumption the death rate in Denmark fell by 34 per cent, and fewer new cases of cancer were notified. Hindhede, a Danish physiologist, concluded from this experience that " the principal cause of death lies in food and drink."

Without being entirely lacking in any one vitamin, our food does not contain enough of them to fill each corner completely. Such a condition is inconsistent with health and if we are to produce an A1 stock everyone must eat " square meals," give up white starchy foods and sugar

and cut down the amount of meat, if necessary, eating instead wholemeal bread, fruit, vegetables, milk products and eggs. A diet of this kind is not necessarily more expensive than the ordinary working class diet. At the end of this book are given two very cheap family diets including menus and prices. They include everything essential at the minimum cost for material, labour and fuel.

Manufacturers of foods are now applying the scientific knowledge about vitamins in the preparation of more suitable products. Tinned fruits and vegetables are more carefully made so as to retain their vitamin C. Preparations containing vitamins A and D are specially made and are added to margarine to make it equal to the best butter. There are some foods containing high amounts of vitamin B which can be taken separately or added to other foods. Wholemeal bread and flour are more easily purchased than was the case a few years ago. The food of the nation is slowly being improved in all directions and one would expect the future generations to have better health than their parents.

CHAPTER X

DIET IN SPECIAL CASES

THE general principles underlying proper nutrition are essentially the same for all people, but in special cases the application of these principles requires more detailed attention. Whether young or old, healthy or invalid, sedentary or active, fat or thin, in the Arctic regions or in the Tropics, everyone requires "Square Meals."

The scattered references made in earlier chapters to modifications in the diet under various conditions will now be collected and discussed under special headings.

The Mother's Diet.

Of all people the expectant or nursing mother most especially requires to be well fed as she has two to feed. It may be said that her meals require to be more than "Square," each "corner" should be almost doubled. This does not mean that she should try and eat twice as much as usual, but that she should eat more of the special vitamin foods (see frontispiece) and a little more protein.

During the earlier months of pregnancy the child grows slowly and the total quantity of food taken by the mother need not be increased. Indigestion, flatulence and sickness at this stage are generally caused by over-eating, or by an unbalanced diet poor in vitamins. If the diet should be quite satisfactory in these respects and "morning sickness" still persists, it may be due to ketosis and can be remedied in

most cases by reducing the amount of fat and increasing the proportion of carbohydrates ; for explanation of ketosis see page 74. Fats which do not contain vitamins A or D, such as lard, bacon fat, fat pork or olive oil can be dispensed with altogether. The vitamin-containing fats, butter, egg yolk, milk or cream can be taken in reasonable amounts, but should not be taken first thing in the morning or late at night. To counteract the sickness, highly-sweetened lemon juice and unbuttered toast or sweet biscuits can be taken at breakfast instead of milky tea and bread and butter. Another drink of sweetened lemon juice should be taken at bedtime.

During the last few months of pregnancy the appetite is generally larger than usual to satisfy the demand of the then rapidly growing child. Pregnant women sometimes have strange fancies for unusual foods, probably because they are unconsciously searching for something which they need and that their food does not contain, just like animals on deficient diets eat their fur, feathers or other queer things. Sometimes these fancies are very sensible, such as a dislike of chocolates and a craving for juicy fruits.

The diet of the nursing mother needs consideration on account of certain superstitions with which she is worried. She may be cut off green vegetables because they are supposed to give the baby wind and urged to take excessive amounts of milk. Orange juice taken by the mother is said to curdle the milk. If she eats cheese that is also supposed to upset the baby.

The mother kept on a nice white diet has a white-faced, constipated nursling.

It is a common belief that any breast-fed infant is receiving ideal food and cannot possibly be wrongly fed. This is only the case if the mother's diet is good. If her food consists chiefly of white flour and sugar with little fruit and vegetables, the child will inevitably suffer. Rickets is not rare in breast-fed children and in the East there is a large mortality

from infantile beri-beri in breast-fed infants, whose mothers live chiefly on white rice. We know that the amount of vitamins in cow's milk depends on the food of the cow and the same applies to the human mother.

The best foods for both the nursing and expectant mother are wholemeal bread, butter, milk, eggs or some other good fat for vitamins A + D, moderate amounts of meat, fish or cheese, and generous amounts of potatoes, fresh fruits and green vegetables. Since the development of good teeth and bone depends so largely upon the supply of vitamin D, open-air sunshine is another necessity.

The Infant's Diet.

The best food is of course breast-milk provided that the mother has a well-balanced and complete diet. The successful lactation of rats has been found to depend upon the supply of vitamin B. In fact, for normal development of the young it has been found essential to provide the mother with 3 to 5 times as much vitamin B as is needed by adults.

