WHAT IS WRONG WITH BRITISH DIET?

BEING AN EXPOSITION OF THE FACTORS RESPONSIBLE FOR THE UNDERSIZED JAWS AND APPALLING PREVALENCE OF DENTAL DISEASE AMONG BRITISH PEOPLES

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INTRODUCTION

A PERFECT human diet is one calculated, given adequate bodily exercise and abundance of outdoor life, to bring about normal nutrition and growth.

Such a diet implies (A) that it shall contain duly proportioned essential nutrient ingredients—proteins, carbohydrates, minerals, and vitamins. But this is not all : a perfect human diet requires (B) that it shall (1) afford adequate exercise for the jaws and teeth, and that it shall (2) tend to leave the mouth clean.

(A) As regards nutritive value, British diet errs mainly in containing an excess of cereals and starchy foods generally, and a dearth of animal and raw vegetable foods. Sugar also, especially among the young, is apt to be in excess.

The need of an ample supply of animal food requires emphasis. In studying Man's past dietetic history one fact stands out prominently—the fact, namely, that the evolving Man attained his full manhood, his status of *homo sapiens*, as a hunter. It was, indeed, the conditions afforded by a hunting career which inevitably led to his progress humanwards. Hence Man is essentially a mixed feeder. Judged by what we know of extant pre-agricultural peoples, the diet of our ancestors at the time when agriculture began to be practised, was, measured by its nutrient value, about one-half animal and one-half vegetable.

Such being the case, it is not surprising that Man cannot thrive, cannot, *i.e.*, attain his full development and enjoy to the utmost the sense of well-being, on a diet wholly derived from the vegetable kingdom, no matter how skilfully enriched by cultivation, nor how carefully selected. It is now known that

certain animal proteins and fats have a higher nutritive value than is met with among the vegetable forms.

Note that the effect of agriculture was greatly to augment Man's supply of vegetable food, at the expense of his animal food ; for it was not until some time after the introduction of agriculture that he began to breed animals for food. Yet, even with the additional animal food thus produced, vegetable food among the earlier agriculturists must, for all but the most favoured, have been in excess of animal food ; and, indeed, ever since the introduction of agriculture Man's supply of animal food has tended to lag behind that of vegetable food. This comparative dearth of animal food has been most keenly felt in densely populated countries, such as India and China, and among the poorer classes in Western countries.

Man has, however, discovered a means of augmenting his supply of animal food which bids fair, in this country at least, to raise it to the physiological level for the entire community—I refer to the plan of diverting to his own use the food provided by nature for the young of certain warm-blooded vertebrates. In this way he has vastly increased the milk-yielding capacity of the milch cow and the egg-laying capacity of the farm-yard hen. These valuable yields of animal foods have of late been greatly augmented in this country, and are likely to continue to increase for many years to come.

The supreme importance of eggs and milk as human foods lies in the fact that they are animal foods and thus can take the place of the flesh foods (birds, beast, and fish). So-called " vegetarian " diet consisting of carefully selected vegetable foods (in which cereals, raw fruit and salad figure prominently), fortified by milk (and its products) and eggs, is nutritionally adequate for Man, who nevertheless displays a strong instinct for some measure of the more stimulating flesh foods. Perhaps, in the fullness of time he will learn to subsist on a purely vegetarian diet, but at the present one finds no evidence of any such trend.

Exactly how far the people of this country are undernourished is not certainly known. Sir John Orr, as the result of a laborious investigation, estimates that 20 millions of our people are underfed. Be this as it may, there is abundant evidence that our national catering, in spite of its many defects, is making definite headway, both in the way of nutrient value and effective distribution. Mr. Walter Elliot assures us that our people are better fed to-day than they have ever been, and there is good reason to believe that, before many years have run, a sufficiency of nourishing food will be placed at the disposal of all. In estimating this probability we need to take into account the practical certainty that we are rapidly approaching the time when our population will begin to decline.

(B) We have seen that normal human diet requires not only to be nutritionally efficient, but (1) that it shall ensure adequate exercise of the jaws, and (2) that it shall tend to promote mouth-cleanliness. In both these respects the customary diet of the British people fails lamentably. Hence our small jaws and shocking teeth.

(1) How comes it that nearly all British jaws of to-day are ill-developed? By which I mean that they fail to attain a size permitting all the thirty-two permanent teeth to take up their positions in the gum-ridges without jamming or irregularity. There is a notion abroad that the prevailing undersized British jaws are the expression of a spontaneous racial trend. This view will not bear serious examination. *The real cause is inadequate use owing to a paucity in our diet of foods compelling vigorous mastication*. Professor Brash and others assure us that quite a moderate exercise of the jaws suffices to secure their normal growth. A study of the normally developed human masticatory mechanism points to a different conclusion: normal human jaws are fashioned to sustain powerful stresses and strains and are furnished with singularly powerful muscles (see Fig. 9); they are, moreover, provided with an armature of teeth capped with

enamel, a tissue rivalling in degree of hardness many exquisitely hard metals.

For what purpose has such a powerful apparatus been provided unless it be to cope, not merely with moderately soft foods, but also with foods demanding vigorous mastication ?

Now British food is for the most part soft ; much of it, such as porridge, pudding, cooked vegetables, is capable of being dealt with by toothless gums, and so lacking is the ordinary British diet of grown-ups in firm fibrous foods, that its mastication is well within the capacity of the slender jaws and the temporary teeth of a child of three or four years. It is obvious that the fully developed human masticatory mechanism is designed for coping with food compelling far more vigorous chewing than that within the capacity of the small child. Would it not be reasonable to expect that the undersized jaws of the British would fail to achieve their normal dimensions, cheated as they are of the full functional activity for which they are manifestly designed ?

The conclusion suggested by these *a priori* considerations is borne out by actual experience : British jaws can be made to develop normally by providing them with adequate exercise—for instance, by the limitation or total abandonment, of soft cereal foods, the employment of moderately coarse-grained, well-baked bread (not necessarily brown), the restriction of cooked vegetables other than potatoes, and the increase of fruit (especially apples) and raw salads.

(2) British diet errs also in that, taken as a whole, it tends to leave the mouth dirty. Ill-baked ultra-refined, spongy bread, buns, scones and the like, pultaceous puddings, and the seductive products of the pastrycook, to say nothing of jams and sweets, abound in British diet ; while such cleansing foods as well-baked (not too refined) crusty bread, raw fruits and salads are all too scantily provided.

I stress this need of cleansing food and the maintenance of a clean mouth on account of its supreme practical importance.

If the mouth, including of course the teeth, is kept consistently clean between meals the teeth cannot decay. Decay is initiated on the surface of the teeth by the corroding action of an acid (acids ?) generated by " plaques " of fermenting saccharide food which cling to the teeth. This danger can be averted by a perfect system of oral hygiene.

The teaching that safety from decay is to be sought for by building up teeth capable of offering an active *vital* resistance to the initiation of decay (*e.g.*, by such means as the administration of vitamin D), and that oral hygiene is of little or no avail in preventing decay, is erroneous : the evidence against this doctrine, as I seek to show, is overwhelming. Enamel is to all intents and purposes a lifeless tissue, and perforce yields passively to any acid (of sufficient concentration) that may chance to come in contact with it, much as a piece of marble might do. It is true that, when by the corrosion of the enamel the dentine is exposed, this structure may put up some show of resistance which, in subjects lacking sufficient vitamin D, may be increased by the administration of that vitamin ; but such resistance can rarely be relied on by the practical dentist to check the process of decay : in treating a decayed tooth, he resorts, where feasible, to the time-honoured practice of preparing the cavity and inserting a filling.

The failure to appreciate the supreme importance of oral hygiene as a preventive of dental decay arises from ignorance of what effective oral hygiene implies (see Part III, Chapter XIX). It requires, for instance, as a prime essential, ample development of the jaws, and this implies that they shall be adequately exercised from birth until the final eruption of the wisdom teeth ; for undersized contracted jaws and consequent overcrowded teeth are incompatible with perfect oral hygiene ; in fact, our small jaws are in large measure responsible for our bad teeth.

At the present time dietitians are concentrating mainly, if not entirely, on the nutritive aspect of diet, while *the aspects considered under B are receiving little or no attention.* Nevertheless,

as far as concerns the diet of the British people, the two aspects of B are as much deserving of consideration as aspect A. Were all future British children from birth onwards provided with a sufficiency of food perfect as to its nutrient quality, yet remaining unaltered in respect of the B requirements, the average nutrition of the community would no doubt be improved, but the jaws would still be undersized, the mouth still dirty, while dental decay and pyorrhœa would continue to rage. If, on the other hand, future British children were provided with food not better in nutrient quality than it is to-day, but satisfying the requirements of B, *i.e.*, affording adequate use of the jaws and leaving clean mouths, the great majority would have well-grown jaws, regular, well-ground and well-placed teeth ; while there would ensue an almost entire freedom from dental decay and a pronounced fall in the incidence of digestive disorders—appendicitis among many others.

It is, indeed, a debatable question, whether, among the British at least, more good might not accrue from an improvement of B requirements than those of A.

Be that as it may, the correction of the defects pertaining to B is a hygienic measure of immense importance, and is in urgent need of being enforced. The main object of my book is to emphasise this truth and to get the public to realise its importance. It has not been possible wholly to avoid technicalities, but I have endeavoured to write in a way intelligible to those who seriously desire to know something of the fundamental truths I have sought to expound.

I am hopeful that the book will be of help to mothers, teachers, as well as to voluntary workers in health propaganda.

CHAPTER I

EUGENICS

A BRIEF word on the subject of eugenics. If a farmer can prevent degeneration of his stock, or even improve it, why should not similar results be achieved by human eugenics, *i.e.*, by man-breeding ? Certain fundamental principles underlying the science of eugenics need mention here.

The position of a given animal species in the animal scale (evolutional ladder) we may speak of as its *evolutional status*. We gauge the evolutional status of a species by the degree to which its members can control their environment. Passing from animalcule to Man we find an ever-increasing power of control over environment. This, after a nervous system surmounted by a unifying brain has evolved, implies a progressive growth and complexity of brain organisation, and a corresponding progressive increase in mental capacity.

Two prime movers have been put forward as playing an essential part in this progressive evolution—the " natural selection " of advantageous inborn *variations* (of the type *mutation*), and the hereditary transmission of advantageous *acquirements* (Lamarckism). There is no convincing proof that the latter plays an essential part in the progressive animal evolution, and for practical eugenics we shall do well to *concentrate our efforts on selection*.

The primates constitute the highest division of mammals, and of these Man is the most advanced. The human brain far surpasses in size and complexity the brain of any other primate. It is estimated that the grey covering of the human brain contains some 14 thousand million neurons, or nerve-cells, each highly complex in structure. The number of corresponding neurons in the brain of the primates nearest allied to

man (*i.e.*, chimpanzee, gorilla and urang) is definitely less than one-half that number. Now it is a striking fact that the neurons in the human brain *do not increase in number after full-time birth, exercise them how we may*. The like probably applies to all primates, probably indeed to all mammalian brains above the marsupials (pouched mammals which are born prematurely). We thus seem driven to the conclusion that the mammalian brain has advanced in size and complexity by the " natural selection " of brains above the average in these respects, and not by the hereditary transmission of cerebral acquirements after birth, *e.g.*, an increased number of cerebral neurons, such as one might expect to be brought about by intensive education.

Some naturalists appear to assume that animal species have an inherent tendency to progress by " orthogenesis," and that there is no need to postulate natural selection, even as an accessory factor. They lose sight of the fact that *retrogression has been as active in evolution as progression :* organisms as high in the animal scale as primitive vertebrates have retrogressed, even to the extent of losing, among other organs, the brain itself, and becoming sessile, like plants, for which they were once indeed mistaken.

Some such retrogression has probably taken place in the human race (as represented by modern civilised peoples), since the introduction of agriculture about 5500 B.C. Before that great event the struggle for existence must have been intense beyond measure, notably during the ice ages when only those with the sharpest wits stood any chance of survival. The artificial cultivation of food greatly lessened that struggle, enabling many to survive who otherwise would have succumbed. Note this fundamental truth : evolution all along has worked on the principle of a *high birth rate* and a *high death rate*, conditions which give the fullest scope for selection. Evolution, working on these lines, produced Man. The synchronous fall in the birth rate and death rate during recent years is hastening the retrogressive process ; the fact that, in neo-civilised countries the birth rate has fallen least among the least intelligent section of the community has definitely conferred survival value on sub-average mental capacity.

If the annual birth rate per 1,000 of Great Britain continues at its present level, the national expectation of life remaining the same, and immigration and emigration balancing one another, the population of Great Britain will become extinct at a date mathematically calculable.[1]

Such extinction is, of course, not likely to take place in the present geological era. Nevertheless, the low birth rate among the white populations of the British Empire presents a grave problem, for, if it continues, it will inevitably lead to the disruption of the Empire. The have-a-good-time spirit, the unwillingness to sacrifice self, are symptoms of national decay. Too often men and women of outstanding ability, the types of which we stand most in need, leave the fewest children : money and looks count for more in the marriage market than brains, and, too often, the limelight has a stronger lure for young women than motherhood ; whereas, among our pre-agricultural ancestors, it was precisely the men who displayed the greatest ability and force of character who helped on progressive evolution by leaving the largest number of children.[2]

Apart from dyshygienic conditions which prevail among the civilised, it is probable that civilised Man of to-day is, on the average, both mentally and physically inferior to his pre-agricultural ancestors.

A fact of immense significance from the point of view of eugenics deserves emphasis. In the primates, of which Man is the supreme representative, the brain is the one organ, or system

[1] The birth rate of a community needful to secure a stationary level, assuming immigration and emigration to balance one another, is obtained by dividing 1,000 by the average life expectation of the community. This, for England and Wales at the present time, is 58, which gives a little more than 17 as the needful figure, whereas the actual birth rate for that country is below 15.

[2] The Hon. B. S. B. Stevens, Premier of New South Wales, speaking on the man-power development in Australia, referred to Germany and her 70 million inhabitants occupying a comparatively small territory, and Switzerland with her four millions occupying a territory no more than half the area of Tasmania —and compared them with New South Wales possessing an area of 323,000 square miles, and a population of a few million.

of organs, capable of *infinite progressive evolution*. Of no other organ, or system of organs, can this be said : the complex cardio-vascular system of a mouse constitutes as finished a product, as functionally perfect, as the corresponding system of Man. The *human brain*, on the other hand, the most complex integrate of which we have any knowledge, *admits of further integration to an infinite degree*. This has been rendered possible by the peculiar structure of the cerebral integrate, and by the possession of hands. Vertebrate evolution has essentially been an evolution of brain.

In America and some European countries eugenics has taken practical shape in the way of sterilising the seriously unfit and the certification of pre-nuptial fitness. In Germany some 56,000 people underwent voluntary sterilisation in the first twelve months after the introduction of a sterilisation law. In our own country eugenics has made no further advance than the formulation by the Eugenic Society of a scheme of voluntary pre-nuptial health examination.

CHAPTER II

HYGIENE

IT will, I suppose, generally be admitted that, in a perfectly regulated society, each member from birth onwards should enjoy those conditions most favourable to the development of mind and body, and that, in so far as anyone is denied those advantages, he is being cheated of his birthright, one of incomparably greater account than mere material wealth inherited by legal enactment and rigorously safeguarded by the law ; for surely it is better to enjoy, in poverty, abounding health of body and mind than to be a sickly misanthropic millionaire, robed in purple and dwelling in a palace.

How greatly we can be influenced for good or ill by our environment, material and mental, is forcibly brought home to us by picturing the case of identical twins—girl twins, let us say—born into the world with the potentialities of ideal health, beauty, intellect and goodness. Let us suppose that, from birth onwards, one of these sisters is brought up under the conditions best calculated to promote the realisation of these potentialities, while the other is doomed to conditions least favourable to that realisation. Let us suppose that, at the age of eighteen, the two sisters are brought together—the one the perfection of radiant womanhood, the admired of all, the other a blighted, deformed creature, from whom many would find it difficult not to turn away in disgust. Surely such a one might justly complain that she had been cruelly robbed of her birthright.

Were all children to be brought up under perfect hygienic conditions—to be fed on the best food, to live in the country,

spending much of their time in the open, with full opportunity to indulge in healthful bodily exercise—the difference between such children and the poorer class of slum-bred children, as we know them, would (I speak of averages) be unmistakable. We should then understand how far, in the matter of health and physique, our children fail to realise their inborn possibilities.

Excluding such inherent defects as epilepsy, insanity, mental deficiency, and pronounced errors of refraction (which could be greatly reduced by a sane application of eugenics), we should have an army of boys and girls much above their present stature, full of the joy of life, with well-developed jaws, well-placed teeth free from decay, and ample nasal passages, while there would be an almost complete absence of such pests as "adenoids and tonsils," middle-ear disease and appendicitis. They would, nevertheless, probably fail to realise the high standard of physical fitness attained by their pre-agricultural ancestors.

In order to achieve proper development of the body and sound health, the principles to be observed are simple in the extreme. The three outstanding requirements are—proper food, fresh air, and full opportunity for gratifying the instinctive craving for bodily exercise. Abundant outdoor life is of immense importance during the years of development. Hospitals, schools and similar institutions should be situated in the country and constructed on the open-air system. All schools should be provided with ample playing grounds, and these, in the case of boarding schools, should (preferably) be in the nature of a park, so as to allow a considerable part of each day to be spent in the open.

So much for eugenics and hygiene. Immense improvement in the health and physical fitness of the human race might be brought about by their means. Yet we must be careful not to exaggerate their possibilities and indulge the fond hope, as some have done, that it is possible to eradicate disease from the human

race. The fact is, all living organisms are liable to disease—and ever will be. One needs to study physiology and pathology to realise in some measure how infinite are the ways in which the complex human machine may be disordered.

CHAPTER III

THE ADAPTABILITY OF THE NERVOUS SYSTEM

ADAPTABILITY is one of the fundamental attributes of living organisms—the capacity to adapt themselves to everyday routine changes in the environment, as well as to profound and entirely novel environmental conditions.

Man has spread far and wide over the earth and has learned to accommodate himself to a great variety of food. Thus the peoples of different countries get accustomed to the particular diet on which, from childhood, they have been nurtured, even though, as in the case of vast sections of Eastern peoples, it may be far from the ideal kind. Hence the importance of cultivating in our children a liking for the right kind of food, such as raw salad and farinaceous food of a kind calculated to stimulate the masticatory instinct. It is very necessary that children should not develop fanciful dislikes, for in this way they may get to avoid, for the rest of their lives, many wholesome foods. It is of the utmost importance to educate the child's palate, so that he may favour those foods which promote normal nutrition and health —healthy blood, well-developed jaws, well-spaced teeth.

Sir Peter Chalmers Mitchell in his Cavendish Lecture drew attention to the readiness with which animals adapt themselves to different kinds of food.

" Taking the animal kingdom as a whole, the processes of digestion and assimilation are much more accommodating than we are disposed to think." The French racehorse " Azote was on a purely nitrogenous diet; John Hunter brought up a seagull on grain. . . . Apes and monkeys are typically vegetarian, feeding on shoots, leaves, and fruits of all kinds." Nevertheless " some of the marmosets and smaller monkeys and lemurs

feed on grubs and insects, and in captivity at least, even the great apes and most of the baboons will take animal food. A mandril . . . was noticed to catch, kill and eat grey squirrels which had rashly entered the cage in quest of nuts. . . . The pair of gorillas now in the gardens had learned to take a mixed diet of milk, fruit, vegetables, fish, and occasionally cooked meat, before they came to us, and are living on a continuation of that diet. We habitually add fat to the boiled vegetable rations of most of the apes and monkeys. I have little doubt but that under natural conditions the great majority of the apes and monkeys take grubs and insects, and eggs, and even young birds and mammals when they have the opportunity. So far as can be inferred from the evidence of structure and habit, the ancestors of the human race were not purely vegetarian.''

In point of fact all available evidence suggests the conclusion that Man evolved from a lower primate phase essentially as a hunter.

CHAPTER IV

PRE-AGRICULTURAL DIET CONTRASTED WITH THE DIET OF CIVILISED MAN

CIVILISATION dates from the introduction of agriculture, in Upper Egypt or its near neighbourhood, about 5500 B.C.

All the civilised peoples of the world to-day are descended from pre-agricultural peoples of the northern hemisphere—the ancestors of the Mediterraneans, Alpines, Mongols and Nordics. Before the introduction of agriculture those ancestors of ours were wandering hunters without fixed abodes, pottery, metals, domesticated animals (save, perhaps, the dog), or cultivated vegetable food. They subsisted on animal food gained by hunting and fishing, and on the products of the uncultivated plant world.

They had no bread, the " staff of life," as we term it.
,, ,, no milk other than that of the human mother.
,, ,, no butter, or cheese.
,, ,, no regular supply of eggs, such as we enjoy to-day.
,, ,, no concentrated sugar, save occasional finds of wild honey, or sugar gained by " tapping " the maple tree.
,, ,, no cultivated fruits (such as the fig, date, grape, cocoanut, banana, apple, orange) or vegetables (such as potatoes, carrots, turnips, peas, beans, cabbages).
,, ,, no cereals (such as wheat, maize, oats).
,, ,, no alcohol, beer, wine, spirits—no tea, coffee, cocoa.

Observe that the command over the environment of these pre-agricultural ancestors was limited in the extreme as compared with that of civilised Man of to-day. This was not due to lack of intelligence, but to lack of tools. What could we of to-day

achieve without metals ? and yet there is reason to believe that, at the time of the introduction of agriculture, our ancestors were, on the average, superior to us both mentally and physically. The human population of the Northern Hemisphere at the birth of agriculture was probably no more than a few millions ; the struggle for the bare necessities of life was of the severest : only the physically fittest and the most quick-witted survived ; and it *was the severity of the struggle for existence which ensured progressive mental evolution*.[1] The introduction of civilisation by increasing the supply of food and fostering communal life lessened the severity of that struggle, which was essential not only for the continued progressive evolution, but also for the maintenance of the average mental and physical standard prevailing at that time. The lessening of the struggle brought about by civilisation has thus lowered the mental and physical average.[2]

We may learn a useful lesson by trying to realise the severely rigorous, primitive conditions under which the evolving Man advanced in intellectual stature, more than doubling the size of his brain, acquiring the gifts of speech and abstract thought, and the power of pondering over the past and the future.

If this rigorous life, this intense struggle, was the agency which raised Man to his present exalted position, does it not follow that a serious slackening of that struggle may have grave consequences ? Not only is individual struggle needful for racial advance, but as I have said, even for the maintenance of the standard already achieved.

The beneficence of struggle should be kept in view in devising an ideal nurture for children. We need to guard against the danger of over-pampering, both in the material and the mental

[1] Anatomically, Man at that time had, apart from his brain, practically reached the limit of his progressive evolution. On the other hand, as already stated (Chapter I) *in respect of brain and mind there is no limit to Man's progressive evolution.*

[2] I have dealt with this subject in a paper on "The Factors which have Determined Man's Evolution from a Primitive Primate." Read at the Annual Meeting of the British Association, Sheffield, 1934.

sphere. I do not, of course, advocate harsh treatment, but rather that life should not be made too easy for the young—that they should learn to face difficulties and to be content with, and even get to appreciate, plain, wholesome food.

I do not doubt that children could grow up healthily (and happily) under much more rigorous conditions than falls to the lot of many of them to-day—that, for instance, a sturdy infant of civilised parents, if brought up, let us say, from birth onwards, with a tribe of unspoiled Australian aborigines, *i.e.*, without any other than human milk, and without any of the dietetic luxuries of civilised peoples, would grow up a strong well-developed adult, with surprisingly well-developed jaws and good teeth, and with complete freedom from such maladies as adenoids, " tonsils " and appendicitis.

CHAPTER V

PHASES IN MAN'S DIETETIC HISTORY

In order to gain a clear insight into the kind of food best calculated to promote Man's welfare, it is necessary to know the essential changes his food has undergone from a remote period of his ancestry. The following are the chief landmarks in Man's dietetic career from the dawn of mammalian life onwards.

(1) *The Initiation of Mammary Nutrition.* Shortly after the coal measures were laid down, many million years ago, the primitive mammal made its appearance ; the evolution of the human mammary function has thus a remote history. During this long period Nature has (so to say) been evolving many different types of milk, each subtly adjusted to the requirements of an individual species of mammal : for instance, the milk suitable for the bovine calf is not suitable for the human infant. Note that milk, being an animal food, all young mammals begin their post-natal career on animal food.

(2) *The Adoption of Hunting and Fishing.* An eventful phase in Man's dietetic past was the search for animal food and the adoption of a hunting career. Elsewhere I have sought to show how this mode of life expedited Man's evolution ; for the early pre-human hunter, essentially a vegetable feeder as he was, lacked the equipment, anatomical and instinctive, of the carnivore ; on the other hand, he was pre-eminently endowed with the twin gifts of high intelligence, and prehensile hands capable of giving effect to that intelligence. The capture of an elusive prey without the help of a specialised equipment, anatomical and instinctive, for that purpose, compelled him to rely for

success upon his mother-wit: necessarily, the most quick-witted were the most successful in the hunt. Thus it came about that, in the struggle for existence, *super-average intelligence enjoyed a survival value unprecedented in the history of the world;* and it was the eventful situation thus created which led to the phenomenal development of brain and mind characteristic of Man.

With increasing intelligence and increasing skill in the hunt the evolving Man came to subsist more and more on animal food, until eventually some measure of animal food—bird, beast or fish—became necessary for his normal growth and vigour: he grew to be a mixed feeder. We may regard this as a basic truth. To assume that animal foods other than milk and eggs are necessarily harmful to Man is to ignore the fact that he achieved his manhood on a highly animalised diet; it was indeed essentially his hunting career which brought about that evolution in the way I have sought to show.

The need of some admixture of animal food in Man's diet is evidenced by the eloquent fact that animal fats and proteins both possess for him a higher nutritive value than the corresponding vegetable forms. Moreover, experience shows that a purely vegetable diet does not suffice for Man's needs, not even when fortified by the addition of concentrated starch, sugar, vegetable fats and proteins artificially extracted in their pure forms.

No doubt the primitive hunter, leading an active out-of-door life, was able to consume with impunity a larger quantity of animal food than modern civilised Man leading a sedentary life can cope with, but this must not blind us to the fact that some portion of animal food is necessary for Man, if he is to achieve his highest nutritional level. In truth, more harm results to-day from the excessive consumption of cereals and sugar than from an excess of animal food, which is kept at a low average level on account of its greater expense. The poorer classes among civilised peoples tend to suffer from a dearth of animal food, which

includes not only meat, fish and bird, but eggs and milk, butter and cheese ; especially is this true of the masses in many countries of the Far East.

(3) *The Initiation of Cookery*. The latter part of the hunting period was marked by one of the most outstanding of human discoveries—that of cookery. This was already practised by the Neanderthal race which became extinct many thousand years ago without having attained the status of *homo sapiens*. No doubt cookery was first mainly employed for vegetable food, the digestibility of the coarser forms of which is greatly facilitated by heat, which, by breaking up the non-digestible cellulose chambers of vegetable tissue, liberates the imprisoned nutriment —starch, fat and protein. At the same time cookery promotes the digestion of the liberated starch.

An important effect of cookery was greatly to increase the supply of vegetable food and at the same time to diminish that of animal food consumed.

Before the introduction of cookery, all food was of necessity eaten raw ; the coarser forms of vegetable foods demanded vigorous use of the jaws and teeth, which were correspondingly massive and powerful. At that time dental decay and pyorrhœa must have been rare, as they still are among extant pre-agriculturists. The practice of cookery, by softening the coarser forms of vegetable foods, led to a diminution in the size of the jaws and teeth. It also increased the tendency to dental decay and pyorrhœa : raw " natural " foods tend to leave the mouth clean, whereas many cooked vegetable foods, such as porridge and puddings, are apt to leave it dirty and in a condition favourable to the production of both these affections. Nevertheless, the extant pre-agriculturists, all of whom cook their food, have well-developed jaws, and dental decay and pyorrhœa are comparatively rare among them, *because much of their vegetable food is eaten in the raw state*, and because such of it as is cooked is of a simple and for the most part detergent kind.

Not only did the practice of cookery increase the supply of vegetable food: it served to open the way to agriculture and civilisation. Without cookery Man might indeed have cultivated valuable fruits, such as the date, fig, grape, banana, cocoanut, lemon, orange, apple, but it is doubtful whether, without the aid of cookery, it would have been worth while to cultivate that most valuable class of all vegetable foods, the cereals (including wheat, barley, oats, rye, rice, maize, millet), the supreme value of which lies in their richness in proteins, and their capacity for storage; for, in the raw state, they are practically useless as food. This highly nutritious, *storable* cereal may be said to have played an essential part in civilisation. (The nearest rival of the cereal berry is the seed of the legumes.) Thus cookery opened the way to cereal agriculture, and thus to civilisation. Apart from the axe, Man's supreme discovery was the making of fire, which led to cookery, and subsequently to the smelting of iron, etc.

(4) *The Adoption of Agriculture and the Breeding of Animals for Food*. No doubt the cultivation of the plant world long antedated the breeding of animals for food. Agriculture did not begin in real earnest until the introduction of cereal cultivation (in Upper Egypt or thereabouts), which is thought to have taken place about 5500 B.C. This is as yesterday compared with the long period that has elapsed since the human began to emerge from the anthropoid phase.

Until the advent of agriculture the total human population was perforce small (owing to the limited food supply), probably not exceeding a few millions; and their food was in the main confined to the flesh of wild animals and fish, and to the products of the uncultivated plant world.

By the adoption of food culture Man enormously increased his supplies of nutriment and multiplied accordingly. Instead of having to search laboriously for fruits, roots and the like, he took to growing them ready to hand and greatly improved their quality: he cultivated groves of fig trees, cocoanut and date palms, improv-

ing their fruits out of all recognition ; he planted fields of roots such as manioc, potato, yam, and greatly increased their nutritive value, and instead of depending for his cereals upon the seeds of wild grasses, collected with infinite labour, he diligently tended and promoted their growth until he developed the noble maize and wheat, of which he has eventually come to grow millions of acres. And, as regards the animal kingdom, not only did he learn, in course of time, to increase his supply of fish by building fleets of fishing vessels to reap the inexhaustible harvest of the sea, but he also, in place of spending long hours in the hunt, learned to raise vast flocks and herds of sheep, oxen, goats and pigs, and to breed birds of many kinds. Again, he has bred mammals for the milk they yield, and birds for their eggs. Yet, inasmuch as the supply of vegetable food has been increased even more than that of animal food, the total effect of food culture has been to make Man more vegetarian than carnivorous.

Another effect of agriculture has been to augment to an enormous extent the supply of starchy farinaceous food. This leads me to direct attention to an evil in British diet which it is one of the chief objects of this book to emphasise. Within recent times it has been the custom among British peoples, both at home and abroad, to consume most of this starchy food in soft, pappy, or spongy forms, such as refined spongy bread, pultaceous puddings and porridge—all-too-easily swallowed—with the result that, in striking contrast to the dietetic customs of earlier times, the modern British stomach is apt to be flooded with imperfectly insalivated starchy food. This pernicious practice has led to contracted jaws and overcrowded teeth, and has promoted to a disastrous extent the occurrence of dental decay, pyorrhœa and digestive disorders.

Agriculture has further enormously increased the supply of concentrated sugar which, in pre-agricultural times, was limited to occasional finds of wild honey and sugar derived by " tapping " the maple tree.

CHAPTER VI

THE EFFECT OF AGRICULTURE ON THE RELATIVE PROPORTION OF ANIMAL AND VEGETABLE FOOD

THE effect of agriculture (the cultivation of foods derived from the plant world) on Man's supply of animal food (*i.e.*, food derived from the animal kingdom, vertebrate and invertebrate) has been to lessen the proportion of animal to vegetable food consumed. Prior to the advent of agriculture when the men spent much of their time in hunting and fishing and the women in gathering and preparing food from the uncultivated vegetable kingdom, the proportion of animal and vegetable food consumed, as measured by their respective nutrient values, was probably about equal. No doubt the proportion differed in different regions, but it may be regarded as certain that the proportion of animal food was always fairly high.

Bear in mind that in those days the only milk available was that of the human mother, and that there was no regular supply of eggs.

The effect of agriculture after it had become firmly established was greatly to reduce the average supply per individual of animal food, and to increase that of vegetable food, especially cereal food. Mammals and birds were not bred for their flesh, nor for their milk and eggs, until long after the introduction of agriculture ; yet in spite of the artificial rearing of mammals and birds for food eventually adopted, never since the advent of agriculture has the supply of animal food been able to keep pace with the needs of the increasing population. Along the coast and in the neighbourhood of large inland lakes and rivers, a plentiful supply

of fish may have been available, but we are probably safe in concluding that, taking the human population of the world as a whole, the proportion of animal to vegetable food as measured by nutrient value, has been, and still is, far less than it was in pre-agricultural times; not only so, but large sections of the population of countries like India and China, and the poorer portion of the population of European countries, are to-day suffering from a dearth of animal food, more particularly of meat, the most highly prized of staple foods (except perhaps milk), throughout the world.

It is just here—and this is the point to be emphasised—that the value of cow's milk and hen's eggs is displayed. These *highly nutritious animal foods are substitutes for the meat food man secured as a hunter*. The increasing production of eggs and milk is helping to make good the world deficiency in the flesh foods provided by beast, bird and fish.

An outstanding defect in the food of our people, as well as of many other nations, is an excess of cereals and a deficiency of animal food. Professor E. Mellanby has emphasised this disproportion, notably as it affects children, and has insisted on the necessity of reducing their cereal food, and of increasing the supply of such foods as milk, butter, cheese, eggs, and even, perhaps, supplementing these by cod-liver oil (on account of its richness of vitamin D).

The most effective way of combating this evil I conceive to be the following :

(1) Let most (preferably all) the cereal food be limited to well-baked, crusty bread. This will confer the threefold advantage of

(*a*) Affording abundant exercise of the teeth and jaws,

(*b*) Facilitating the digestion of the cereal food,

(*c*) Preventing the stomach from being deluged with an excess of imperfectly insalivated cereal food.

The total effect of this restriction will be (among other advantages) to reduce the consumption of cereal food.

(2) The second desideratum is to increase the consumption

of animal food. Many forms of animal food are available for this purpose, not only milk, butter, eggs, cheese, but meat, bird and fish. Dairy produce and eggs are, no doubt, highly nutritious forms of animal food which Man, in his ingenuity, has side-tracked from their natural purposes, to subserve his own nutritive needs ; but they are not absolutely essential foods, the absence of which would lead to the extinction of the human race. Children after cutting all their temporary teeth (twenty-fourth to thirtieth month) or even before that time, can enjoy and digest meat, bird and fish, and, if the family purse allows and they are not destined to be brought up as vegetarians, there is no reason why they should not thus early indulge in these foods, as well as in eggs and butter, or indeed to the entire exclusion of these.

The provision of a daily glass of good milk is an admirable way of supplementing the modicum of animal food which the very poor can afford their children, and the daily service of milk in our elementary schools is all to the good. Nevertheless, except for the very poor and for invalids, the routine practice of taking milk by itself in the form of a drink, prolonging as it were the lactation period, is by no means essential. If milk is to be swallowed in the liquid form, it should, for those otherwise well supplied with animal food, be as an adjunct to tea, coffee cocoa or chocolate. (See also Chapter XI, Part I, on the subject of milk for children.)

CHAPTER VII

ANIMAL *VERSUS* VEGETABLE FOOD

PRE-AGRICULTURAL Man, as we know him to-day, is not able to subsist on wild, uncultivated vegetable food alone, even with the help of cookery which has so greatly increased his supply of food from this source : he needs to supplement his vegetable food by hunting, fishing and other ways. Excluding the Esquimaux (some groups of whom subsist almost entirely on animal food) and certain African tribes, I estimate the diet of the still-surviving pre-agriculturists, such as the Australian aborigines (as estimated by its nutrient value) to be, on the average, about one-half vegetable and one-half animal. Immediately before the discovery of cookery, which increased the supply of vegetable food, the proportion of animal food was probably even higher than this.

The nutritive value of vegetable food has been enormously increased by cultivation, but it would seem that few, if any, persons can subsist in the full enjoyment of vigorous health on vegetable food alone—no matter how carefully selected, even from the most nutritious cultivated varieties. Mr. Henry Light, who for thirty years had been intimately associated with " vegetarian " athletes, and for twenty years had captained their cycling club, had only known one man who was able to maintain health on a purely vegetable diet ; yet even in his case slackness would after a short time set in ; the addition, however, of a small quantity of animal food in the shape of milk or eggs, sufficed to re-establish his wonted vigour.

It is evident that the long period, amounting to many hundred thousand years, during which the evolving Man subsisted as a hunter on a highly animalised diet, has rendered the Man of to-day in some measure dependent upon animal food.

It may therefore be concluded as a basic truth that for complete, vigorous health, *homo sapiens* needs some animal food, whether in the shape of bird, beast, or fish, or of the milk or eggs, with which the " vegetarian " supplements his vegetable food.