In artificial feeding the ideal mixture for babies corresponds as closely as possible to human milk in its proportions of fat, carbohydrate and animal protein. The supply of vitamins must be attended to carefully as the young need more than the adult. Admixture of cow's milk with cereal foods alters the relative proportion of the constituents. The addition of sodium citrate to the milk mixture to make it more digestible is destructive of vitamin C. There is no objection to the use of a reliable brand of dried milk, and it is preferable if there is any doubt as to the purity of the local milk supply. As milk is such a common vehicle for tuberculosis and other infections, the pasteurisation or sterilisation of milk is advisable, although some of the vitamins are to a certain extent destroyed in the process.

Since the vitamin-content of milk is always a variable and unknown quantity, it is advisable to give all infants,

even the breast-fed ones, supplementary supplies of the vitamins. It is now customary to give babies orange juice as an antiscorbutic. Grape juice (page 22) will not do as a substitute for orange juice, but tomato or swede juice strained through muslin can be used instead.

It is often forgotten that the other vitamins must also be given. Additional vitamins B_1 and B_2 can easily be given to bottle-fed children in the form of marmite, $\frac{1}{2}$ a teaspoonful a day, either added to the food mixture or mixed with water. Sieved boiled potato is a better supplement than most patent cereal foods as potato provides both vitamins B and C. Potato was recommended for infant feeding by Sir Thomas Barlow many years ago and its value appears to have been forgotten. Ample vitamins, A + D, can be given by $\frac{1}{2}$ a teaspoonful a day of cod liver oil. Sunlight in the open air helps to maintain the supply of vitamin D.

The Child's Diet.

Sieved spinach is an excellent source of vitamins A and C and of iron salts for the weaned child. Vitamins B_1 and B_2 can be supplied by marmite, bemax and whole cereal products.

Care must be taken on weaning not to reduce the amount of animal protein and fat by overloading the diet with cereals and sugar (pages 55, 59, 70, 76). Milk puddings are a greatly over-rated dish and it is to their common use in the nursery that the faulty balance just mentioned is principally to be attributed. White rice, sago, tapioca and cornflour, often highly sweetened, are the chief ingredients of these puddings and are foods to avoid as being unbalanced by vitamin B. These puddings are often more cereal than milk. Moreover the pudding is gently simmered for hours thus destroying vitamins C and A in the milk. Cereals suitable for milk puddings, because they are balanced by vitamin B, are whole rolled wheat, rolled oats, whole brown rice ("un-

polished" is no better than "polished") or wholemeal bread. Milk and egg custards, junket, milk jelly set with gelatin are good. Jellies made with fresh fruit and gelatin, light steamed puddings or sponge cake and apple charlotte all made with wholemeal are alternatives. The milk drunk separately ensures that the child gets a proper quantity of milk. If only white cereals are obtainable, they should be mixed with wheat germ to supply the vitamin B which they lack.

It is often forgotten that milk is a food and not a drink and is best given at meal times. The child should be accustomed as soon as possible to have only three meals a day without a mid-morning lunch. Tea and supper should form one meal. Nothing should be given in between meals except plenty of water, or lemonade or some juicy fruit. It is a common sight to see children allowed to browse continually upon biscuits, sweets and chocolates and to refuse proper food at meal times.

The child is often subjected to many kindly meant temptations and offered an overwhelming choice of artificial products, such as fancy cakes, ices, sweets, chocolates, and brightly coloured jellies and moulds made from packets and devoid of any essential nutriment.

Without forcing the child to eat foods that he intensely dislikes, the formation of fads should be avoided as far as possible. The persistent refusal of certain articles of food may lead to an unbalanced diet. For instance, in schools green vegetables and salads may be provided, but how many children will eat them regularly if left to their own devices. Other children dislike fat and have a craving for sugar. If their fads are encouraged too much, the child grows up into a pernickety adult who is generally a miserable dyspeptic.

As regards quantity the actual requirement of children from

0 to 6 years is about $\frac{1}{3}$ to $\frac{1}{2}$ that of the adult.
6 to 10 years is about $\frac{1}{2}$ to $\frac{2}{3}$ that of the adult.
10 to 14 years is about the same as that of the adult.

The child's appetite must be the eventual guide, as at the same age there is much individual variation in the quantity eaten. The child seldom overeats, if only plain and wholesome foods are provided. Between the ages of 12 to 18 a healthy girl eats and requires more than an adult woman, the greatest amount being eaten between 14 and 15. In the same way boys eat more than men, but their maximum requirement for food comes about two years later than in girls ; from 16 to 17 boys eat about $\frac{1}{3}$ as much again as a man.

As regards the composition of the diet children of all ages require "Square Meals" and if properly fed from infancy should have a sufficiently good digestion at three years of age to be able to take most of the foods named in the "Square" of the frontispiece. In the case of hard nuts or tough skinned fruits the materials should be grated or sieved : peanuts should always be cooked.

We have already shown on page 76 that by over-fussiness a number of valuable foods may be withheld from the child, until eventually cod liver oil has to be administered to make up for the deprivation of foods containing vitamins A + D which were considered too rich. Other methods of child feeding advocate such a high fat content that the child gets acidosis (a form of ketosis, page 74), and large amounts of sugar have to be given to restore the balance of fat and carbohydrate. The happy mean is to give moderate amounts of the fats which contain vitamins A + D and to withold the fats poor in vitamins (see frontispiece).

The child's protein requirements are discussed on page 70.

Diet for Severe Muscular Work.

With the idea that meat gives strength, athletes and hard manual workers as a rule eat high protein diets. As already pointed out the adult man needs relatively less protein than the growing child and expectant or nursing mother. There is definite physiological proof that the energy for muscular activity is supplied by the fuel foods such as bread and butter. Large amounts of flesh foods are not needed. The use of protein as a fuel food causes fatigue more quickly than if the extra energy is derived from the proper fuel foods, fat and carbohydrate. The superior powers of speed and endurance of athletes on well-balanced mainly vegetarian diets have confirmed the physiological experiments that protein is not required for hard muscular work. A little more protein is all that is needed to make good the extra wear and tear. The general ratios of the food constituents (page 69) must be maintained, it is simply necessary to eat more of everything until the increased appetite induced by extra muscular work is satisfied.

Diet in Middle Life and Old Age.

As we get older our output of muscular energy is diminished. The sedateness of the middle-aged person consists in an unconscious economy of movement; the activities are directed to carrying out some special purpose with the minimum expenditure of energy. Since the output of energy is less than in youth, the intake of energy-producing foods must be correspondingly curtailed. The middle-aged "spread," which is viewed complacently by most men if not by women, is testimony that the intake exceeds the output.

Records kept by the Life Extension Institute of New York show that, among people aged 45, those who have the greatest expectation of life are 20 lbs. under the average weight. In other words, the majority of middle-aged

people are unhealthily fat. The middle-aged should eat less than they have been accustomed to do, in order to keep their weight from increasing beyond what it was at 25. The secret of keeping healthily slim is not to cut out certain foods believed to be fattening, but to eat moderately of a well-balanced diet.

In old age all the activities of the body are reduced to a very low level. An analysis of the diet of a number of people who lived to a healthy old age, showed that $\frac{3}{4}$ of the diet consisted of carbohydrate as compared with $\frac{2}{3}$ in the average diet ; the total food eaten was equivalent to about $\frac{7}{10}$ of the ordinary adult diet.

The supply of vitamins should be maintained.

Diets for the Prevention and Cure of Obesity.

Obesity is much easier to prevent than to cure. Except in rare cases, caused by the failure in the secretion of an endocrine gland, the superfluous flesh is merely a sign that the intake of energy-giving food is greater than the output of energy in the form of muscular activity. This proper balance can in early stages be regained by taking more exercise, but exercise alone will not benefit the really corpulent, as it is inclined to increase the appetite.

The most economical and easiest method is to reduce weight by curtailing the amount of food eaten, taking care not to destroy the balance of the diet. All fuel foods are fattening if eaten in too large quantities. A common mistake in reducing diets is to cut out certain necessary foods, such as potatoes and butter in the belief that they are especially fattening. In this way the diet becomes unbalanced ; butter and potatoes are needed for the supply of vitamins A, D, B and C. Other mistakes are the use of dry concentrated foods such as toast, rusks and biscuits instead of bread, and the limitation of the quantity of liquid. This procedure reduces the weight temporarily by drying

up the body, just as dried fruit weighs less than fresh fruit, but it does not alter the amount of fat. Weight for weight bread containing water is less fattening than the concentrated dry foods which contain no water. It is a chemical impossibility to form fat from water. A slimming diet should therefore consist of the more watery rather than of the dry concentrated foods. The extra bulk of wet foods produces a feeling of satiety sooner than if dry foods are eaten.

Non-Fattening Foods :

Juicy fruits, cabbage, etc., and milk with 90 per cent water.
Potato . . . . 80 „ „
Egg, fish, banana . . . 70 „ „

Fattening Foods :

Of all the concentrated foods sugar, either as sugar, jam, sweets or chocolates, is the most to be avoided ; it is all solid fattening material and has no compensating virtues. Fats supplying vitamins A + D must not for health reasons be cut out, but bacon, fat pork, lard and olive oil may be dispensed with. Dry biscuits and thin toast contain little water.

Meat, cheese and bread are intermediate between the two groups and can be taken in moderate quantities.