That a " vegetarian " diet from the weaning period onwards is consistent with perfect health and development is certain. I have visited a public school at which one of several " houses " is devoted to boys who have been brought up from early years on such a vegetarian diet. In athletic and scholastic competitions these boys easily hold their own against any of the other houses. They struck me as singularly bright, well-grown and healthy lads; the only fault I was disposed to find in them physically was one common to most of the boys and girls of this country, namely, defective development of the jaws and over-crowding of the teeth, through lack of food compelling vigorous mastication. This fault I am pleased to know has been in some measure corrected.

The fact that Man has risen from a lowlier being to his present dominant position as a hunter, involving the wholesale slaughter of animals, must be admitted. Nevertheless, the custom of breeding mammals (which belong to the highest class of back-bone animals, and which, like the human mother, suckle their young and nurture them with self-sacrificing care) for the express purpose of consuming their flesh, seems not a little inconsistent with the exalted destiny which he has dreamt of for himself. Seeing that vegetarianism (which limits animal food to milk and eggs) supplies the needs of human nutrition, it is conceivable that Man may one day abandon the slaughtering of animals for food: we may conceive of him as first omitting butcher's meat from his diet, while permitting bird and fish; later as excluding bird also; and finally even fish. At present there is no indication of any such trend: the breeding of cattle solely for milk, and poultry solely for eggs, is not commercially feasible.

Meat in moderation is for the average person a valuable food.

CHAPTER VIII

THE NEED OF RAW VEGETABLE FOOD

MOST, if not all, animals among the mammals seem to stand in need of a modicum of raw vegetable food. This would appear to be true even of the carnivora.

We learn from Sir Peter Chalmers Mitchell that in the London Zoological Gardens the large carnivora are given fresh-cut grass at least once weekly, and that " many of the animals classed as carnivorous are really omnivorous ; bears, dogs, wolves, foxes, and others, for example, all take fruit, vegetables, and other potash-containing substances. Even flesh-eating carnivora, like sea-lions, seals and elephant seals take vegetable food greedily ; we lost a valuable elephant seal at the London Zoo because it acquired an uncontrollable passion for buns, and used to stand up and beg for them."

Before the introduction of cookery our ancestors obviously consumed all their vegetable food in the raw state. Even after the introduction of cookery pre-agricultural man consumed a large proportion of his vegetable food uncooked. Among all surviving pre-agricultural peoples (other than the Esquimaux) the women spend much of their time in gathering a variety of vegetable foods which are eaten raw. These include wild lettuce, sow-thistle, the leaves of plants, wild clover, and many different kinds of seeds and roots. The primitive Californians consumed large quantities of green food in the spring, especially clover, the early gathering of which was celebrated by a clover dance ; a whole village might be seen squatting in a lush clover meadow plucking the blossoms.

No doubt the extant pre-agricultural child early partakes of raw vegetable food, even before the termination of the lactation

period when this is prolonged. It is not yet realised how soon the young human is capable of digesting food of this kind. The early eruption of the incisor teeth is significant. Dr. Sim Wallace suggests that its purpose may be to pierce the rind of fruits and suck the contained juices.

Children from an early age display an instinctive liking for raw vegetable food. Those brought up in the country, not pampered by too luxurious food, and free to roam in the kitchen garden, will help themselves not only to fruits, but to vegetables of many kinds, such as carrots, onions, turnips, peas and the heart of cabbage. I am told that the children attending the cookery classes in the elementary schools are so partial to the raw carrots and peas provided for the cookery class, that care has to be taken to protect them from depredation. Country children are also in the habit of eating the young green leaves culled from the hedges, and known as " bread and cheese."

This instinct for raw vegetable food should be fostered. I have watched a little girl of some six or seven summers, sitting by herself in the market-place of a country town, very deliberately and daintily, with finger and thumb, picking peas from their containing pods—of which she had a treasured supply in a small paper bag—and eating them with manifest relish. I say treasured, for every now and again, she would take out the unopened pods, and after placing them in a row by her side, and counting them carefully, replace them in the bag. I discovered that they originally represented a pennyworth. How much better it were if children spent their pennies in this way, than at the seductive sweetstuff shop, an institution I shall never cease to deplore. A cheapening of fruit would go a long way to abate the artificially nurtured greed of children for sweets. I have it on the authority of a street hawker that there is a greater demand for fruit when in season than for sweets. When fruit abounds he finds it more profitable than sweets.

On another occasion, noticing a child two or three years old

toddling about a greengrocer's shop, I asked the shopkeeper, his father, if the boy was fond of fruit : he informed me that since the age of twelve months or so, he had freely helped himself promiscuously to the produce of the shop, and apparently no harm had come of it.

Highly erroneous notions prevail among the public concerning the foods suitable for children : small children have a natural instinct for raw fruits and salad foods ; this should be encouraged from an early age, so that they may learn to appreciate the delicate flavours of this class of foods.

We need to eat far more salads than we do in this country. In this respect we are a long way behind our Continental and transatlantic neighbours ; with them salads are a prominent dietetic item. " Every city in America has scores of small shops which cater for salads and sandwiches—the multiplicity of these shops almost equals that of our teashops."

Raw salad foods and fruits have the twofold virtue that they provide essential salts and vitamins, while they tend to leave the mouth clean and to prevent dental decay and pyorrhœa.

In a discussion on school diet held at University College, London, the question of cooked *versus* raw vegetable foods came up for consideration. The evidence went to prove that children as a class show little liking for cooked vegetables. Thus Miss Margaret Anderson, Superintendent of the School Dining Centres, West Ham, had almost invariably found, in feeding thousands of children from the age of four to fourteen years, that children disliked cooked vegetables ; it was rare to find a child of four taking to them naturally. Mrs. Alfred Lewisohn concurred. Her children preferred vegetables in the raw state. Miss Hyatt, King Alfred School, agreed with the previous speakers. Mrs. Rosina Thornburgh said : " Children enjoyed raw vegetables, especially the sweetness of raw carrot and the raw artichoke." Dr. Catherine Chisholme found it possible to give chopped raw greenstuff to babies. She advocated plenty of water.

This preference for raw vegetables is no doubt instinctive, and should, I repeat, be encouraged. After lactation some raw vegetable food should be consumed daily throughout the year.

Home-grown Fruits and Salads. Seeing that everyone should daily eat a modicum of raw vegetable food, whether in the form of fruit or salad, encouragement should be given to the home production of these foods. Owing to the large supplies from abroad, fruit to-day is more plentiful in this country than it used to be; but fresh salad foods are difficult to obtain at a moderate price in our large towns, and it is here that allotments are so useful. Fruit culture could be greatly developed in the suburban gardens of large towns. Dr. Sim Wallace, who has so long sought to bring home to the public the value of fruit in promoting cleanliness of the mouth, has shown how much can be done in this way, even on a comparatively small plot of ground. He harvests apples, pears and peaches which can compete with the best, and can offer his friends in late winter, and even early spring, not only choice apples, but luscious pears of his own growing.

Happily, orchards are increasing in this country. In 1933 the orchard area increased by 2,100 acres. In Kent a careful study has been made of the soils suitable for fruit trees, and the knowledge thus gained is freely placed at the service of would-be growers.

I do not hold with the practice of planting trees along a hedgeless road traversing beautiful country, but if trees are to line our roadways, why exclude fruit trees? I am told that there are practical difficulties in the way of including them: I cannot but think that these could be overcome.

Sir Leonard Hill and Surgeon-General R. McCarrison have emphasised the importance of cultivating vegetables in the near neighbourhood of the consumers, so that they may be obtained fresh.

"These foods have a value that depends not only on their vitamin content but on their content of essential mineral salts, pigments, cellulose, and 'something else' associated with freshness whose nature is unknown. Year by year we import vast quantities of vegetables. . . . Long before these vegetables reach consumers of the poorer classes they have lost,

especially those of the green leafy kinds, much of their health-promoting properties. Recently it was found in my laboratory . . . that certain green vegetables lost a considerable percentage of their ascorbutic content as the result of a few days storage. . . . Thousands of our people stand idle in the market place who would be well employed in the production and distribution of these health-giving foods."—R. McCarrison.

Figures published by the Ministry of Agriculture show that the annual consumption of fruit per head in this country amounted in 1924 to 50 lb., rising to 68½ lb. in 1928, 85 lb. in 1930, and to 95½ lb. in 1934. To-day the annual value of our fruit industry is estimated at £150,000,000. The population now annually consumes 150 apples and 96 oranges per head.

Large quantities of fruit are imported from the Overseas Empire—Canada, Australia, New Zealand, South Africa, Jamaica, Trinidad. From Cyprus we imported this last year 32,500 boxes of lemons. On a Monday in April, 1936, shipments of fruit from South Africa amounted to 176,588 packages, comprising grapes, apples, pineapples, pears, melons, quinces, medlars and pomegranates.

CHAPTER IX

MILK AND EGGS

IT was not until some time after the introduction of agriculture that Man took to breeding for food certain mammals (*e.g.*, the ox, sheep, pig) and certain birds (*e.g.*, the farmyard fowl, duck, goose) that he came to realise the nutritive value of the milk of the cow and the goat, and the eggs of the fowl.

Here were highly nutritious foods which nature had devised for the young of certain warm-blooded vertebrates—mammals and birds. Accordingly Man set to work to increase the milk-yield of a particular species of mammal, and the egg-laying capacity of a particular species of bird, and to such good effect that he has succeeded in breeding a cow capable of producing 1,500 gallons of milk in a single year (900 is regarded as a good average), and a variety of fowl capable of annually laying eggs to a number approaching 300 (150 is a good average).

In thus augmenting, as it were side-tracking, a natural function of mammal and bird to serve his own nutritive needs, Man has displayed an almost uncanny perspicacity, and devised an *entirely new kind of animal food-culture*, one which is likely to play a yet more conspicuous part in his future. A kindred instance is afforded by his practice of breeding bees for the honey they laboriously gather and store up for their own use.

The unique interest and supreme importance of milk and egg production lie in the fact that these foods, *being of the nature of animal foods, can take the place of the flesh of the bird, beast and fish*. Save for the microscopic germ within the egg, they have never throbbed with life ; consequently a person enjoying good

health on a " vegetarian " diet, *i.e.*, a well-balanced diet of vegetable food supplemented by eggs and milk (and its products), may derive some comfort from the knowledge that his food does not directly involve the taking of animal life and its many gruesome accompaniments. Even so, the fact has to be faced that the vegetarian, although he does not consume the flesh of animals that have once lived, is accessory to their slaughter, for in order that the milk and egg industries may prove paying concerns, the males, and ultimately the females, of the producing animals need to be killed and turned into money.

So far, the cult of vegetarianism has made but little progress. In many countries, however, a considerable increase, in proportion to the population, in the production of eggs and milk has taken place within recent years ; and it seems likely that the increase in the production of these types of animal food will tend to lessen the amount of flesh-foods consumed per individual.

CHAPTER X

BREAST-FEEDING. BOTTLE-FEEDING

THE artificial feeding of infants is a comparatively recent innovation: it was not introduced until the eighteenth century. Before that time the entire human race was breast-fed. We read that in 1783 a cow's horn tipped with leather or parchment was in use. Early in the nineteenth century this was replaced by a glass bottle of similar shape, and gradually the modern bottle was evolved; many kinds of artificial milk have come into use, and bottle-feeding has increased year by year.

The mechanism of breast-feeding differs from that of bottle-feeding; when at the breast the infant does not excite the milk to flow by suction (aspiration), but by mechanically stimulating the gland to pour forth its secretion reflexly, just as happens in milking the cow or the goat. The infant receives into its mouth not only the nipple, but the surrounding areolar portion of the breast also; a mode of functioning which, even at this early stage, favours the normal development of the infantile jaws by spreading them out laterally.

"Sucking necessitates considerable activity of the tongue and the muscles which close the mouth. To some extent this muscular activity is lost when artificial substitutes for the mother's breast are made, and measurements have been given by Sir Frank Colyer which would indicate that the dental arch is not so broad by nearly 1 mm. in bottle-fed children as in the normal. When the gnawing stage is reached—that is, before the incisor teeth commence to erupt—the muscles which close the mouth are still further used. When still further the incisor teeth are used for gnawing habitually and strenuously as is natural to healthy children, over-eruption of the incisor teeth is unlikely to take place . . . if over-eruption of the teeth takes place from lack of sufficient use, it is obvious

that the ' height ' of the palate will be augmented from the earliest age." —Sim Wallace.

Bottle-feeding, on the other hand, involves suction ; notably was this the case when the bottle was furnished with a long tube : the effect of this suction is to diminish the pressure within the mouth and to draw the cheeks in, the total effect being to narrow the jaws and to cause protrusion of the front teeth. A comparison of models taken of breast-fed and bottle-fed children, shows the jaws to be slightly narrower and the teeth slightly more protruded in the bottle-fed children.

There are many reasons why a woman should suckle her own children. From the first dawn of mammalian life, soon (geologically speaking) after the laying down of the coal measures, Nature has been evolving types of milk nicely adjusted, in respect of proteins, fats, saccharides, salts, and vitamins, to the digestive and nutritive requirements of the young of each individual species of mammal.

The following experiment shows how inadequate the milk of one species may be for another species : young mice fed on cow's milk failed to thrive and to breed, but when iron, copper and yestrel were added to the cow's milk, they throve, and were able to rear litters almost up to the normal standard. It would thus appear that, as regards mice, cow's milk lacks certain minerals, and also probably a vitamin factor.[1]

So exquisite is this adjustment that the milk of each species undergoes a progressive modification as the period of lactation advances, in accordance with the subtly changing nutritional needs of the offspring.

We may rely upon the wisdom of Nature. We may rest assured (may we not ?) that the milk of any given species is better adapted to that species than to any other. Must we not therefore conclude that the best milk for the human infant is that of the human mother ? May we not, perhaps, go even further and conclude

[1] G. S. Wilson, M.P., London School of Tropical Medicine.

that, provided the mother is healthy, her own milk is likely to be better suited to her baby than that of any other mother?

The Diet of the Nursing Mother. It is noteworthy that the milk tends to keep up the normal standard at the expense of the maternal tissues, even though the diet of the mother is seriously inadequate. It was observed during the Great War that the normal birth weight of infants in Germany and Austria was not affected in spite of maternal under-nourishment (Miss Murray's Report); and it is remarkable that mothers emaciated from serious disease "often give birth to plump and well-nourished babies" (J. F. Fairbairn).

Nevertheless, the milk of the inadequately fed mother tends to fall below the normal standard; it is well known that the milk-yield of the cow is profoundly influenced by the quality of its food—that it varies, for instance, in quality with the seasonal changes in the pasture, and the kind of the artificial foods given: dairy farmers are careful to feed their herds on those artificial foods which give the best milk.

If the human mother is extremely underfed, her milk is likely to be poor in quality, even though the mammary gland may draw upon the nutriment contained in the mother's tissues. Dr. Helen Mackay found that, among the children attending London Welfare Centres, 45 per cent. breast-fed children and 51 per cent. bottle-fed children were anæmic. In Aberdeen 50 per cent. adult females of child-bearing age were anæmic. No doubt this high percentage of anæmia was largely due to bad housing and deficient sunlight.

Care should, of course, be taken that the nursing mother is adequately fed. There is no evidence that cow's milk possesses any special value for the nursing mother, nor is a daily allowance of "stout" indicated. She should partake freely of ordinary food, and lead, as far as possible, a healthy life.

Philosophers have long disputed over the subtle problem of absolute right and wrong. If we appeal to Nature, the ultimate

court of appeal, for indications of what is right and what wrong conduct, we find that they are almost, if not entirely, limited to the obligations of parenthood, and in cases where the father is not concerned with the care of the offspring, of motherhood alone. Ethical codes are for the most part man-made and differ for different communities : among some primitive communities the young woman gauges the worth of a suitor by the number of scalps he has secured, in others murder and rapine are not only condoned but extolled, and, indeed, it might be difficult to prove *a priori* that such acts, in their case, are absolutely wrong : Nature gives no explicit indication that they are wrong—it might be argued that they have played an essential part in Man's evolution which indeed has involved the shedding of much blood. But the duty of the mammalian mother to suckle and tend her young until they can fend for themselves is not a man-made duty ; manifestly it is a duty imposed by Nature. Nor must it be forgotten that the mother by suckling her infant establishes a peculiarly intimate bond between the two, one which no mother should willingly forego.

If then the healthy mother jeopardises the health of her child by refusing it her own milk, she is robbing it of a heritage which has evolved and been handed down through the ages.

Every woman should make an attempt to suckle her child and undertake the sacrifices of motherhood. The plea is often put forward that the mother is incapable of suckling her infant : it has been proved beyond all doubt that, even among the super-civilised, the vast majority of women, in the absence of serious disease, are capable of this function. Persistent endeavour rarely fails to induce a flow of milk : as showing how abundant the maternal reserves may be in this sphere, it is found that the greater the demand the more abundant is the yield ; thus with twins the amount of milk secreted is normally twice as much as when there is only a single infant to feed. Similarly with sub-

human animals: a litter of five induces the mother to yield five times as much milk as for a single birth.

Any difficulty that may be experienced in suckling the child is nearly always the result of a highly artificialised rearing. On the continent poor women generally suckle their children successfully, and it is on record that the poor women of Glasgow make the best of mothers. One of the aims of hygiene should be to nurture girls in such wise that, in the event of their becoming mothers, they may prove themselves capable of fulfilling this primal duty.

It is chiefly those women who are in a position to hand over the responsibility of their children to paid help who shirk it. The maternal care of the child which should come first is apt to interfere with their selfish pleasures, and the interests of the child are sacrificed to them. I have heard a young woman declare that she had "definitely" made up her mind never to sacrifice her husband in favour of her children, and accordingly when the first child appeared, she put him in charge of a nurse, and for some months journeyed abroad with her husband on pleasure bent—a strangely crooked view of things.

We are told that the child often does as well on cow's milk,[1] duly modified, as when breast-fed, or even better. That may well be if the mother is ailing, but if she is healthy, no milk of a non-human mammal is likely to be as good for the child as the mother's milk.

The bottle enthusiast may point to a vigorous bottle-fed child and triumphantly exclaim: "The proof of the pudding is in the eating"; but is he prepared to guarantee that the nutrition of such a child is as satisfactory as it would have been had it been fed on a healthy mother's milk? Consider the case of identical twins, the one bottle-fed after the most approved fashion, the other fed on healthy mother's milk. Who can doubt that, were it

[1] As regards the suitability of cow's milk (even when modified) for the human infant, it is noteworthy that the calf grows at five times the rate of the human infant.

possible to trace out in minute detail the chemical changes occurring in the alimentary tract of each, striking changes in favour of the breast-fed twin would be revealed ? And if the digestive processes were found to be more perfect in the one case than in the other, would one not expect the nutritive processes of the entire organism to be the more efficient also ?