Diets deficient in vitamin B were observed to cause large deposits of fat, especially round the internal organs (page 41), and a lack of this vitamin also causes the body to be waterlogged and swollen. For weight reduction special attention should therefore be paid to the supply of vitamin B.

The cure for corpulence introduced by Banting was correct in principle by reducing the total quantity of food, especially of carbohydrate. He limited the amount of fluids and used protein as the chief fuel food. The Banting diet is an unbalanced one and should not be continued for any length of time.

It might be thought that the easiest way of curing obesity would be to fast till the desired weight is reached, but this

method has certain dangers. The fat stored in the body is, during starvation, burned as fuel food in the absence of carbohydrate and produces the condition of *ketosis* (page 74). A modified fast, in which small amounts of carbohydrate are supplied by the natural sugar in fruit juices with some milk, is satisfactory. This simple diet supplies protein, mineral salts and vitamins, and the carbohydrate helps to burn the body fat without causing disturbance. After the weight is reduced an ordinary well-balanced diet can be resumed in moderation so as to keep the weight constant.

The Diet of Invalids.

As in the case of the nursing mother and the young child, a nice white diet is generally given to invalids whether they are nursed at home or in hospitals or nursing homes. White flesh, white fish, served with pasty white sauces, white cereals in puddings and gruels are the daily fare of the ordinary invalid. In special cases fruit and vegetables are debarred as likely to cause acidity, flatulence and indigestion. The sick-room diet must be based on the "Square Meal," and if the ordinary foods cannot be taken each individual corner must be considered to see that no essential has been omitted. One frequently finds an invalid put upon a diet so lacking in vitamins that it would kill the healthiest man if continued for a few months. Since resistance to infection depends largely upon the supply of all the vitamins every surgical or medical patient should receive an abundant supply of them as part of the regulation treatment.

Certain articles of food may be prohibited as indigestible. Some foods take much longer than others to digest, but do not therefore necessarily cause any discomfort and may be quite valuable foods. Other foods may contain a great deal of "roughage" material upon which the digestive juices have no effect. The roughage does not normally cause symptoms of indigestion, and may serve the useful purpose

of absorbing, like blotting paper absorbs ink, poisons formed in putrid food residues in the bowel. At the same time roughage stimulates the contractions of the muscular wall of the bowels and counteracts a tendency to constipation.

Indigestion is more often brought about by long continued vitamin-underfeeding rather than by any one particularly indigestible substance.

Stomach acidity is caused by the bacterial fermentation of food and not by eating acid fruits. The gastric fermentation is often due to the failure of the stomach to secrete hydrochloric acid, a normal constituent of the gastric juice which aids digestion and prevents the growth of bacteria. In these cases instead of alkali the right course would be to give very weak hydrochloric acid of the strength normally found in the stomach and to improve the general powers of digestion by giving a properly balanced diet rich in vitamins.

Diet and Climate.

One of the chief purposes of food is to maintain the heat of the body. In cold climates heat is lost more rapidly than in temperate climates. Extra clothing prevents some of this loss, but does not entirely compensate for it. The intake of fuel foods must be increased in proportion to the degree of cold. In Arctic regions the extra fuel is taken in the form of large quantities of fat meat as a sufficient increase in the form of carbohydrate would necessitate too great a bulk of fuel. The extra protein in the meat is in excess of that needed for wear and tear, but it assists in the combustion of fat preventing *ketosis* from too high a proportion of fat (page 74).

In the Tropics the opposite conditions prevail. The normal temperature of the body is at times lower than that of the surrounding air and then food is not required for body heat, but only for activity. There should be less protein and fat as these substances stimulate the combustion of food,

the carbohydrate ratio being increased from $\frac{2}{3}$ (as given in the average diet, page 69) to $\frac{3}{4}$ of the total food. According to the degree of heat the total fuel value of the diet may be reduced from $\frac{2}{3}$ to $\frac{1}{2}$ of the average in temperate regions. Wet foods are the most suitable (see obesity diet). The water leaves the body as perspiration and its evaporation causes cooling.

Europeans like to eat as far as possible their usual diet, even in the Tropics. Their high rate of sickness and mortality is according to the experience of Dr. Eijkman to be attributed to their high protein diet. The natives on a lower protein diet with more carbohydrate and fruit withstand the heat much better.

Alcohol.

Alcohol burns in the body like carbohydrate, but has a much higher fuel value. Moderate amounts in the diet are harmless, but larger amounts lead to various special ills, probably from the poisonous effects of its half-burned products. Since alcohol gives out much more heat than carbohydrate, it should be used sparingly in the Tropics where the object is to keep cool. For the same reason very little should be taken by those who are obese.

Diet and Goitre.

Goitre is a swelling in the front of the neck due to the enlargement of the thyroid gland which is situated just below the Adam's apple. There are several kinds of goitre, some due to over-activity of the thyroid, as in exophthalmic goitre or Graves' disease, and some to failure of its secretion.

Thyroxin, the active substance in the secretion of the thyroid gland, contains iodine. In the absence of this secretion there is a condition of arrested growth and development, known as cretinism. Goitre and cretinism due to the insufficient action of the thyroid are most prevalent in

mountain valleys remote from the sea. Iodine is found in greater concentration in sea water, and in sea water plants and animals, than in fresh water, and because iodine has a distinctly good effect in the treatment of some thyroid diseases it was concluded that lack of iodine was the cause of the trouble in remote inland districts where sea breezes could not penetrate.

The connection is not so simple. McCarrison refers to the records of an Indian school over a period of seventy years. About half the children had suffered from goitre. The disease was eradicated by the substitution of a pure water supply for a contaminated one, although the pure water contained considerably less iodine than the goitre-producing water.

Goitre occurs in England, particularly in the dales of Yorkshire and Derbyshire and is known as "Derbyshire neck." Dr. Turton (1927) published his observations on goitre in Derbyshire and he reported three times as many cases in children drinking water from a limestone soil as in those drinking water from the millstone grit soil, though the latter contained less iodine, and incidentally less lime.

Both McCarrison and Turton agree that this type of goitre is caused by an excess of lime salts. If the iodine salts are increased proportionately to the lime salts, goitre is prevented.

In his summary of 1927 McCarrison refers to goitre as a disease which results from a lack of balance in the various components of the food, each component in itself good. One type may be caused by an excess of butter, another type by an excess of lime. In addition he has shown that the deficiency of vitamins A, B and C, in the modern diet, and particularly of vitamin B, can give rise to a new type of goitre not previously described. He concludes from the experimental evidence that "it is probable that in Western countries this new type of goitre will be encountered in its progressive stage in children and young women whose

food contains much vitamin-poor carbohydrate, little suitable protein and less green vegetables and fruit. In this type of goitre iodine will neither prevent nor cure the disease, but a well-balanced diet rich in vitamins will." Dr. Steiner who has studied the disease in Switzerland has arrived at very similar conclusions to those of McCarrison and Turton.

Within the last few years a number of iodised salts and other patent medicines containing iodine have been put on the market. Iodine in excess is in itself a danger and promiscuous dosing with iodine or thyroid extract, unless under medical supervision, should never be done.

A well-balanced "Square Meal" is likely to provide sufficient iodine. It is advisable to use a natural salt for table use and not a refined table salt from which iodine and other essential mineral salts may have been removed.

EFFECT OF HEAT AND PRESERVATION PROCESSES ON VITAMINS

A complication about vitamins is that treatment with heat, chemicals, drying and other processes, have different effects for each of the three vitamins. For convenience of reference the effect of these agents has been tabulated.

Agent.	*Vitamin A.*	*Vitamin B.*	*Vitamin C.*
Drying—			
(*a*) Exposed to air .	Destroyed.	Not destroyed.	Destroyed.
(*b*) In a vacuum . .	Not destroyed.	Not destroyed.	Not destroyed in certain cases.
Heating—			
(*a*) Exposed to air . .	Gradually destroyed.	Not destroyed.	Gradually destroyed.
(*b*) In a vacuum . .	Not destroyed.	Not destroyed.	Destroyed except in certain cases.
(*c*) Heating under pressure (sterilisation) .	Not destroyed.	Destroyed.	Destroyed.
Soda or Alkali . . .	Not destroyed.	Destroyed.	Destroyed.
Ageing	Slowly destroyed.	Slowly destroyed.	Quickly destroyed.
Preserving—			
(*a*) Tinned Meat . .	Not destroyed.	Destroyed.	Destroyed.
(*b*) Bottled Vegetables and Fruits . .	Not destroyed.	Reduced.	Not destroyed in certain cases.
(*c*) Pickled Eggs . .	Not destroyed.	Not destroyed.	—
(*d*) Frozen Meat, Butter	Not destroyed.	Not destroyed.	—
(*e*) Fruit . . .	Not destroyed.	Not destroyed.	Slowly destroyed.
Milling of Cereals . .	Removed.	Removed.	—

Vitamin D—

Ergosterol, the precursor of this vitamin, is a comparatively stable substance not affected by any of the above processes. Vitamin D, produced by irradiation of ergosterol, is destroyed by too long irradiation. It is not destroyed by the above processes.

TWO SIMPLE BALANCED DIETS AT MINIMUM COST

THESE two diets provide all that is essential in the way of protein, fat, carbohydrate and vitamins for minimum costs in money, time, fuel and labour.

The palatability of the diets can be greatly increased where there is more money for purchasing more expensive varieties of fish, fruits and vegetables and better cuts of meat, but the relative proportions must be kept approximately the same, which can easily be done by reference to the Table, p. 114.