We are apt to lose sight of the fact that health is not an absolute but a relative condition, that in fact innumerable grades of health exist. Somewhere in the world is an infant more perfect than any other. It does not necessarily follow, because a child is vigorous and seems to be enjoying good health, that its nutrition leaves nothing to be desired ; what of the comparative after-histories of bottle-fed and breast-fed children ? Within recent years an alarming list of morbid conditions of the digestive tract has been revealed by the joint labours of the clinical physician, bio-chemist and morbid anatomist ; in the causation of these disorders faulty dietetic methods have played a large part, and among these faulty methods bottle-feeding has to be taken into account, especially among the poorer classes.

Can we be sure that, other things being equal, a child fed artificially, even in the most approved fashion, is as well set up for life as one nurtured on healthy mother's milk ? A Mussolini does not suggest bottle-feeding, nor do the great men of the Elizabethan age.

In judging the respective values of breast-feeding and bottle-feeding, we need, of course, to take into account the remarkable adaptability of the animal organism. Dr. Meyers has said, " Some children can be brought up on almost anything," and Dr. Cameron has drawn attention to the child's capacity to recover " a perfect state of nutrition after a most unsatisfactory infancy." Nevertheless the supreme care which Nature has taken in devising a specific type of milk, varying with every successive phase of lactation, for every species of mammal, must surely be in the interest of the offspring.

CHAPTER XI

WEANING

THE process of weaning consists in the gradual substitution of solid food for the mother's milk, which—take note—is a type of animal food. The digestive system of the infant is thus afforded the opportunity of gradually adapting itself to solid food. The fact that the teeth begin to erupt during the period of lactation is a clear indication for the gradual introduction of solid food, and that not merely of the pappy kind, to supplement the maternal supply. We have seen that human nutrition demands a supply both of animal and of vegetable food. The weanling (newly weaned child), as we may call him, therefore needs to be supplied with both. What then are the ideal types of animal and vegetable food for the weanling? In seeking an answer to that question we need to inquire into the nature of his diet during the late pre-agricultural period, when non-human milk was not available —the period during which early Man was merging into and gradually attained the status of *homo sapiens*. Seeing that but a few thousand years have elapsed since food cultivation was introduced, we may conclude (may we not?) that the weanling of to-day possesses much the same digestive capacities as had been stamped upon the child of the late pre-agricultural period during a long period of evolution.

Non-human milk and a regular supply of eggs not being available before the introduction of agriculture, and some animal food being essential, it is evident that weanlings must at that time have consumed the same kind of animal food as their parents, namely that procured by hunting, fishing, and the like, either eaten raw or subjected to a perfunctory roasting. It is highly probable

that the pre-agricultural human infant made acquaintance with animal food of this kind even before the termination of lactation.

The modern healthy weanling, like his pre-agricultural ancestor, is perfectly capable of digesting similar food in moderation, even during the lactation period. The administration of finely minced raw, or semi-raw, meat is a recognised treatment for infants whose digestive systems have been upset by a glut of farinaceous food.

Such being the case, it is curious, if one comes to think of it, that so illogical a belief should have arisen as that the weaned child imperatively needs the milk of a non-human mammal. The Australian aborigines and other extant pre-agriculturists met with in remote corners of the world, have never tasted any milk other than their mother's, and the like is true of millions of Oriental peoples. Nor must we forget that a regular supply of milk, as well as of eggs, was not available until comparatively recent times, long after the tilling of the soil was introduced. We must then rid ourselves of the notion that non-human milk is an absolutely necessary food for the healthy child, and that, were a famine of cow's milk and other non-human milk to occur, our children would suffer grievously by being deprived of it. No doubt the lack would be fatal to many bottle-fed infants deprived of maternal milk, and it might go hard with some weaklings, already weaned; but the normal weaned child would get on quite well without any milk or its products, or even eggs, on a rational vegetable diet supplemented by meat, bird, or fish. This is a basic dietetic truth, and there is no justification for the prevailing view that the weaned child is nutritionally dependent upon cow's milk.

The cow's milk craze has become a veritable obsession. Not content with employing this milk as a convenient form of animal food for little children—which is wholly legitimate—the public seem to have drifted into the belief that Nature has evolved the cow for the express purpose of providing the young human with her milk. Some enthusiasts insist upon its continuance, to the

extent of a pint daily, during the whole period of development; nay, there be some who plead for a generous daily allowance of this baby-food to the end of life, making of Man a lifelong parasite upon the cow. In the United States the milk craze is even more extravagant than in this country. There the minimum daily milk requirement for a child is thought by some to be no less than a full quart.

There is abundant evidence that *homo sapiens* can attain perfect physical development after a ten months' lactation without any dairy milk, or even eggs. Because a group of children in a particular institution after receiving a daily addition of half a pint of milk to their customary fare, have increased in weight and stature, and improved mentally beyond the children not thus favoured; because of this improvement it does not follow that all children imperatively need cow's milk after the lactation period. What an experience of this kind does show is that the children in question had not been adequately fed; a small daily proportion of fat rump steak and raw vegetable food would probably have given an equally good, if not better, result.

The conclusion that cow's milk is not essential after the period of suckling does not, of course, imply that it should never be given thereafter. Cow's milk and eggs are quite good forms of animal food for children, convenient substitutes for bird, meat and fish; and, indeed, I include an ample supply of milk and its products in my ideal school diet, in order to avoid the necessity of increasing the supply of other kinds of animal food.

Nevertheless, dairy milk has certain disadvantages which need to be guarded against. It is liable to be infected in various ways; tuberculous milk has been the means of destroying and mutilating hecatombs of children. I find by reference to the report of a special committee of the People's League of Health, presided over by Dr. C. O. Hawthorne, that:

> About 6 per cent. of all deaths from tuberculosis are annually caused by the bovine type of tubercle bacillus.

About 2,000 deaths, mostly of children, occur annually from this cause. About 4,000 fresh cases occur annually, and often permanent deformity is caused by this bacillus.

Among other microbic infections of dairy milk are: undulant fever, diphtheria, typhoid and paratyphoid. All these dangers can, however, be averted by efficient pasteurisation. Such injurious effect as this process may have on the nutritive value of the milk is inappreciable.

A second disadvantage of an abundant daily supply of milk for children is its *tendency to favour the consumption of mushy foods*, such as bread-and-milk and " milky " puddings, types of food which fail to afford adequate exercise for the jaws and teeth (see p. 127). Not less fallacious than the milk craze is the fallacy of supposing that all the solid food of little children must necessarily be soft.

Cow's milk may well constitute a liberal proportion of the necessary animal food after weaning, until the end of the second year, by which time, or somewhat later, all the twenty temporary teeth are generally through ; but from the beginning of the third year, provided other forms of animal food are freely available, milk may cease to be a staple food for the child, unless it be decided to bring him up on " vegetarian " lines. In this case care must be taken to avoid the use of spongy and mushy farinaceous foods.

Inasmuch as many of the poor suffer from a lack of animal food, and inasmuch as the milk produced in this country is greatly in excess of that consumed in the liquid form, the daily supply of milk to such children at a cheap price or, in the case of necessitous children, gratuitously, is greatly to be commended.

The explanation of the growing popularity of milk and eggs, as staple human foods, after weaning the infant, lies in the fact that, ever since the introduction of agriculture, the production of animal food has lagged behind that of vegetable food, and throughout the civilised world the proportion of animal to vegetable food available per individual has been considerably less than

was the case among our pre-agricultural ancestors, or than exists among the surviving pre-agriculturists. Only the comparatively well-to-do among civilised peoples are able to secure sufficient animal food, in the shape of bird, beast and fish, to satisfy their physiological needs. The tendency has been for the bulk of the populace to suffer from a dearth of animal food, notably in such countries as India and China. This deficiency is being met in many countries, including our own, by an increasing production of milk and eggs.

CHAPTER XII

CARBOHYDRATES

SUGAR. TUCK-SHOPS

A COMPLETE human diet comprises :

Proteins	Energy-yielding.
Carbohydrates	
Fats	
Minerals.	
Vitamins.	

The first group, *i.e.*, the energy-yielding foods, all contain carbon, hydrogen and oxygen. The proteins (which are necessary for the up-building of the tissues) contain in addition, nitrogen, also a small proportion of phosphorus and sulphur.

The protein molecules are highly complex and need to be split up into smaller molecules before absorption into the blood can take place; after absorption these are re-integrated into complex proteins. The most characteristic of the *carbohydrates*—the subject of this chapter—is *starch*. Its molecules are complex (though far less complex than those of proteins) and need to be split up into the smaller molecules of grape-sugar (glucose) for absorption to take place.

The relative proportion of these energy-yielding bodies in a normal human dietary is somewhat as follows :—

Protein . . .	1 (or less)
Fat	1
Carbohydrate .	$2\frac{1}{2}$

As regards *minerals* the adult human body contains about 7 lb., of which some five-sixths are contained in the bones. The

chief minerals are calcium, magnesium, phosphorus, potassium, sodium, iron, chlorine, iodine and minute traces of silica. Only a small quantity of minerals is needed daily; a sufficiency is contained in an ordinary mixed diet. Deficient calcification of the enamel plays no part in the causation of dental caries (see Part III, Chapter XVI). Deficiency in iodine may cause goitre. Rickets depends less upon a deficiency of calcium than upon a deficiency of vitamin D which is necessary for its utilisation.

Vitamins are dealt with in Part II, Chapters III and IV.

The complex of molecules constituting starch is represented by $C_6H_{10}O_5$ ten times over; thus the formula of starch is $(C_6H_{10}O_5)_{10}$.

In the process by hydrolysis of digestion the starch complex of molecules disintegrates into a series of bodies containing an ever-diminishing number of $C_6H_{10}O_5$ molecules. Thus:

$(C_6H_{10}O_5)$	10	starch
,,	9	the dextrines (poly-saccharides)
,,	8	
,,	7	
,,	6	
,,	5	
,,	4	
,,	3	
,,	2	maltose (di-saccharide)
,,	1	glucose (mono-saccharide)

During this process, the poly-saccharides (dextrines), the di-saccharide maltose, and the mono-saccharide glucose, become hydrolysed by the addition of OH.

The di-saccharides include not only the penultimate phase (maltose) of starch digestion, but sucrose (cane-sugar), and lactose (milk-sugar). Fruit sugar, like glucose, is a mono-saccharide.

The building-up (synthesis) of the complex molecule of starch in the green part of plants under the influence of the sun's rays, from such simple constituents as carbon and water ($C + H_2O$) is one of peculiar interest, in that it constitutes an initial phase in the up-building of living from non-living matter. From this we may infer that the genesis of living bioplasm out of inanimate matter took place—perhaps still takes place—under the influence of the sun's rays.

The solar rays acting upon certain vegetable cells (such as those of leaves and grasses) generate therein chlorophyl granules. These granules possess the power of absorbing the ultra-violet rays of the sun, through the agency of which they are able to extract the carbon from the carbon-

dioxide (CO_2) present in the atmosphere, retaining the carbon and returning the free oxygen to the atmosphere ; and it is by the mysterious vital chemistry of the cell-bioplasm that the complex molecule of starch (which during digestion is resolved into ten molecules of the mono-saccharide glucose) is built up from the carbon (C) and the water (H_2O) ever present in the green of plants. (No doubt in the process of bio-genesis the genesis of the mono-saccharide, glucose, took precedence of that of the more complex starch molecule, which, being insoluble, constitutes a storage product.)

The starch molecule, being too bulky to pass through the blood capillaries, undergoes during digestion, as we have seen, disruption, through a descending scale of dextrines, into the penultimate di-saccharide stage of maltose, and finally into the mono-saccharide glucose, ready for absorption by the capillaries of the digestive tract, thereby gaining entrance to the general blood stream.

The mono-saccharides, glucose and fructose, need no further digestion and are rapidly absorbed. Hence, honey, which consists largely of these two sugars, is helpful in feats of endurance. The di-saccharides, cane-sugar and maltose, need to be digested into the mono-saccharide glucose before they can be absorbed into the blood.

After absorption any excess of sugar in the blood is synthesised into animal starch (glycogen), which is stored in the liver and the muscles, or the excess may be run out by the kidneys.

An adequate proportion of sugar in the blood is as necessary as an adequate proportion of oxygen ; indeed, a fall of the blood-sugar much below the normal level is as serious as a like fall in the level of blood-oxygen.

Though necessary to the normal functioning of all the tissues, the blood-sugar is chiefly consumed by the muscles, providing the fuel for the work they perform.

In considering the value of sugar as a food we need to bear in mind that Man evolved to his present status on a diet from which (save for occasional finds, in limited regions of the world, of wild honey) sugar, in a concentrated form, was absent. Even honey is not pure sugar : it contains all the ingredients necessary for the nutrition of the bee. Note too, that, as provided by Nature, *i.e.*, " mixed with a fibrillar network of cellulose, dilute acids, and aromatic substances which stimulate the flow of saliva " sugar is harmless to the teeth (Sim Wallace).

A consideration of Man's dietetic history thus prepares us for the conclusion that civilised Man, like his not very remote pre-agricultural ancestors, can thrive without any concentrated sugar, and that he does not crave for sweets or intensely sweet things if they do not come his way. All the sugar needed for human nutrition can be obtained from the starch present (often in excess) in the cereals, and foods such as potatoes—the starch, after its digestion, entering the blood as soluble grape-sugar. Moreover, as Wallace points out, sugar is by no means an economical food for the very poor in this country: seeing that they get all the carbohydrate they require from bread and potatoes, it follows that the addition of jam (which contains half its weight of sugar), treacle, and the like, to foods made from flour is, from the standpoint of nutrition, an unnecessary expense. Bread-and-butter is much preferred by children to bread-and-jam. Again, "fruit made into a jam is reduced from a hygienic and palatable form, in which Nature has provided it, into an unhygienic form calculated to destroy the teeth."

In the days of Elizabeth—that so virile period of our history—the quantity of sugar consumed in these Isles was almost negligible; yet this lack did not daunt the spirit of a Drake nor impoverish the genius of a Shakespeare.

To-day, in the United Kingdom, we annually consume 95 lb. of sugar per head, and spend annually £50,000,000 on sweets alone. More than 72,000 insured workers (apart from uninsured) are engaged in their manufacture. Sweets, unless due precautions are observed, and especially if taken between meals, are injurious: they spoil the appetite and injure the teeth (see p. 227). In this country every inducement is held out to children of the poorer classes to indulge inordinately in sweets. In London a sweetstuff shop is sure to be found in the near neighbourhood of an elementary school, where it can always reckon upon a substantial clientele; and frequently a vendor of sweets and ice-creams takes up his stand at the school exit. I am told that teachers have to be

constantly on their guard against the practice of smuggling sweets into school.

The itinerant ice-cream vendors who throng the streets throughout the country at certain seasons of the year are as little commendable as the multitudinous hoardings inviting travellers to indulge in ribbon development.

Regarding the use of sugar, Mr. Arthur T. Pitts writes :

In the eighteenth century " Tea and coffee were expensive luxuries, and so little sugar was consumed in this way. Sweets were rare, and the sweetstuff shop rarer still ; no doubt home-made sweets were eaten, but as a luxury, while to-day the modern child would seem to regard them as a necessity. Jam was a less common article of diet ; the home-made preserves contained less sugar than the modern shop-bought article, and far less of it was used, while the sweet dishes of our modern dinner table were far less conspicuous two hundred years ago. It is therefore easy to see why the consumption of sugar has increased, especially as the production of sugar from beet has cheapened the price so that it is now brought within reach of the poorest classes. . . .

" With the afternoon cup of tea (an essentially modern development) biscuits or cakes are usually eaten, and these are sticky foods. . . .

" Sweets are essentially a luxury, and the tendency is to eat them at odd times especially at the close of day. The child is often bribed to go to bed with a sweet which it takes with it, and the dose of medicine is followed with a sweet.

" . . . The active movements of the tongue, cheek, and lips, which during the day play an important part in cleansing the teeth, are in abeyance at night, while the flow of saliva which in the day time helps to wash away particles of food, at night is much lessened." (See further, Part III, Chapter XX, p. 227, on the subject of sugar and caries.)

Tuck-Shops. This is a convenient place to refer to tuck-shops. Boarding-school children should be provided with an ideal diet, *i.e.*, one best suited to their needs ; this—let us not forget—implies that the food be of a kind calculated to awaken a lusty appetite. Manifestly in the ideal boarding-school the tuck-shop is out of place. Our aim is, or should be, to enable the young human to attain his full mental and physical stature. Can this object be achieved if our boys and girls are allowed systematically to glut themselves in the tuck-shop with foods specially devised

to tickle the palate and spoil the appetite for healthy fare? The tuck-shop must unconditionally be ruled out.

A house-master at one of our public schools recently expressed the opinion that tuck-shops are an unmitigated blessing, he loved "to see the boys rush off to the tuck-shop after a meal."

Surely the school meals should provide the boys with all the wholesome food they require, and if this is done, any further food consumed at a tuck-shop must be in excess of normal requirements. Were schoolboys adequately fed, tuck-shops would not be missed. I speak from experience. The sight of means to do ill deeds makes ill deeds done.

"A present Etonian" sought to defend the tuck-shop, but amusingly gave his case away by acknowledging that "socking" was rigidly forbidden while the boys were undergoing training, for "rowing a hard race, or playing football, is not a thing to be done on a course of lemonade and strawberry messes."

It assuredly is not. Boys, by the way, should not need to go into training: they should always be fit, like the professional river man, against whom the amateur competes in vain, because, being habitually soft, he has to train laboriously to reach a moderate degree of proficiency, which implies the capacity for endurance.

The manager of the official tuck-shop at Harrow writes: "I now sell more fruit than sweets and cakes, partly because it is cheaper, and partly because boys now know what is good for them. As a matter of fact, during the training season they eat nothing else. I believe that the orange-eating record for Harrow at the present is twenty-five at a sitting."

This, when not in extravagant excess, is all to the good.

I have no hesitation in affirming that tuck-shops and hampers (except, perhaps, hampers of fruit) are inadmissible at school. The school fees should suffice to provide an ideal diet for the pupils—one most conducive to health. If the food is appetising and all-sufficing, the tuck-shop will not be missed, and the sum total of abounding health, joy of life, and relish of simple health-giving foods will on balance far outweigh that which can be derived from the most seductive of tuck-shop delicacies.

Lord Frederick Hamilton in his " The Days before Yesterday," has some significant observations on this head :

" Little boys are now pampered in public schools, our method of life appears very spartan. We never had fires or any heating whatever in our dormitories, and the windows were always open. We were never given warm water to wash in, and in frosty weather our jugs were frequently frozen over. . . . We rose at six, winter and summer, and were in school at 6.30. The windows of the school room were kept open, and the only heating came from a microscopic stove, jealously guarded by a large iron stockade to prevent the boys from approaching it. For *breakfast* we were never given anything but *porridge and bread and butter*. We had an excellent dinner at one o'clock, but nothing for *tea but bread and butter*, never cake or jam. (The italics are mine.) It will horrify modern mothers to learn that all the boys, even little fellows of eight, were given two glasses of beer at dinner. And yet none of us were ever ill. I was nearly five years at Chiltenden's, and I do not remember a single case of illness. We were all of us in perfect health, nor were we ever afflicted with those epidemics which seem to play such havoc with modern schools, from all of which I can only conclude that a regimen of beer and cold rooms is exceedingly good for little boys."

Both Lord Balfour and Mr. George Wyndham were at this school. It cannot be said that the boys were pampered at Chiltenden's, and it is evident that they throve on very simple fare. Doubtless the abundance of fresh air they enjoyed played a notable part in the good result. A life in the open is the ideal, and we may safely predict that some day all our boarding-schools will be conducted on open-air lines.

Glucose as a Drug. We have seen that concentrated sugar is not an essential constituent of Man's diet (or that of any other mammal). It is, therefore, of interest to find that in certain affections, such as the cyclic vomiting of children, benefit results from the administration of glucose (grape-sugar). In this condition " acidosis " is present, *i.e.*, a shifting of the alkaline reaction of the blood and tissue fluids towards an acid reaction.[1] At the same time, the *percentage of sugar in the blood falls, not from a deficiency of carbohydrate in the body*, but from some unknown cause which prevents glucose from entering the blood. Such children suffer from sugar starvation, a definite pathological condition. A certain percentage of sugar in the blood is, as we have seen, as necessary to life

[1] This change is due to the development of certain acids as the result of faulty " fat metabolism," giving rise to the condition known as " ketosis."

as a sufficiency of oxygen ; it is not, therefore, surprising that the administration of glucose in cyclic vomiting should afford relief. This experience has led some to suppose that children are in need of concentrated sugar as a food, and glucose is not only now being sold and administered to children as a drug, but by some it is even being added to their diet as an essential ingredient thereof. The fact is that acidosis with cyclic vomiting in children is a morbid condition, mainly the result, in all probability, of faulty dietetic habits, prominent among which is an excessive indulgence in carbohydrates. Healthy children, properly fed, do not require concentrated sugar, whether glucose or sucrose (cane sugar). The tendency is for children to consume too much carbohydrate, all of which, after being digested, enters the blood as *glucose*.

I am not of course contending that concentrated sugar in moderation and taken with due precautions, is harmful to children : my object is to make it clear that it is not an essential food for them. This is a basic truth. The ideal sugar for children is that contained in ripe fruit ; honey is next best, and may be given occasionally, as a luxury.

Cod-liver oil in excess appears to give rise to acidosis. It is claimed for halibut-liver oil that it is free from this objection.

CHAPTER XIII

THE CEREALS. BREAD

THE cultivation of cereals, said to have begun about 5500 B.C., in or near Upper Egypt, was an outstanding event in the history of Man. Cereals possess the double virtue of yielding highly *nutritious* forms of vegetable food, which are, moreover, capable of *prolonged storage*. Their intense cultivation by a community thus released a considerable section thereof from the food quest, rendering possible a complex division of labour and opening the way to civilisation. Inasmuch as the cereal grain in the raw state is unsuitable for human food, the discovery of cookery was, as we have seen, a necessary prelude to the cultivation of grain.

Varieties of Cereals. The chief cereals are wheat, oats, barley, rye, rice, maize, millet and buckwheat. The latter two are not used for human consumption in this country ; millet (durra) is a staple human food in some parts of India, Upper Egypt, and Southern Europe. Buckwheat is popular as a human food in Brittany and Holland.

In Great Britain wheat, oats and rice are the most common cereal foods consumed by Man. Maize, in spite of its high nutrient value, is not in vogue with us. It is a staple human food in some parts of South America, and has recently become popular in Ireland. Ground into a coarse, gritty, non-sticky meal (note these features), needing thorough mastication, it constitutes " mealies," a staple cereal food with many African tribes (see p. 142).

In point of nutritive value oats stand first among the cereals by reason of their rich content of proteins and (especially) fat, but,

lacking in gluten, they do not yield a leavened bread, and are consumed either as mushy porridge or oat-cakes which are not for all tastes. Sometimes oatmeal is mixed with wheaten flour to make bread.

The wheat grain is supreme among cereals, combining as it does high nutrient value, delicate flavour, and a rich gluten content. This richness in gluten enables the flour, when mixed with water, to form dough, which entangles the gas generated by yeast (or other form of balm) during the process of baking, thus causing the dough to rise and form a light, *leavened bread* containing abundant air spaces.

"There are several races and many varieties of wheat, some hard, some soft, some possessing so-called red-bran, others white-bran, some yielding white flours, others yellow flours, some growing and maturing rapidly, others slowly" (R. W. P., "Encyclopædia Britannica").

Rye ranks next to wheat in respect of its gluten content. Its flour when mixed with water gives a stiff dough, which yields a somewhat dense *black bread* (Pumpernickel), a popular food among the working classes in some parts of Germany, Poland and Russia. Rivita (Knacklebrod), a form of unleavened rye bread, is a staple food in Sweden, especially among the working classes. It is made of the crushed whole rye grain, and contains only 10 per cent. of water as against 40–60 per cent. in English bread. Rivita, being hard and dry, compels thorough mastication and insalivation, enabling digestion to proceed more rapidly than occurs in the case of "ordinary white bread," the relative times of digestion of the two breads being estimated as two to three and a half hours. A further virtue of rivita bread, which it shares with the coarser varieties of well-baked, crusty wheaten bread, is its detergent and cleansing action in the mouth.

Barley-bread, a coarse form of unleavened bread, was, until quite recent times, largely consumed in this country, and no doubt afforded ample exercise for the jaws and teeth.

Regarded as human food, the wheaten grain ranks first in this country. Ground into flour, it constitutes the basis of our bread and the various productions of the pastrycook.

The Wheaten Grain. The wheaten grain (berry) consists of (1) the germ containing the embryo, (2) the endosperm, which provides nutriment for the embryo, and (3) the protective rind or bran. Enclosing the whole is the husk, which is separated as chaff in the process of threshing.

(1) The germ, which constitutes 1½ to 2 per cent. by weight of the entire grain, contains, besides the embryo, fat which is apt to turn rancid; the germ also provides ferments capable of digesting the nutrient material of the endosperm and rendering it suitable for assimilation by the embryo. For these reasons it needs to be eliminated, if the flour is to be kept for more than a short time. This could not be done by the old crude method of stone-grinding, but is readily accomplished by the more recent method of steel-roller milling.

(2) The endosperm contains 70 per cent. by weight of the grain; it varies in composition in different species of wheat; thus, while English wheats may contain 10 per cent. of the proteins constituting gluten, American wheats may contain as much as 20 per cent. Some wheats, *e.g.*, Hungarian, are much harder than others.

The endosperm differs in composition from without inwards, *e.g.*, the outer part, rich in protein, yields baker's or household flour, the central part, poorer in protein, yields patents; and these varieties can be separated by steel-roller milling. Semolina consists of the central part of hard wheats such as the Hungarian.

(3) The bran or protective rind contains much dense cellulose and a high percentage of minerals. It is very resistant to disintegration, whether in the digestive tract, or in the soil, where it is necessary to keep the grain intact until the embryo is capable of fending for itself. The bran consists of an outer "flinty," readily detachable layer, known as bees-wing, and an inner layer

containing cells laden with pigment, to which the colour of brown bread is due.

Special mention must be made of the layer of large cells, rich in the protein known as aleurone. This layer generally comes away with the bran, but belongs more properly to the endosperm, constituting its outermost portion.

Wheaten Flour. By the older crude methods of stone-grinding the bran alone is separated, leaving the whole remaining portion of the grain, including the germ, for which reason the bread made from stone-ground flour cannot be kept long without becoming rancid. With the addition of a small quantity of the inner pigmented layer of the bran, this stone-ground flour constitutes the original wholemeal brown loaf.

Steel-roller milling is a product of the industrial age : by means of parallel pairs of cylindrical steel rollers, rotating at different rates, and at a distance from one another, capable of being graded to a nicety, it is possible not only to separate out the germ as well as the bran, but to mill the endosperm into a variety of different flours ; and, by mixing in various ways the flours thus derived from many different varieties of wheat, the miller is able to obtain a bewildering number of blends.

The bran does not, like the endosperm, admit of being ground into fine powder, even by means of steel-roller milling, which, however, is more effectual in this respect than stone-grinding.

The many varieties of flour into which the wheaten grain can be milled by the steel-roller method have enormously increased the scope of the baker, the pastrycook and the domestic cook. The more refined of these flours have, in the hands of these craftsmen, yielded a multiplicity of culinary products—spongy breads, buns, scones, tea-cakes, sponge-cakes, swiss-rolls and the like ; a variety of pultaceous puddings, and an endless assortment of pastries—all characterised by the common property of demanding little exercise of the teeth and jaws, and having the further disadvantage of forming in the mouth a soft, non-deter-

gent, sticky mass (intensified, perhaps, by a rich admixture of sugar) which tends to cling to the teeth, the more so that it fails to excite the mouth-cleansing activities associated with vigorous mastication. The refined flours are chiefly responsible for our ill-developed jaws and the abundance of dental caries among us.

Brown Bread. The original brown bread was made from wholemeal minus the bran, to which was added a sufficiency of the bran to give a brown colour. The various brown breads on the market in this country approximate in varying degrees to the wholemeal type. In the United States wheaten flour is accepted as wholemeal if no more than one-tenth of the entire grain has been removed.

White Bread. This is made from flour which is milled from the endosperm alone, and contains neither germ nor bran, and there are as many varieties of white bread as there are of flour and blends of flour, milled from the endosperm.

The comparative nutritive value of ordinary white and wholemeal bread. Respecting this point the truth would appear to be that for those who can afford a moderately varied diet, it matters little what kind of wheaten bread they eat, provided it is sufficiently crusty to compel thorough mastication ; but, in the case of the very poor, for whom it is important that their bread shall have the maximum nutritive value, wholemeal bread, or at least bread approaching the wholemeal standard, is desirable. The public, however, rich and poor alike, prefer the white loaf to the brown, and probably will continue to do so in spite of all our teaching.

The Modern British Loaf. That the cereal food of our Danish and Saxon ancestors was largely of a detergent kind, demanding vigorous chewing, is suggested by the extreme degree to which their teeth were worn-down, and by the comparative rarity of dental caries among them.

Coming to more recent times in our own country, we need to remember that not so very long ago all our bread, whether made

of wheat, barley or rye, contained most of the grain, and that, prior to the advent of industrialism and the introduction of roller-grinding, British bread was coarse and demanded vigorous exercise of the jaws. Since that time the British loaf has undergone steady deterioration so far as the health of the jaws and teeth is concerned. Our soft, spongy, highly watered, ill-baked wheaten bread, made of roller-milled flour, is swallowed after a perfunctory chewing and insalivation; in consequence, the full flavour of the wheat berry is not experienced, its digestion is prolonged, the teeth and jaws are inadequately exercised, and the mouth tends to be left dirty.

Our loaves are insufficiently baked, they contain an excess of water, too little crust, and are too spongy in texture. In respect of oral hygiene, however, it matters little whether the loaf is white or brown, so long as it is not made of ultra-refined flour, and so long as it contains a generous proportion of well-baked crust.

In order to obtain *a maximum of crust, loaves should be spindle-shaped, cylinder-shaped, or bun-shaped.* Such loaves, made of suitable flour, and well baked, give the jaws, teeth, and salivary glands the exercise they crave for. Ill-baked new bread is more sticky than when stale, and more apt to be swallowed after perfunctory mastication, and to cause indigestion, but well-baked, crusty bread, compelling vigorous mastication, can be eaten with impunity almost hot from the oven; with a liberal supply of good butter it constitutes for the growing human a healthy and tasty food.

In travelling from one end to the other of Great Britain, I have experienced no little difficulty in getting bread even approximating to these requirements. As a rule the loaf offered me has displayed a thin, pale crust enclosing a soft, spongy mass which, when scooped out with the hand and squeezed between fingers and palm, has yielded a solid dollop of uninviting dough. Often the young serving woman has expressed naïve surprise when asked for "something more crusty," evidently regarding the

proffered sample as displaying the very extreme of crustiness, sublimely ignorant of the fact that her usually narrow jaws, bad teeth (obtrusively supplemented by the dentist's art) were the penalty she was paying for the highly artificialised, soft cereal food on which she had been nurtured.

Varieties of Wheaten Bread. Many varieties of wheaten bread are on the market. If the bread is made of flour containing the inner pigmented layer of the bran, it has a brown colour ; if it is made of flour from which the coloured bran has been removed, it is white. In either case the outer, highly mineralised, flinty layer of the bran is usually got rid of.

Hovis bread is made by sterilising the wheat germs by means of super-heated steam, and adding one-third of the flour thus obtained to two-thirds of ordinary flour.

Standard Bread. So-called standard breads contain varying proportions of whole wheaten flour from 80 per cent. downwards. Wholemeal ensures that the bread shall contain a proportion at least of both bran and germ. Assuming the diet to be well balanced in other respects, there is no urgent need for either bran or germ in the bread, for let us never forget that in pre-agricultural times Man was without bread of any kind, which is not therefore an *absolutely indispensable* item of human diet. Nevertheless, in most civilised countries bread of some kind has come to be a staple food, and we are probably wise in advising that the bread of the growing human should contain a proportion, be it only 25 per cent., of wholemeal.

Bran, together with the aleuron layer of cells, constitutes *offal*, which is a valuable food for poultry and farm animals.

Sour breads are obtained by using, instead of yeast, a substance which on fermentation produces acid.

Frame foods contain as their essential constituent a dried extract of bran.

The annual consumption of bread in this country per head has declined since the tea habit has been contracted. This has led to

a great increase in the consumption of cake, scones and " small foods," which is much to be regretted, especially in the case of the young, inasmuch as soft farinaceous foods not only cheat the teeth and the jaws of their proper work, but tend to leave the mouth dirty.

Our consumption of wheaten flour per head annually has of recent years remained stationary, *i.e.*, 227 lb. In the United States it has declined from 224 lb. in 1900 to 176 lb. in 1924.

The first historic evidence of the manufacture of bread comes from Egypt. The ancient Egyptians are said to have carried the art of baking white bread to high perfection; this, made into small loaves and elongated rolls, was used by the rich. As to the precise nature of this white bread history is silent. Coming to a later period we read that many of the disinterred houses at Pompeii are provided with their own mills and bake-houses.

There is evidence that as early as the fourteenth century, London had its " Companies of White Bakers and Brown Bakers." At so late a period as 1836, it is laid down by Act of Parliament " that it shall and may be lawful to make or sell bread made of flour or meal, of wheat, barley, rye, oats, buckwheat, Indian corn, peas, beans, rice or potatoes . . . and with salt, pure water, eggs, milk, barm leaven, potato or other yeast." Manifestly considerable progress in the art of bread-making has been made since that time.

CHAPTER XIV

FATS

FAT, which, like the carbohydrates (starch and sugar), contains no nitrogen, is a necessary constituent of a normal diet. Animal and vegetable fats resemble one another in that they consist essentially of glycerine and fatty acids, but from the standpoint of human nutrition, animal fat has a definitely higher value.

Fat is a much more condensed food than carbohydrate, yielding for a given weight two to three times more energy; for this reason, nuts, which contain a large percentage of fats, tend to be smaller than the luscious fruits.

The edible vegetable *oils* include olive oil, cotton-seed oil, sunflower oil. Of these olive oil is the most important. Cotton-seed oil also ranks high; in the United States the average annual crop yields 3,200,000 barrels of oil (each barrel containing 50 gallons), which, after being refined, yields nearly 3,000,000 gallons. Two-thirds of this is used for edible purposes, largely as salad oil. Sunflower oil is largely consumed in Russia.

Among the vegetable *fats* used as food, cocoa butter may be mentioned; it is a semi-solid fat obtained by pressure from cocoa beans.

Vegetable oils and fats are distinguished from animal fats in containing little or no calcifying vitamin D, but many of them, olive oil, *e.g.*, contain the pro-vitamin D, which, when subjected to ultra-violet rays, develops into the actual vitamin D. Animal fats differ considerably in regard to their vitamin D content. Cod-liver oil is rich in this vitamin, beef-fat and butter moderately rich, while lard contains little, if any.

The fat of the body serves as a protective covering under the skin, rounding off the contours of the body, and as a soft, cushion-like packing material to support and protect the internal organs.

It also constitutes a storehouse of potential energy to be drawn upon as occasion demands.

The main fat-forming foods are the carbohydrates (starch and sugar), and fat itself (which, however, needs to be digested and re-elaborated before it is deposited in the tissues). Proteins also give rise to fat. So fattening are carbohydrates that a person may put on abundant weight in the entire absence of fat from the diet; one is therefore led to ask whether fat is a necessary food. There are several reasons for concluding that it is—most people display an instinctive liking for animal fat, especially those living in cold regions; many animal fats, *e.g.*, butter and dripping, are rich in vitamins A and D; fat, being a highly concentrated food, possessing weight for weight more than double the energy value of starch or sugar, tends to lessen the bulk of carbohydrate necessary for a complete dietary; finally, fat requiring, as it does, a comparatively long time for digestion and absorption (being the last food constituent to leave the stomach),[1] its presence renders a meal so much the more enduringly sustaining.

The nutritional value of fat is shown by the importance attached to its edible varieties during the Great War. At that time the shortage of edible oils led to a considerable advance in oil refining —by means of which oils previously regarded as of industrial value only, were rendered available for food.

Professor Cathcart and Dr. A. N. T. Murray, when studying the diet of Glasgow families, found the consumption of protein to be distinctly below the accepted standard, and that of fat, even among the very poor, to be much above the standard. There was evidence that increase of income led to increase in the amount spent on fat, or fat-containing foods. *Clearly there is an instinctive demand for fat*, the significance of which is not yet wholly understood. The children of the *poor are apt to get too much starch and too little fat.*

[1] Much of the fat remains unabsorbed by the time all the carbohydrate has entered the blood as sugar.