These diets were included in a pamphlet *How to Feed the Family*, by Col. P. S. Lelean, Professor of Public Health in Edinburgh.[1] This pamphlet also includes the more usual working class diet, with quantities, menus and costs planned by Col. Lelean. His well-balanced diet works out at 8*s.* 6*d.* per man per week, but requires labour and fuel in preparation, which are saved in our simple diets.

[1] Published 1927 by William Hodge & Co., Ltd., 12, Bank Street, Edinburgh. *Price* 6d.

"POTATO DIET."

A Week's Food for a Family Equivalent to Three Men.

	Ozs.	s.	d.		s.	d.
[1]Ox heart, minced	24 at	0	8	per lb. cost	1	0
Fresh herring	48 „	0	6	„ „ „	1	6
Corned beef, tinned	24 „	0	8	„ „ „	1	0
Cheese (Colonial)	24 „	1	0	„ „ „	1	6
Potatoes (3 stone)	672 „	1	6	„ stone „	4	6
Bread, *whole-meal* (21 lbs.)	336 „	0	9½	„ 4 lbs. „	4	0
Flour, *whole-meal*	24 „	0	2¼	„ lb. „	0	3½
Oatmeal	24 „	0	3	„ „ „	0	4½
Margarine	24 „	0	6	„ „ „	0	9
Dripping	8 „	0	8	„ „ „	0	4
Butter (imported)	12 „	1	6	„ „ „	1	1½
Milk, fresh, whole (7 qts.)	280 „	0	6	„ quart „	3	6
[2]Sugar (or treacle)	16 „	0	3½	„ lb. „	0	3½
[2]Onions	32 „	0	1½	„ „ „	0	3
[2]Cabbage, tomato, parsley [2]Watercress, etc.	in season				1	0
[2]Oranges, four	16 ozs. at	0s.	1d.	each „	0	4
Salt, cooking					0	1
Cost for three men				per week	21	10
For one man				„ „	7	3½

The protein, fat and carbohydrate ratios of this diet are ⅓, ⅓, ⅓, which are the right proportions. Calorie value 3,300 is ample. There is sufficient animal protein.

[1] Minced ox heart is a stock article in Scotland not always easy to get in England. Cheap cuts of imported meat are about equivalent in food value and in cost per lb.

[2] If these items, which are not essential in this diet, are omitted, the cost per man per week would be 6s. 8d. They are included to make the larger amount of potato palatable.

The cost of this diet would be very much less if potatoes, onions and green-stuff are home-grown.

"POTATO DIET."

WEEKLY MENU FOR STANDARD-SIZED FAMILY—MAN, WIFE, BOY OF 12, GIRL OF 6.

	Breakfasts.	Dinners.	Teas.
Sunday .	Oatcake and butter; bread; milk; sugar or treacle.	Minced heart; cabbage; potatoes (3 lbs.); bread; margarine; cheese; oranges.	Mashed potatoes (3 lbs.); bread and margarine; milk.
Monday .	Porridge; milk; bread and butter; sugar or treacle.	"Bubble and squeak" (shredded corned beef and cabbage and potatoes fried together in dripping); bread and margarine.	Cold sliced potatoes; cheese; watercress; bread; margarine; milk.
Tuesday .	Same as Sunday.	Fried herrings; potatoes; wholemeal biscuits (home-made); bread; margarine.	Baked potatoes; margarine; bread; cheese; milk.
Wednesday	Same as Monday.	Potato mould and minced corned beef; bread; biscuits; margarine.	Potato and cheese pie; bread; margarine; milk.
Thursday .	Same as Sunday.	Potatoes and onion sauce; bread and cheese.	Potato soup, with (dripping) dumplings; bread.
Friday .	Same as Monday.	Herrings; potatoes; bread; biscuits and margarine.	Mashed potato, with grated cheese; bread; watercress; milk.
Saturday .	Same as Sunday, but margarine instead of butter.	"Shepherd's Pie" (= ¾ lb. minced heart, 2 ozs. margarine, 3 lbs. potatoes, onion or tomato).	Potato, parsley and cheese cakes (fried); bread; milk.

Note—Potato diet = 2 lbs. potato per man per day.