Ninety-seven per cent. of the fat of the body may disappear during starvation, some fat always remaining after death from starvation.

Fats, as offered for consumption, differ much in their flavour, and it is upon their flavour that the liking or disliking of them mainly depends. Thus butter, the fat of meat, and of ham, all have distinctive flavours. Some delight in meat-fat; others abhor it, so much so that they may not be able to eat more than a very small portion of a fat mutton chop, which, for such, is a highly expensive food. The flavour and acceptability of meat-fat depend largely upon the manner of its cooking: well browned, if consumed in suet puddings, or in the form of bread and dripping, it may be tolerated or even relished by many to whom the fat of underdone meat is distasteful to the point of nausea. Few dislike butter or cream (which are rich in fat-soluble A and D): some people, however, appear to be wholly fat-shy.

Apart altogether from the taste of fats, individuals differ in their ability to digest them. In children excess of fat may set up cyclical vomiting with acidosis (see p. 49), and the view has been put forward that the present fashion of deluging children with cod-liver oil has increased the frequency with which they suffer from this condition. In the malady known as Gee's disease most of the fat ingested passes through the alimentary canal wholly undigested.

The dislike of fat meat often goes with a dislike of meat in general. This is difficult to explain in the light of Man's history, for there was a time when Man consumed all his animal food in the raw state. I am told that butchers not infrequently display an instinctive liking for raw meat, which they have ample opportunity of gratifying. What proportion of children (and adults) have a congenital dislike of meat I do not know. In any case, viewed in the light of Man's ancestry, such dislike is abnormal.

Dr. W. B. Vaile, Medical Officer to the Church Army Sana-

torium, Aldershot, has shown that boys fond of fat are much less liable to tuberculosis than those who detest it.

"The great bulk of the infected, the dead, and the dying have had a life-long dislike of it. . . . In family after family I found this peculiarity dominating the situation. . . . In many families *all the fat-eaters had escaped, while all the fat-shy had become infected. In some the only fat-eater was the only person who escaped. In others the only fat avoider was the only victim.*" (My italics.)

CHAPTER XV

IDEAL FOODS. CO-OPERATIVE CATERING

THE ideal to be aimed at in the choice of foods is simplicity. Simple foods include :

Animal : meat, bird, fish, eggs, milk (and its products, butter and cheese).

Sausages, ham, bacon, salted meat, salted and smoked fish have undergone some preparation before purchase, and do not altogether come under the category of simple foods ; nevertheless, provided due care is taken in their preparation, they are sufficiently wholesome foods.

Vegetable : the cereals (wheat, oats, maize, rice, rye, barley), potatoes and " roots " in general, green vegetables and salad food, and all the well-known fruits when ripe. With the exception of the cereals, all these are usually purchased without having gone through any artificial process.

Among the cereals, rice may in its preparation be so effectually bereft of an essential vitamin (B_1) that, when consumed as a staple food without adequate accessories, the disease beri-beri may be induced. Wheat may be milled to different degrees of refinement and thus lose in different degrees its nutrient value.

In this country wheat is the national cereal food. The ideal form for wheat consumption is well-baked bread made with standard flour. A number of fanciful forms of wheaten foods for breakfast are on the market : they are good enough foods, but they are more expensive than bread, and they fail for the most part to provide adequate exercise for the jaws and teeth.

Prepared Foods. A considerable proportion of our food can

now be purchased at the shops partly or completely prepared for consumption. The baker and pastrycook provide bread, biscuits, cakes and cooked pastries. Uncooked pastry, ready to be put into the oven, can now be purchased, thus saving the housewife time and trouble. Many forms of cooked animal foods can be obtained from the cooked-meat shop—ham, beef, tongue, chicken, brawn, and a variety of sausage products. Then there are the cooked tinned and bottled foods, including beef, tongue, rabbit, Irish stew (*sic*), salmon, lobster, sardines, soups, peas, beans, tomatoes, asparagus, peaches, raspberries and many kinds of "potted" meats.

Again, chipped potatoes ready to be warmed up for consumption are now turned out from the factory in large quantities.

It is not surprising that there should be a growing tendency (especially among town dwellers) for the "poor" and people of small means generally to resort to these prepared foods, saving as they do the time and labour spent in preparing meals. Especially are they a boon for those living in small flats and engaged during the day in work away from home.

Canned and bottled foods, though for the most part wholesome, cannot be said to rank with good home-prepared food. Not only do they tend to be more expensive, but they are apt to lose in the process of preservation something of their delicate native flavour, if not of their nutritive value. In any case one would not choose them as ideal foods for the growing human. We should aim at nurturing children on simple natural foods prepared in the home, or in a good communal kitchen.

Co-operative Catering. Much might be done by way of improving the food of the poorer classes in large towns by a co-operative system of food supply and preparation. More and more the flat is coming to be the recognised form of town dwelling. In the more central parts of large towns the ideal to be aimed at for the poor, and even perhaps for those of moderate means, is a group of tenements providing dwelling-quarters for several

hundreds of persons—men, women and children. Such a group of tenements should possess, (1) a common catering department or store, where all wholesome essential foods can be obtained at a price no higher than suffices to cover expenses, and (2) communal kitchens where food can be cooked for a small payment, and where certain routine foods are daily cooked according to the probable demand.

The catering department of such tenement colonies should provide essential foods only, and be under the control of a central board able to give expert advice on questions of human diet.

To set forth in full the many advantages of such a system would need more space than I can allow myself. Not the least of its virtues would be its educational value for the mothers, and the opportunities afforded for feeding the growing human on physiological lines, permitting the jaws to develop normally, and lessening the disastrous prevalence of adenoids, dental disease, appendicitis and digestive disorders in general. The catering department or store would also afford an admirable centre for teaching children elementary truths concerning food.

Only by means of institutions with communal kitchens is it possible to bring up large numbers of children on a common diet ideally conceived, at a moderate cost, and with a minimum of waste and labour.

At the present time the L.C.C. is engaged in the task of re-housing some 375,000 persons living in overcrowded slum areas ; this involves, among other schemes, the erection of blocks of tenements, some of considerable size. For instance, the Council has recently built on three and a half acres of parkland two blocks of flats affording accommodation for 900 people. Here is an ideal opportunity for a system of catering on the lines suggested.

Lillian M. Faithful is testing the practicability of establishing

a kindred system, consisting of " cookhouses " for the people, claiming for them the following advantages :

(1) The small house is exempted from the all-pervading smell of cooking, and the inconvenience of using the same room for the kitchen, laundry and living-room.

(2) The superiority of the food in quality. There is a growing tendency among the poor to buy tinned food, which is disastrous from the point of view both of health and of economy.

(3) A greater variety of food is obtainable than is possible in a small household.

Customers bring their dishes and are served with hot or cold food which can be eaten at home. The menu is constantly varied.

CHAPTER XVI

IDEAL SCHOOL DIET

It is to be regretted that an accredited system of standard diet, accepted by all diet experts, suitable for the average individual from, say, the sixth year to late adolescence, has yet to be devised, one which, making due allowance for idiosyncrasies, should be accepted as a standard for all schools. The breeder of live stock is careful to adopt methods which he knows from experience are the most likely to achieve his ends. Why should we not be equally careful about the food of our youth ?

We need to devise a simple appetising diet—it *must* be *appetising*, for appetising food promotes its ingestion and digestion—suitable to the nutritive requirements of the developing human, *i.e.*, one aiming at adequate ingestion, perfect digestion, perfect assimilation, perfect blood, and yielding a sense of abounding health and joy of life.

To this end there must be no pampering of the palate—no sweets, ices, tarts, jellies and suchlike—except perhaps on special occasions. This may sound unduly Spartan ; yet it is not ; for the transient gustatory pleasure derived from the habitual indulgence in such luxuries is at the expense of sound digestion and sound health generally ; while the indulgence in them spoils the appetite for plain, wholesome fare, for which there should be a keen appetite. Weighing the evanescent pleasures obtained by tickling the palate with the kind of fare provided by the tuck-shop and its harmful consequences, weighing the satisfaction thus derived against the healthy enjoyment of good plain food and the sense of vigorous health and well-being it engenders, the

balance will be found to be emphatically in favour of the latter.

I do not propose to discuss school diet in any detail, and shall content myself with formulating fundamental principles, which doubtless will be regarded by the majority of school heads as constituting a counsel of perfection—traditions handed down from generation to generation are not readily thrown over—but my suggestions may, perhaps, lead to improvement in schools where improvement is called for. Manifestly, our primary object is to provide the growing human with plain, *appetising* foods containing all the necessary nutrient ingredients. It is physiologically essential that the pupil should relish his food. In order that plain foods, as distinguished from luxurious delicacies, such as ice-cream and angel-cake, may be eaten with genuine relish, two requisites are needed: (*a*) On the one hand the school authorities must see to it that the food provided is good, and that it is properly prepared and served; and (*b*) on the other hand the pupil must on his part come to his meals with a healthy appetite, *i.e.*, provide the hunger which is the best sauce. This implies that he is living under conditions favourable to abounding health.

(*a*) Proper preparation of the food requires an adequate kitchen staff. Mr. Frank Preston, Head Master of Malvern College, insists on this point. He writes:

> "The most important element in all school-feeding is the cook, and unless the nation is going to improve the supply of cooks beyond the few incompetent people who toy with a gas-cooker, it is almost waste of time to consider the diet suitable for anybody. This applies more to schools than anywhere else."

Here Mr. Preston shows his keen appreciation of the need to provide the boys with appetising food.

In short, those responsible for school catering and cookery should be at pains to provide plain, wholesome food, and to see to it that it is prepared and served in an appetising form: there is all the difference in the world between stale, ill-baked bread and

ill-flavoured butter, and fresh, crisp, well-baked bread and good fresh butter ; a potato well cooked is likely to prove appetising, one ill cooked may be quite the reverse.

A supervisor should be present during the dinner and have an eye on individual servings. Inborn idiosyncrasies need to be considered. A list, for example, might be made of those who cannot eat fat or very underdone meat. She should take account of the leavings on individual plates and seek to minimise them by adapting the servings to individual liking. By such means both the pupil and the school exchequer benefit. It need hardly be said that great care should be exercised in the choice of a supervisor : she needs to be not only capable, but patient and amply endued with the milk of human kindness.

(*b*) Not only must the caterer and the cook, with the help of the supervisor, provide plain fare as potentially relishable as the daintiest morsel, but the pupil must, as I say, come to his meals with a keen appetite the outcome of abounding health ; and it is, of course, the business of the school authorities to achieve this essential. To this end the ideal large school should be situated amid ample grounds, preferably parkland, and the plan of life should, as far as possible, be arranged on the open-air system No violent exercise should be allowed for half an hour before and after dinner, which should last at least three-quarters of an hour. Breakfast and tea should each occupy not less than half an hour. No food of any kind should be allowed between the chief meals other than that supplied by the school.

If, under these conditions, the pupil has no appetite for his meals, he is not well, and the school doctor should be consulted. No healthy boy or girl with a normal appetite will refuse plain, wholesome fare properly prepared and served.

Here a word on the question of varying the diet. One may read in journals devoted to " The Care of the Small Child " elaborate breakfast, dinner and tea menus, specially devised for each day in the week. This bewildering variety is wholly unneces-

sary. We need to educate the appetite to appreciate, and the digestive system to deal with, a simple and not inordinately variable diet.

Breakfast and tea may remain much the same every day, say, from the age of three to adolescence, and even beyond. Such variety as is advisable and convenient should be provided by the mid-day meal; but there is no desperate urgency to change its composition every day in the week. If a healthy boy grumbles at being expected occasionally to eat precisely the same kind of dinner two days running, I should begin to think him overfed, and be tempted to prescribe total abstinence for twenty-four hours in order to whet his jaded appetite.

A few words regarding foods most suitable for the developing human:

Pure sugar, jams and the like do not enter into my conception of an ideal school dietary, although sugar need not wholly be excluded. It is as well to remember that Man achieved the status of *homo sapiens* practically without any pure concentrated sugar, and it has been abundantly proved that it is not essential to normal nutrition. All the sugar we actually need is provided by bread and potatoes (both of which are rich in starch which enters the blood as sugar), and by ripe fruits and such vegetables as carrots and beetroot. Pure sugar, notably in the form of sweets, tends to spoil the appetite for plain food, and, unless special precautions are taken, it proves a dire enemy to the teeth. After a brief abstinence from sugar it is not missed. I myself spent two years without a break at a school abroad; the only sweet food provided was stewed fruit in season. Sweets (which are much to my liking) had faded out of memory: nevertheless, I enjoyed exuberant health.

How far are condiments permissible? These are accessory foods consumed not for the energy they yield, but for their flavour and appetising properties. With the exception of salt, they are all, including vinegar, derived from the vegetable kingdom.

The cooking of vegetables causes considerable loss of their salts, and hence those who eat little or no raw vegetable food, in the shape of fruit and salad, are so much the more inclined to resort to artificially prepared condiments.

Among the vegetable products yielding condiments are peppercorn, mustard-seed, horse-radish and spices (*e.g.*, cloves, nutmeg), ginger, onions. These have distinctive tastes and flavours, and tend to sharpen the appetite and to promote the flow of the digestive juices. From them pickles and a variety of sauces are made.

My ideal school diet excludes condiments save salt, mustard and vinegar. The young healthy stomach does not need condiments, provided a sufficiency of the right kind of raw vegetable food is available ; but such accessory food as spices and ginger are permissible.

Dr. Ackerly holds that no more than 30 grains of salt daily are required by the human, and that this is supplied by the food. Rice is one of the few foods which do not contain a sufficiency of salt, while a considerable quantity is added to bread, butter, and other foods. This authority maintains that the thirst engendered by salt is Nature's way of getting rid of a harmful excess, and he draws attention to the number of sanatoria on the continent in which salt-free food is provided.

Mr. Sibly has for many years eliminated pepper, vinegar and mustard from his school diet. One authority reports a craving among university women students for vinegar, especially as an adjunct to salt fish. I do not know of any harm likely to result from vinegar taken in moderation. It seems to be an appropriate ingredient of salads : I recall reading how certain primitive tribes had a custom of allowing ants to swarm over their raw green food, doubtless for the formic acid (a near ally of vinegar, *i.e.*, acetic acid) yielded by them.

Some raw vegetable food should be eaten every day—preferably at the end of a meal, as it tends to leave the mouth clean. Breakfast should, if possible, end with fruit. Salad goes well

with bread and cheese at dinner, and a carefully prepared salad is a welcome dish at tea. Raw vegetable foods are rich in vitamins.

Regarding cereals, all soft forms, failing as they do to compel vigorous mastication, are inadmissible—here we touch upon an outstanding fault of British diet. This prohibition excludes from the dietary ill-baked, spongy bread, puddings, porridge, all but the simplest kinds of cakes and all fancy pastry : *cereal food is to be limited almost entirely to well-baked, crusty bread*, made into bun-shaped loaves averaging the size of the familiar penny bun. Such bun-loaves, baked sufficiently to ensure a physiological degree of mastication, can be eaten with impunity soon after they have left the oven. When at the stage of unappetising staleness, the loaves can be rendered crisp and appetising by a short warming in the oven. The allowance of butter for them should be 3 to 4 oz. daily, chiefly divided between breakfast and tea.

They should contain a proportion of wholemeal (see p. 57).

No limit should be put to the indulgence in this bun-loaf bread : compelling as it does vigorous mastication, excessive indulgence in bread is not likely.

Note that the bun-loaf, amply spread with butter, ensures a liberal supply of the vitamins A, B, D (A and D from the butter, B from the bread). Bread-and-butter should constitute the main food for breakfast and tea. At each of these meals the drink may consist of whole milk (boiled) 4 parts, moderately strong coffee (recently milled) 1 part ; this preferably without sugar. (After a short time the sugar will not be missed.) It should be poured out hot at about the middle of the meal and should on no account be gulped down, but slowly sipped from time to time, so as to allow the full flavour to be appreciated, and should only be taken when the mouth is empty. Tea with plenty of milk may be substituted for coffee, if preferred, or the milk taken by itself. The quantity of milk supplied for both these meals should vary from a half to three-quarters of a pint according to age.

The breakfast should end with fruit where possible (apple,

orange or banana), and salad should always, if possible, be provided for tea.

If these two meals are carefully prepared, they will (after a short initiation perhaps) be enjoyed by healthy youth, without any further item. The combination as described provides an ideal meal for breakfast and tea : it is appetising, it contains a sufficiency of energy-yielding foodstuffs (proteins, carbohydrates and fats), a sufficiency of minerals, and the vitamins A, B, C and D. It gives abundant exercise for the jaws and teeth, thus favouring normal development of the one, and normal arrangement of the other ; finally it tends to promote oral hygiene.

From the nutritive point of view, such a meal suffices, and more than suffices, provided the dinner be ample. With the approach of adolescence tea might perhaps be supplemented by fish, ham or the like ; but this is doubtfully necessary in the majority of cases. Tea as defined lends itself perhaps more than any other meal to an elaborate salad.

The mid-day meal should consist of lentil or pea soup (occasionally), fish or meat or bird, abundance of vegetables, followed by bread and cheese and salad, or raisin bun.[1]

A diet on these lines, together with an abundance of open-air life, consistently carried out year after year, would reduce dental caries, adenoids, indigestion and appendicitis almost to the

[1] The raisin bun is compounded as follows :—

Ingredients : ½ lb. wholemeal (stone ground) ; ½ lb. white flour (without any bleaching agent) ; 2 ozs. sugar ; 1½ ozs. butter ; 2 ozs. sultanas or raisins; 2 eggs ; 1 oz. yeast ; 1½ gills hot milk and water (half and half) ; ½ teaspoonful salt ; grated rind of a lemon. *Method :* Rub together the butter, flour, sugar and salt, add raisins and lemon rind and make a hole in the mixture. Beat the eggs and add to the hot milk. Beat the yeast to a cream with 1 teaspoonful sugar and mix with it the egg and milk, which should be tepid or 100° ; pour this into the mixture. Stir in a little flour from the sides, cover the basin with a clean cloth and stand in a warm place to sponge for half an hour. Then beat well with a wooden spoon and set to rise three-quarters of an hour. Then beat again and put in a tablespoonful on a warm greased baking sheet and leave to rise in a warm place until quite soft and puffy. Bake in moderate oven for fifteen minutes and then more slowly until hard outside. These buns necessitate adequate mastication and are used in the place of pudding or other variety of " sweets."

vanishing point, and greatly reduce pyorrhœa. Unfortunately, in private schools holidays intervene, when the principles of correct feeding are thrown to the winds and the artificial tickling of the palate is allowed to run riot. A correct system of feeding the growing human can only be consistently carried out in institutions such as " residential " schools, where the yearly routine is not interrupted by holidays.