A Week's "Fuel and Labour-Saving Diet" for a Family Equivalent to Three Men.

	ozs.	s.	d.			s.	d.
[1]Corned beef, tinned . .	48	at 0	8	per lb.	cost	2	0
Cheese (Colonial) . .	40	„ 1	0	„	„	2	6
Milk, fresh, whole (7-qts.) .	280	„ 0	6	per qt.	„	3	6
Eggs, 1-dozen . . .	24	„ 0	2	each	„	2	0
Bread, *whole-meal* (32-lbs.) .	512	„ 0	9½	per 4-lb.	„	6	4
Butter (imported) . .	16	„ 1	6	per lb.	„	1	6
Margarine . . .	48	„ 0	6	„	„	1	6
Bananas, six . . .	24	„ 0	1	each	„	0	6
Oranges, nine . . .	36	„ 0	1	„	„	0	9
Jam, treacle, or dried figs, etc.	24	„ 0	6	per lb.	„	0	9
Watercress, three bunches .		0	1	per bunch	„	0	3
For three men .				per week		21	7
For one man .				„	„	7	2

The protein, fat and carbohydrate ratios are $\frac{1}{8}$, $\frac{1}{8}$, $\frac{2}{3}$ and the amount of animal protein is adequate. The calorie value is 3105. All the vitamins are present in sufficient amounts provided that wholemeal bread is eaten. If white bread is substituted, there will be a deficiency of vitamin B.

[1]Alternative to corned beef—pickled herring from fish shop.

Although this diet costs more than the "Potato" diet, there is a saving in cost of fuel and time spent in preparation. Only the eggs require to be cooked, but toasted cheese is suggested to make a variety

"FUEL AND LABOUR-SAVING DIET."

WEEKLY MENU FOR A STANDARD-SIZED FAMILY—MAN, WIFE, BOY OF 12, GIRL OF 6.

	Breakfasts.	Dinners.	Teas.
Sunday .	Bread ; jam ; margarine ; milk.	Bread and butter ; corned beef ; sliced oranges.	Toasted cheese ; milk ; bread ; butter ; jam.
Monday .	Same as Sunday.	Bread and cheese ; margarine ; watercress.	Egg sandwiches ; bread ; jam ; milk.
Tuesday .	Same as Sunday.	Potted corned beef; bread; margarine ;[1] sliced banana, and orange.	Bread and milk ; bread ; butter ; cheese ; watercress.
Wednesday	Same as Sunday.	Fried eggs and fried bread ; banana sandwiches.	Bread and cheese; butter ; jam ; milk.
Thursday .	Same as Sunday.	Bread; margarine; corned beef ; watercress.	Bread ; butter ; milk ; sliced hard-boiled eggs.
Friday .	Same as Sunday.	Potted corned beef ; bread ; margarine ; oranges and banana (sliced).	Bread ; cheese ; jam ; milk.
Saturday .	Same as Sunday.	Scrambled eggs ; bread ; margarine ; oranges.	Toasted cheese ; bread ; butter ; milk.

[1] Potted corned beef—minced or grated beef pounded to a paste with margarine.

[2] Oranges, eggs, bananas, etc., are served *sliced* so as to divide into equal portions when there is not a whole one for each member of the family.

PERCENTAGE ANALYSES OF THE COMMONER FOODSTUFFS

Analyses of the various foodstuffs are frequently required in making up and checking diets. The various kinds of meat differ mainly in the amount of fat, which is very variable. The lean of meats can be taken as having the same, or nearly the same, composition. Fish can be grouped into two main classes. Vegetables are of the root, or leaf, variety, and those of a class are very similar. Fruits are very similar.

For practical purposes it suffices to use *an average* for the several classes of foodstuffs, which is as follows :—

	Water.	*Mineral Salts.*	*Protein.*	*Fat.*	*Carbo-hydrate.*
Lean of Meat (Average of beef, mutton, veal, pork)	72.0	1.3	20.7	5.8	—
Heart	76.5	1.3	16.6	3.9	1.7
Kidney	76.6	1.7	17.3	3.2	—
Liver	71.1	1.6	18.3	2.5	6.5
Tongue	64.3	1.2	16.2	18.0	—
Poultry—					
Average of chicken, turkey, pigeon	66.2	1.3	23.7	8.5	—
Average of duck and goose	56.7	1.0	18.6	23.0	—
Game, average	63.8	1.3	22.4	12.2	—
Hare and rabbit, average	73.1	1.3	22.0	3.1	—
Fish—					
Fatty (average of herring, mackerel, sprats, salmon)	66.5	1.6	18.1	13.8	—
Non-fatty (average of cod, halibut, whiting, etc.)	79.4	1.3	18.5	0.4	—
Eggs, whole	73.7	1.1	12.3	11.3	—
white	87.2	0.6	10.7	0.1	—
yolk	47.1	2.0	15.5	33.3	—
Milk	87.6	0.7	3.3	3.6	4.8
Cheese, Cheddar type	31.6	4.7	25.7	35.0	—
Butter, Margarine	13.9	0.4	0.2	84.5	—
Dripping, Lard	—	—	—	100.0	—
Bacon	27.1	6.5	9.5	54.6	—
Ham	31.0	4.4	11.5	41.0	—
Gammon	40.1	8.1	15.1	21.3	—
Sausage	53.5	2.4	11.2	17.7	15.2

PERCENTAGE ANALYSES OF THE COMMONER FOODSTUFFS
—continued.

	Water.	*Mineral Salts.*	*Protein.*	*Fat.*	*Carbo-hydrate.*
Cereals—					
Barley	10.5	1.3	7.5	1.3	78.9
Oatmeal, rolled oats	8.0	1.9	12.2	7.5	69.4
Rice, white	11.4	0.6	6.5	0.4	80.8
Wheat flour	11.3	0.8	10.1	1.6	75.5
Biscuits, plain	7.7	2.1	12.5	0.7	75.8
Bread, brown	43.2	2.3	7.0	0.4	47.7
white	42.3	1.8	7.2	0.2	48.1
Fresh vegetables—					
Potato, average	76.2	1.1	1.9	—	20.1
Artichoke, carrot, parsnip, average	80.4	1.1	1.8	0.2	15.7
Beetroot, swede, turnip, cauliflower, tomato, average	90.7	0.9	1.1	0.1	6.2
Cabbage, kale, sprouts, etc. average	87.3	1.5	2.9	0.2	6.8
Lettuce, watercress, etc., average	93.8	1.1	1.5	0.2	2.6
Green peas	76.1	1.0	5.4	0.5	15.2
Beans, runner, French	72.6	1.2	6.5	0.2	16.6
Pulses—					
Dried beans, peas, lentils	11.9	3.2	19.7	1.0	61.7
Fresh fruits—					
Apples, plums, oranges, etc., average	86.6	0.5	0.7	0.1	8.4
Bananas	70.8	0.8	1.2	0.1	24.9
Dried fruits, average	22.6	2.3	2.3	0.3	56.3
Jam, honey, syrup, average	20.0	0.5	0.3	—	72.4
Nuts, average	8.4	2.5	16.5	56.9	13.6
Chocolate	1.0	1.4	4.8	31.1	59.9
Cocoa	4.9	6.3	18.1	26.8	40.3
Sugar	—	—	—	—	100.0

This table has been compiled from *Analyses and Energy Values of Foods* by R. H. A. Plimmer (H.M. Stationery Office).

QUANTITY (DRY WEIGHT) OF PROTEIN, FAT AND CARBOHYDRATE CONTAINED IN THE ORDINARY FOODSTUFFS

An average day's food (p. 69) consists of

Protein		Fat	Carbohydrate	
Animal	Vegetable			
1½	1½	⅛	⅔	of total dry weight.
2 to 2.5	1.5 to 2.5			
3.5 to 5		2½ to 3½	14 to 18	oz. dry weight.

The following table has been compiled to show the amount of protein, fat and carbohydrate present in 1, 4, or 8 oz. of the common foodstuffs. It will thus be easier to check the actual consumption of each food constituent.

Animal Foods.	oz. *Dry Weight of*		
	Protein.	*Fat.*	*Carbo-hydrate.*
4 oz. *of*			
Lean of Meat (Beef, Mutton, Pork)	0.9	0.3	—
Poultry, Rabbit, Game	0.9	0.1	—
Kidney, Heart	0.7	0.1	0.1
Liver	0.9	0.1	0.1
Tongue	0.5	1.1	—
Bacon (Streaky)	0.4	2.2	—
Sausage	0.4	0.7	0.6
Cod and White Fish	0.7	—	—
Herring, or Mackerel or Salmon	0.8	0.4	—
Eggs (2)	0.5	0.4	—
Cheese	1.0	1.3	—
Milk, 1 pint (20 oz.)	0.6	0.7	1.0
1 oz. *of*			
Butter, Margarine	—	0.8	—
Meat Fat, Suet	—	1.0	—

Vegetable Foods.	oz. *Dry Weight of*		
	Protein.	*Fat.*	*Carbo-hydrate.*
4 oz. *of*			
Flour, Rice, etc.	0.4	—	3.0
Oatmeal	0.5	0.3	2.8
Bread	0.3	—	1.9
Biscuit (plain)	0.5	—	3.0
Sago, Tapioca	—	—	3.5
Dried Peas, Beans Lentils	0.9	—	2.5
8 oz. *of*			
Potato	0.2	—	1.6
Cabbage, Lettuce, etc.	0.1	—	0.4
Carrots, Roots, etc.	0.1	—	0.8
Fresh Green Peas	0.3	—	0.7
Apple, Orange, etc.	—	—	0.8
Banana	0.1	—	2.0
4 oz. *of*			
Raisins, Prunes, etc.	0.1	—	2.4
Jam, Honey	—	—	2.8
Nuts	0.7	2.3	0.5
Cocoa	0.7	1.1	1.6
Chocolate	0.2	1.0	2.4
Sugar	—	—	4.0

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