Whenever, in an institution for the young, it is found that the rate of growth and development can be advanced by modifying the customary diet, it is evident that the customary diet has been inadequate. Within recent years dietetic inadequacy has frequently been shown to exist in such institutions, and even where one would least have expected it. The distinguished medical officer of a large public school has by judicious modifications of the traditional diet brought about a truly remarkable improvement in the nutrition and rate of growth of the pupils.

Points which must not be lost sight of in considering the diet of the growing human are quantity and the appeal to appetite. An unlimited supply of really good bread-and-butter and abundant outdoor life would go a long way in an institution for the young to secure normal nutrition.

CHAPTER XVII

QUANTITY OF FOOD

A Sufficient Diet. An Excessive Diet (Obesity)

A DIET may be sufficient, excessive or insufficient. This chapter treats of sufficient and excessive diets.

Factors Influencing the Quantity of Food Required. The quantity of food required varies with age, sex, idiosyncrasy, stature, external temperature and amount of exercise taken.

Age. The quantity of food required for building up new tissue is greatly in excess of the quantity which is converted into and retained as new tissue ; for consider how small is the daily increase in weight of a growing person as compared with the quantity of food consumed ; from birth to the age of twenty years that increase averages about one-third of an ounce daily—a quantity represented by a moderate mouthful of food.

Leaving out of consideration the factor of exercise, less food is required per unit of body-weight after adult life is reached than during the period of growth ; during the declining years the amount required tends to become less and less. Hippocrates said : " Old people bear abstinence well " : one might add that they tend to " bear excessive eating ill," although it must be admitted that they sometimes display amazing powers of digestion.

Sex. The vital fire burns more intensely in the man than in the woman, a feature which shows itself in the higher percentage of red blood-cells (which convey oxygen to the tissues) and the proportionately larger lungs in the one than in the other. The smaller respiratory need of the woman is further shown by the

facility with which she can, without discomfort, restrict her breathing capacity by corsets; even the modern corsets do not permit full breathing.

It follows that weight for weight the man needs more food than the woman.

Idiosyncrasy. Apart from sex, some burn more intensely than others, and consequently require more food. Compare the thin, wiry, energetic person with his fat, phlegmatic brother: the one no amount of stuffing will fatten, while a spare diet may fail to reduce to the normal the weight of the other: in the one the chemical clockwork is set to go fast, in the other to go slow.

Stature. Obviously those of large stature need more food than those of small stature, although, per unit of body-weight, they require less, seeing that the activity of the vital fire tends to vary inversely as the body-weight, for the less the body-surface, the greater proportionately is the loss of heat—the mouse requires much more food in proportion to its weight than the elephant.

External Temperature. The colder the weather the greater the loss of heat and the greater consequently the demand for food. Thus it is that the Esquimaux consume prodigious quantities of food, largely in the form of fat. Again, by so much as clothing lessens the loss of heat, by so much does it lessen the need of food to maintain the body temperature.

Muscular Exercise. A person lying quiet in bed needs comparatively little food, but when the muscles are doing laborious work, as in the case of the navvy or the soldier on a forced march, a much larger quantity is required—it is indeed difficult for those engaged in sustained, heavy muscular work, systematically to over-eat, as witness the rarity of obesity among them. Compare in this respect the postman and the middle-aged policeman. The sedentary should constantly be on their guard against excesses of the table. On the other hand, the ill-effects of a sedentary life may be greatly reduced by recourse to a spare diet.

We not infrequently read of some recluse who, having for years lived in one room on semi-starvation rations, has finally died at an advanced age.

A Sufficient Diet. A sufficient diet is one which, if properly constituted, is just enough to maintain the normal body-weight. For a given adult, the normal weight may be defined as the *minimum weight consistent with the best health of which he is capable.* This can only be ascertained by experience.

In the endeavour to arrive at a person's normal weight due allowance must, of course, be made for age, sex, stature and idiosyncrasy. The middle-aged normally incline to stoutness, and the aged to leanness ; young women are naturally stouter than young men ; some, again, are by nature thin, and others stout, irrespective of age and sex.

An Excessive Diet. Animals in a state of nature seldom over-eat, so fierce is the struggle for existence ; the securing of the necessary supply of food entails great activity, and the food is usually so simple and unvaried that the appetite is satisfied when a sufficiency has been consumed.

Civilised man, on the other hand, is often compelled to lead a sedentary life ; his food tends to be highly concentrated, consisting as it does of such forms as butter, cheese, eggs, meat, fish, and bird ; while far from being monotonous, it is infinitely varied, and often rendered appetising by subtle culinary devices —all of which tempt to excess.

Seeing that over-eating throws extra work on most of the organs and tissues of the body, it might perhaps be thought that the alimentary tract would absorb no more food than suffices for the needs of the organism ; but such is not the case : most of the excess ingested is absorbed and has to be dealt with in special ways—broadly speaking, by storing the overplus in the shape of fat or glycogen (against times of dearth), by its consumption (chiefly in the muscles), or by its elimination in the form of sugar or albumin.

Long-continued over-eating promotes tissue degeneration and lowers the level of health.

It is chiefly in middle life that the evils of over-eating begin to show obtrusively, becoming more and more pronounced with every advancing year. We may sometimes see an old man of sedentary habits—old women less frequently err in this way—whose appetite and whose enjoyment of food survive amid the general decay of his physical powers, loading his stomach with the same quantity of food and alcohol as he consumed in the heyday of his youth, and expecting his organs to perform the same physiological feats as of old, often with the result that he becomes a nuisance alike to himself and to those about him. It is true that, as already observed, some can continue these excesses into extreme old age without much apparent harm, but such cases are exceptional: almost all centenarians have been moderate eaters. For the most part the aged need a spare diet: we must beware of extinguishing the flickering flame by piling on too much fuel.

Concerning such dietic excesses Dr. Leonard Williams refuses to compromise:

"He consumes cooked animal food for breakfast: cooked animal food for luncheon, cooked animal food for dinner, and he fills up the interstices with sticky cooked and concentrated starches and sugars; which ungodly conglomerations of artificial intoxicants he washes down with stimulant in the form of tea, coffee and alcohol. He takes very little exercise, and he never fasts. Is it any wonder that half the world is ill, and the other half has something the matter with it?"

Of the fashionable afternoon tea Dr. Williams is even more condemnatory.

"A large and heavy blue pencil should obliterate the words afternoon tea from out the schedule of any sensible self-respecting civilised community. Of all the inventions with which a cunning spite seeks to lure people to physiological perdition, this stodgy assemblage of saccharine and starchy horrors, insinuated between luncheon and dinner, is at once the most indefensible and most deadly. One of the worst features about this subtle, sly and specious self-indulgence, is that it has managed to

surround itself with an atmosphere of smug, social respectability. It manages to masquerade as a harmless excuse for uplifting conversation, whereas it is in reality a medium for sustained and steady satiety, in comparison with which an occasional bout of vinous access is physiologically venial."

Infants and small children are often plied with an excess of food. Not only is food given them in a highly concentrated form, consisting of almost pure protein, starch, sugar, and fat, with little unabsorbable material, but in a form which is soft or even liquid, permitting it to pass into the stomach with fatal facility. A small child is often, in fact, much in the same predicament as the far-famed Strasburg goose : at a period of life when it is little more than a stationary animal, and prevented from working off an excess of food by abundant muscular activity, its digestive organs are burdened with an excess of richly nutritious foods.

Older children may be similarly victimised. I recall the case of a mother who was obsessed with the idea that the more food she could cram into her only child, a boy of eight, the stronger he would grow. She would stand over him when he was already overgorged, and entreat him to take " just a little more," and the child, with flushed face and eyes protruding, would say, " Oh, mother, *must I?* " then, with a heavy sigh, " mother, I can't." The child, in due course, developed an abundant crop of adenoids as such children often do !

Obesity. We need to distinguish between constitutional obesity and that form which is the result of over-eating. Constitutional obesity may be the result of disease ; or it may be physiological in the sense of being compatible with good health and a long life, and in the sense that the reduction of the fat below a certain level would be injurious.

The normal weight of a person may, as I have said, be defined as the lowest at which he enjoys his best health. Any weight above this is superfluous : it implies, assuming the diet to be well balanced, that an unnecessary quantity of food is being consumed, and this imposes an unnecessary burden upon his organs which

may lead to disease; moreover, the excessive accumulation of fat constitutes a mechanical encumbrance: to be weighted with several stones of superfluous fat is a nuisance, to say the least—it hampers activity, over-taxes the heart and tends to beget breathlessness.

The vast majority of obese persons have induced the condition by consuming food beyond their physiological needs, and have it in their power to reduce their weight to the physiological level. Those who allow themselves to get too stout by eating too much are guilty of physiological unrighteousness. Nor are they altogether guiltless in an altruistic sense; they may justly be charged with being anti-social, for not only do they consume food which others may stand in need of, but they are apt to offend the sensitive æsthetic eye; added to which they may prove highly inconvenient companions in an overcrowded public conveyance: who has not witnessed the exasperating unconcern with which a monstrousiy obese person plumps himself down between two unoffending passengers?

The reduction of over-weight to normal proportions is in most cases a very simple matter: it consists in reducing fattening foods, and increasing bodily exercise; in others special routine treatment is called for, such as that devised by Mr. F. A. Hornibrook.

In their own interest, people should not allow themselves to exceed their normal weight, a warning which is particularly necessary when middle age is reached. It is natural for many to put on weight at this time, a tendency which should be kept well in abeyance. Not only is obesity irksome: among other evils, it greatly increases the dangers associated with heart and lung disease.

CHAPTER XVIII

QUANTITY OF FOOD (*continued*)

Insufficient Food. The ability to endure starvation differs in different animal species. Beasts of prey, whose supply of food is apt to be precarious, can fast for days together without harm, whereas we have it on the authority of Sir Peter Chalmers Mitchell that the Great Apes do not endure fasting well; in the London Zoological Gardens they are fed at least three times daily; on the other hand, the lions receive daily 12 lb. of meat, but are kept without any one day in the week.

Age and constitution influence the capacity to endure starvation. The demand for an ample daily supply of food is more insistent during the growing years than after growth has ceased. Much, of course, depends upon the capacity to store food: the camel is capable of storing a reserve sufficient for several days' travel in the desert; hibernating animals can survive a long winter without food. Among humans those of the active (katabolic) type are less able to go without food than those of the sluggish (anabolic), yet in spite of these constitutional differences the average person, old or young, is far more able to endure semi-starvation than is generally supposed.

While in this country many may be under-fed (often in the sense of not being provided with a properly balanced diet), very few die from actual starvation. Even the subjects of serious disease can survive a long time on an extremely meagre diet. The public have a great idea of "keeping up the patient's strength," and believe that the most effectual way of doing this is to cram as much food as possible down his throat. They fail

to realise that a person, especially if kept warm and quiet in bed and allowed to drink water, can continue to live a considerable time without any food whatever, and that, given the three requisites—warmth, rest and water—life can be sustained for a surprisingly long period on a very small daily ration. It is amusing to watch the incredulity often expressed by a patient and his friends when, for instance, some over-fed bronchitic, suffocating under a superabundance of fat, is told that he could live for days, and that with benefit, without any food whatever.

Fasting. There are several varieties of fasting; thus we may speak of (1) therapeutic fasting, (2) pathological fasting, (3) professional fasting, (4) ethical fasting, (5) strike fasting.

(1) *Therapeutic Fasting*. Many can testify to the beneficial effect of occasional fasting which permits the system to get rid of accumulated poisons. We are apt to forget that our primitive ancestors were not only compelled to hunt and otherwise to search laboriously for their food, but that often they had to be content with scant fare, or were even obliged to go without food for days together. Thus it has come about that it is, as it were, natural for Man to fast from time to time. Those who, leading sedentary lives, have daily placed before them three or four appetising meals of which they freely partake, would greatly benefit by periodic fasts, such as their primitive ancestors had perforce to submit to. Sometimes Nature comes to the rescue in the shape of a bilious attack which compels abstinence for a whole day or longer.

(2) *Pathological Fasting*. This may take the form of *anorexia nervosa*, in which the subject, a young woman of hysterical type, refuses persistently all food and, unless artificially fed, would starve herself to death; more frequently, however, she refuses food for the sake of the limelight it provides, and obtains her supplies surreptitiously.

Refusal of food entailing artificial feeding is frequently encountered in mental hospitals.

The fashionable practice of slimming may imply semi-starvation which may have serious consequences.

(3) *Professional Fasting*. The practice of undergoing long terms of fasting for the purpose of gaining a livelihood has hitherto, as far as I know, been confined to men. Strange to say, not any of these professional fasters have rivalled the phenomenal feats of the Cork fasters.

(4) *Ethical Fasting*. Presumably religious fasting is undertaken primarily as a disciplinary exercise and secondarily as a hygienic measure. One day's abstinence from meat in the week, amounting as it does to nearly two lunar months in the year, may be beneficial to health provided it is not accompanied, as it sometimes is, by excessive indulgence in other foods: I have seen a person, apparently under the full conviction that he was undergoing a genuine self-sacrifice, take generously of a recherché meal, including such items as cream soup, salmon mayonnaise, alluring pastries, dainty savouries, and rare fruits, the whole generously sprinkled with choice wines.

(5) *Strike Fasting*. We have it on the authority of Dr. Pearson —the medical officer at the Cork prison at the time of the hunger strikers (1920)—that nine of the eleven strikers took no food for ninety-four days. How much longer they would have survived had the strike continued we do not know.

These are the most remarkable instances of fasting hitherto recorded.

"No one previously has ever experienced cases in which men free from active disease and under perfect nursing tried to starve themselves to death and held out for so long a period as ninety-four days.

"The patients were not picked men, and they had no nourishment whatever to the best of my belief and that of the prison officials. They would not take medical treatment of any sort, but, of course, they were very carefully nursed. Everything was considered in the way of temperature and comfort. No one had a bed sore. They refused to have water beds, but air cushions and special mattresses were provided.

"The wonder is that they all had a desire for death" (Dr. Pearson).

Two cases have been recorded independently, of fat pigs

which, having by chance been buried in a corn rick in the course of its construction, survived, after complete starvation and absence of drink, the one 160, the other 161 days. (One wonders whether a correspondingly fat human subject would rival this feat, if allowed an ample supply of air and water.) I conclude that those two animals must have passed their period of incarceration in a condition of hibernation, for otherwise they could not, one would think, have survived without water.

CHAPTER XIX

THE NATIONAL FOOD SUPPLY

BEFORE the introduction of agriculture the entire human population was limited to a few millions. We may be quite sure that these pre-agricultural peoples, in spite of their severe struggle for existence, secured on the average a sufficiency of foods ideally suited to their needs, and that subsisting, as they did, on simple natural foods, which at most had been subjected to perfunctory cooking, and living much in the open, they were on the whole hardy and healthy, and little, if at all, afflicted by such affections as rickets, dental decay, adenoids or appendicitis.

The introduction of agriculture, and the consequent enormous increase and spread of the human population, has led to many difficulties in the way of providing an efficient supply of essential foods to each individual group of the human population.

Imported Foods. Not very long ago this country was able to produce sufficient food for its moderate population, but the time came when our increasing population compelled us to import food. To-day, it seems, we produce only enough food to provide a sufficiency for two and a half days of the week. It is thought by some that by intensive cultivation we might produce 80 per cent. of our requirements. As it is, we are obliged to import large quantities of beef, mutton, bird, bacon, eggs, butter, cheese, cereals, vegetables and fruit.

The ability to transport from remote parts of the world perishable food has been rendered possible by refrigeration and canning, processes which have now reached a high level of perfection. Though the flavour of the food subjected to these processes tends

to lose some of its delicacy, it does not appear that any appreciable loss in nutritive value takes place. The only vitamin likely to suffer serious damage in canning is vitamin C.

The Fallacy of Self-sufficiency in Food Production. (Back-to-the-land movement.) While many are for increasing the number of workers on the land, giving special encouragement to small-holders, there are some, including Lord Astor and Mr. B. Seebohm Rowntree, who do not view the result of such a movement hopefully.[1] They maintain that the falling population throughout the Western World, the advance in agricultural productivity, and the development of agrarian protectionism in Europe, have profoundly altered the agrarian outlook. They urge that the imports of fruits, vegetables, poultry and eggs, which could be produced much more abundantly at home, are already largely restricted by protection, and that further restriction would create serious difficulties.

While a drastic restriction of the imports of such staple foods as wheat, beef, mutton, bacon, would certainly increase the home market, it would at the same time entail on this country " a substantial rise in the cost of living, a further loss of export trade, and an increase of unemployment in the exporting industries." Further, " it would imperil the solidarity of the British Empire, and our good relations with other food-producing countries." In short, self-sufficiency in food production is not an end for which Great Britain should strive ; and it is " an illusion to suppose that agriculture offers a promising outlet for the absorption of unemployment by the creation of small holdings on a grand scale, although the system of allotments might be extended with advantage to make a useful contribution to the relief of unemployment in the distressed areas."

Defective Nutrition and Frequency of Disease among Civilised Peoples. It is well known that in civilised countries a considerable proportion of the population fall below a moderate standard of

[1] See " The Agricultural Dilemma," P. S. King & Son.

physical efficiency. In our own country this is clearly shown by the large percentage of C 3 men among would-be recruits for the army. The army recruiting figures for Great Britain, 1932–33, show a rejection on medical grounds of 22,000 out of 56,000 applicants.

The record of health among school children, although steadily improving, is still far from satisfactory. Of 1,638 five-year-old L.C.C. children

66 per cent. had two out of eight signs of rickety bones.
5 per cent. had middle-ear disease or deafness.
4 per cent. had defect of the lower limbs.
5 per cent. had heart disease.
2 per cent. had considerable visual defect.
6·7 per cent. had adenoids.

Only 4·7 per cent. had perfect teeth.

This low standard of health and physical fitness is (*a*) in part the expression of inferior stock consequent on a slackening of that rigorous elimination by natural selection, which is needful for the maintenance of the high level of efficiency which characterised our pre-agricultural ancestors, and obtains among wild animals ; and (*b*) in part the result of the unhealthy conditions imposed by the industrial age—confinement in factories, crowding into towns, and the multiplication of slum areas, to which must be added insufficient food : Sir John Orr, after a laborious, carefully thought-out investigation, finds that no less than 20 millions of our people are seriously underfed. His plan has been, firstly to estimate (by means of information derived from agricultural statistics, the return of exports and imports, and the like) the total annual amount of food consumed by the people of this country ; and next to work out the average weekly income per head of the whole population. This he places at about 30*s*., of which he computes 9*s*. are spent in food (see table on page 88).

His next step was to classify the population into six groups according to the weekly income available per head : it will be

Group	Income per Head per Week	Estimated Average Expenditure on Food	Estimated Percentage of Population
I	Up to 10/–	4/–	10
II	10/– to 15/–	6/–	20
III	15/– to 20/–	8/–	20
IV	20/– to 30/–	10/–	20
V	30/– to 45/–	12/–	20
VI	*Over* 45/–	14/–	10

seen that group I consists of those with a weekly income per head up to 10*s*., of which 4*s*. are available for food, *i.e.*, about 7*d*. per day ; while group VI consists of those with a weekly income of 45*s*. and over, of which 14*s*. are available for food, *i.e.*, 2*s*. per day.

The consumption of bread and potatoes was shown to be practically uniform for all groups, and the consumption of meat, fish, milk, eggs, fruit, vegetables, to rise from group I to group VI.

Thus, passing from the lowest to the highest group, the money spent per head per week on :

Milk rises from 1·8 to 5·3 pints.
Eggs ,, ,, 1·5 to 4·5
Fats ,, ,, 10·2 to 15·8 oz.
(including butter)
Fruit rises from 2½*d*. to 1*s*. 8*d*.

From these data it is estimated that the three poorest groups (representing half the population), while enjoying a sufficiency of bread and potatoes, are suffering from a dearth of meat, butter, milk, eggs, fruit, and vegetables (other than potatoes).

These gradations in respect of nutriment express themselves in the way of growth, health and degree of mental alertness, all of which tend to improve from the lowest to the highest group, clear evidence that extreme poverty does not provide the most favourable conditions for the normal development of mind and body.

Factors contributing to this malnutrition other than inadequate food must not, of course, be overlooked. Among them inadequate housing, overcrowded rooms, and a smoke-ridden atmosphere preventing free access of sunlight, play a prominent part. Children sleeping in crowded, stuffy bedrooms have little appetite for breakfast, and often come to school without having had any.

The slipshod hand-to-mouth *ménage* of the poor homes (sometimes consisting of no more than a single room) is little realised by the inexperienced ; the work of domestic science teachers in the elementary schools is for this reason too often disappointing ; how can the high standard taught be practised in the home where, for instance, a tablecloth is never laid and where the family meal is served from the saucepan ?

Then there is the highly strung nervous child who, as Dr. Hector Cameron has said, in midst of plenty, displays all sorts of fancies in respect of his food, at the expense of good digestion and good nutrition.

Again, many mothers among the poor fail to lay out the money available for food in the most profitable way ; meals, moreover, are apt to be irregular as well as uninviting.

We are led to conclude that the only satisfactory plan of feeding children of the very poor in the centre of large towns is by the co-operative method of communal stores and communal kitchens (see pp. 64, 65).

By the proper selection and proper preparation of essential foods, it is possible to feed children much more cheaply than is generally supposed, always provided their homes are healthy and that they can enjoy an abundance of active open-air life.

It is interesting to ask oneself what would happen if a normal breast-fed child from an early age led a life in the country, spending much of the day in the open, on a diet somewhat as follows: good standard bread and beef-dripping *ad lib.*, carefully chewed raw vegetable food including fruit, a modicum of cheese and perhaps an occasional egg, say once a week. On such a diet a sufficiency of vitamins would be provided—the bread and dripping ensuring a sufficiency of A, B and D, and the raw vegetable foods providing, besides other vitamins, a sufficiency of the all-important ascorbutic vitamin C. Of this we may be sure—such a regimen would at least ensure good jaws and teeth, and we might further expect from it a comparative freedom from adenoids, tonsillitis and appendicitis.

Food Distribution. One of the difficulties besetting the commissariat of nations lies in the food distribution between different countries (largely owing to tariff restrictions), and different parts of individual countries.

These difficulties are especially felt in connection with the distribution of highly perishable foods. Consider our milk industry which, immediately before the establishment of the Milk Marketing Board (September, 1933), was on the verge of bankruptcy. In England and Wales 160,000 farmers, scattered over 26 million acres, are engaged in this industry, producing annually 1,200 million gallons of milk to the value of 60 millions sterling, about one-quarter of the value of our total agricultural output. That we should spend nearly as much annually (50 millions sterling) on sweets—a mere luxury, and one by no means health-promoting—as on the production of a food of such high nutrient value as milk is characteristic of our casual dietetic methods.

Valiant efforts are being made by Food Marketing Boards, and improved methods of distribution, to bring to the doors of the poor an adequate supply of staple foods at a minimum price.

As regards milk, the enormous development of this industry has rendered its marketing increasingly complex and difficult.

Difficulties in respect of milk distribution may arise from the remoteness and comparative inaccessibility of farms. Summer pastures, giving as they do an increased yield of milk, may increase the difficulties of marketing it. Again, the large exodus of the population to the coast for the summer holidays causes difficulties in the way of diverting milk from its usual market. These difficulties were seriously threatening the milk industry : every man sold his own milk in his own way, and producer-retailers, in their desperate efforts to gain customers, were suicidally undercutting one another. " Many a dairy farmer had to walk the streets from dairyman to dairyman hawking his milk like boot-laces." Happily, the Board, by skilful handling of difficult problems, has changed all this, and in the words of Mr. Keith J. Thomas : " the chaos of yesterday is almost forgotten in the ordered system of to-day."

Railway transport has enabled the milk to be conveyed rapidly for long distances. The introduction of motor transport since the war has still further facilitated rapid milk transport : a single motor-lorry can collect milk from several farms and convey it to a railway station or direct to a central depot. To-day London milk is sent up by rail and lorry to the extent of a hundred or more million gallons annually from within a radius of 400 miles (Robert Beresford). Milk is now conveyed to London depots in glass-lined lorry tanks with a capacity up to 2,500 gallons (12 tons).

The Need of Cheaper Milk. It appears that some 250 million gallons of milk are annually produced in this country over and above that consumed as household milk. This surplus is sold at a little more than a third of the price obtained for household milk, to factories for the conversion into condensed milk (some of which is exported), butter and cheese. The best way of increasing the market for household milk would be to lower the price. I suggest this could be done without any loss to producer, middleman, or retail distributor, by diminishing the milk sold to the factories and increasing that sold as " liquid " milk. It ought, one would think, to be possible to retail milk at 5*d.* per quart, or even less, without any loss to the industry.

The principle of regulating the price of staple foods applies, of course, to foods other than milk.

The subject of food distribution is coming more and more to the front. With improved methods of distribution, *e.g.*, of potatoes and fish, it might be possible to cheapen the prices of essential

foods in poor districts : the experiment of supplying cheap potatoes to the unemployed at Bishop Auckland was a striking proof of this.

Lord Linlithgow, speaking in connection with the Grocers' Exhibition in London, March, 1936, hinted that Government might some day approach the retail distributors of food with a view to their co-operating in a national food policy, involving changes in organisation which might have far-reaching consequences ; he emphasised the need for friendly relations between the producer and shopkeeper. " He had never accepted the view that the shopkeeper was the villain of the piece, robbing now the producer, now the consumer, and waxing fat on the proceeds." Even so, " all was not right with the distributive trades . . . the ideal of personal service, of the relationship between the tradesman and his consumers was getting blurred ; it was all too mechanistic and soulless."

CHAPTER I

THE SOLAR SPECTRUM

SEEING that the sun's rays play an essential part in the generation of vitamin D, a brief reference to the solar spectrum seems appropriate (see Fig. 1, p. 96).

By means of a prism the solar complex of rays is broken up into a scale of rays having progressively diminishing wave-lengths. At the lower (bass) end of the scale are the invisible ultra-red rays having comparatively long wave-lengths [1]; next follows a succession of middle-register visual rays (red, orange, yellow, green, blue, violet); these are succeeded by the invisible ultra-violet (treble) rays with still shorter wave-lengths.

Beyond the ultra-red, in the extreme bass, are the rays employed in wireless telegraphy, having the longest wave-lengths; beyond the ultra-violet, in the extreme treble, are the Röngten rays, having the shortest wave-lengths. The invisible ultra-red, or heat, rays are revealed to the touch, and by the thermometer, which enables differences of one millionth of 1° C. to be registered. The invisible ultra-violet rays are revealed by their chemical effects such as bleaching, the production of pigment in the mammalian skin (tanning), the generation of chlorophyl in plants, and the chemical changes produced on a photographic plate.

The wave-lengths of the visual rays range from 760$\mu\mu$ (red) to 390$\mu\mu$ (violet).[2] The rays most effective in rickets lie in the mid-portion of the ultra-violet, *i.e.*, between 315$\mu\mu$ (or 390$\mu\mu$) and 260$\mu\mu$.

[1] The wave-length is the length between the crests of two successive waves.
[2] μ = one-thousandth of a millimetre; $\mu\mu$ = one-millionth of a millimetre.

Direct Unreflected Sunlight. We need to distinguish between *direct* and *reflected* sunlight. The sun radiates its rays in all directions. On striking objects in their path the rays may, in varying degrees, (*a*) pass through them, (*b*) be absorbed by them, or (*c*) be repelled (reflected) from them. Such reflected rays—ultra-red, visible, ultra-violet, and the rest—behave in the same way, though with less intensity, as direct rays. When we are

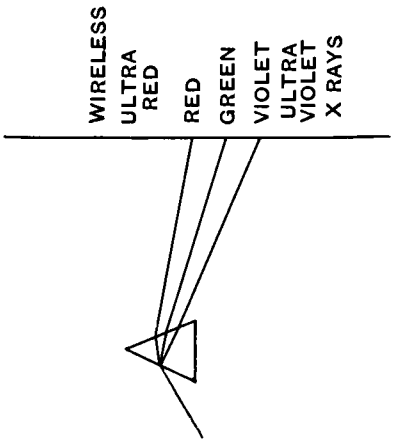


FIG. 1.—The spectrum, showing the wireless rays in the extreme bass, the X-rays in the extreme treble and the coloured rays in the middle. The ultra-red (heat) rays, and the ultra-violet (chemical) rays are also represented.

looking at the sun, there being no intervening opaque screen, we receive direct solar rays of greater or less potency.

The diffused light filling empty space is reflected light, by means of which we perceive the forms and colours of objects. Were light not thus reflected, the only visible objects (no opaque screen intervening) would be inherently luminous objects, *i.e.*, those emitting light-rays generated by themselves (such as the sun, the fixed stars, and luminous animals and plants).

In their clamour for direct sunshine, enthusiasts are apt to forget that these reflected rays exhibit the same properties, though in a milder degree, as the direct rays. Different objects possess different powers of reflection. A perfect reflector of all the direct rays of the sun would reflect rays having the same potency as the direct rays of the sun, just as a perfect mirror gives an image indistinguishable from the original. Such being the case, it is obviously not necessary to expose our bodies to the direct solar rays in order to derive benefit from sunlight. Indeed, when the sun is shining powerfully, reflected ultra-violet rays may (as shown by their ability to cause bronzing of the skin) be more potent than the direct rays of a milder (*i.e.*, more effectively screened) sunlight.

So-called sky-shine (which consists of the solar rays reflected by particles in the atmosphere on to the earth) contains all the rays of the spectrum including the ultra-violet rays, now known to be capable of producing the calcifying vitamin D in the skin of man and beast (see pp. 113–114).

That reflected ultra-violet rays reach regions where direct sunshine never enters is obvious. How otherwise could plants, such as ferns, which flourish in shady places, generate their abundant stores of chlorophyl ?

The Influence of the Ultra-violet Rays on the Living Organism. Directly or indirectly, the ultra-violet rays play an essential part in all vital activities. At some time or other the spontaneous generation of animate from inanimate matter must have taken place on this planet. We can by no means be certain that it does not take place at the present time, for the earliest product would assuredly be an exquisitely diminutive form of ultra-microscopic organism incapable of identification except by indirect means.[1]

There is reason to believe that the first step in spontaneous

[1] It is estimated that the smallest ultra-microscopic viruses are no bigger than some protein molecules. It has not definitely been proved that the viruses are living organisms, though they probably are.

generation of bioplasm takes place, as already suggested, by the action of ultra-violet rays on water containing some or all of the essential chemical constituents of living matter. So far as living organisms are concerned, we know that these rays are necessary for the up-building of chlorophyl in plants, and that chlorophyl with the help of these rays is able to build up the complex molecules of starch. It is noteworthy that in the attempt, not altogether unsuccessful, of Professor Baly and his collaborators to induce the initial phases of bio-genesis, they made use of ultra-violet rays.[1]

Acting on the skin of mammals, these rays generate the calcifying vitamin D from the pro-vitamin ergosterol (see pp. 113–114).

Those inhabiting tropical regions get enough and to spare of sunshine, and need a copious deposit of pigment in the skin to protect the underlying tissues from an excess of solar radiation. Yet it must not be forgotten that the inhabitants of temperate regions, living open-air lives, secure a goodly supply of reflected solar rays in the shape of sky-shine, sufficient in all probability to generate a considerable proportion of the necessary vitamin D.

Ultra-violet rays are also able to augment the quantity of this vitamin in food, and even to develop the vitamin anew in substances wholly lacking it, such as olive oil and cotton-seed oil.

Protective Measures Against an Excess of Solar Rays. The amount of solar radiations permitted to enter the tissues of living organisms needs careful grading. Plants are protected by special devices from too fierce solar rays. Birds are protected by their feathers. In the majority of mammals light is for the most part shut out by a furry coat. The tissues of some animals at least (such as moles and cave animals which have lost their sight) must, one would think, be shrouded in utter darkness.[2]

In the case of Man, protection against too powerful heat rays

[1] "Life," Geddes and Thompson, p. 1104.

[2] The mole, which possesses an osseous skeleton and teeth, presumably gets its vitamin D from its animal diet, insects, etc. Certain mammals are completely naked; these include the pachyderms—elephants, rhinos, swine—whose coarse skin must be well-nigh impervious to light, and Man himself.

is afforded by the sweat glands, which, by the evaporation of the water they secrete, are able to reduce an excessive body temperature to the normal.

Protection against an excess of ultra-violet rays is achieved by the deposit of dark pigment in the deeper layers of the epidermis, the deposit varying in amount in proportion to the intensity of the rays which have to be guarded against. Hence, races living in temperate, cloudy regions tend to be blonde, and those inhabiting tropical regions, deeply pigmented. The pigment, in greater or less degree according to the intensity of the rays, intercepts, " absorbs " the ultra-violet rays, converting them into heat rays, any excess of heat being got rid of by an outpouring of sweat which, by evaporation, cools down the surface. As might be expected, the dense layer of pigment in the negro's skin does not permit the moderate sunshine of the temperate zone to penetrate, even in a small degree, beyond the pigmented layer, to encounter ergosterol (the pro-vitamin of D), and hence it happens that negro children, when transported to temperate regions, tend to suffer from dearth of this vitamin and are in consequence apt to develop rickets.

It is noteworthy that in furred animals the abdominal region is partly bare : in the cow, for example, the mammary region is scantily covered. Is this with the object of allowing the mammary gland to come under the influence of ultra-violet rays ? We know that these rays increase the vitamin D content of milk. The bareness of the scrotal region is also significant.

It would seem that in the case of furred animals, just sufficient skin is left bare as suffices for the production of the necessary complement of vitamin D. The fact that so little of the skin is left bare in mammals shows that, so far as they are dependent upon ultra-violet rays for their supply of vitamin D, a small naked area suffices. This accords with what we know concerning the ultra-violet treatment of rickets, which requires only a limited area of the surface to be irradiated.

Ultra-violet rays penetrate light clothing to a considerable degree; the thicker and darker the clothing the more impervious is it to these rays.

Ordinary window glass, while readily transmitting visible rays and heat rays, tends to intercept ultra-violet rays; quartz transmits a considerable proportion of these rays; specially prepared window glass, such as vita-glass, transmits a larger percentage, but this virtue tends to wear off in time.

CHAPTER II

SUNLIGHT TREATMENT

SUNLIGHT treatment as ordinarily understood means treatment by the direct rays of the sun ; but it may also be made to include the benefit obtained from ordinary (reflected) daylight, such as those living open-air lives receive in abundance even when the sun is not shining.

The curative value of sunshine was recognised by the Greeks and Romans, but it is only within comparatively recent times that this method of treatment has been revived. It has been practised on systematic lines and popularised by Rollier in Switzerland, and Sir Henry Gauvain in this country ; while Sir Leonard Hill and Dr. Argyll Campbell have investigated the scientific aspect of the subject.

That the sunlight treatment, *i.e.*, treatment by the direct action of the solar rays, as carried out in the Alps and Hayling Island, is useful in certain diseases of the skin (*e.g.*, lupus), and in surgical tuberculosis, is certain, but it is doubtful whether treatment by solar rays has any specific influence on pulmonary " consumption " : the two great needs in the treatment of this disease are good food and open-air life in a healthy district. Concerning the Alpine treatment of disease, Sir Leonard Hill and Dr. Argyll Campbell wisely remark : " The open air is a great factor in the cure ; the cool air stimulates and increases metabolism."

No doubt much of the good resulting from the sunlight treatment is due to the open-air life which accompanies it. (A plentiful supply of vitamin D can be obtained, apart from sunlight, by means of the mercury lamp and from calciferol.) Of recent

years open-air treatment for slum children just past the stage of infancy has been instituted. The children are taken from their slum houses early in the morning and returned at night, the entire day being spent in the open under ideal hygienic conditions. It would be difficult to exaggerate the improvement in health accruing from this return to something like ideal conditions. Equally good results have been obtained from open-air hospital wards for children.

Apart from its physical effect, sunlight acts beneficently by promoting cheerfulness: one is wont to feel more cheerful on a bright than on a dull day. Sunlight is, besides, a great purifier, destroying many forms of bacterial life, and a great deodoriser: witness the sweet odour of sun-bleached linen. For these reasons we who live in northern latitudes choose houses and rooms with a sunny aspect. The high value attaching to sunshine is further shown by the eagerness of our sunny health resorts to display the records of their annual sunshine; and for the tendency of the best residential quarters of towns to extend westwards or south-westwards, thereby securing the maximum of sunshine during the day.

Sun-bathing. There is a widespread belief that the exposure of the nude body to strong sunlight is healthful, and that the more completely the entire body gets tanned, the better: never was there a greater fallacy. The sun-bathing enthusiast fails to realise that this very tanning is a protective effort on the part of the organism against the penetration of any but very moderately intense ultra-violet rays beyond the most superficial layers of the skin. The naked human, lacking either feathers or fur, is provided with the means of depositing pigment in the skin; this pigmentary barrier causes any excess of ultra-violet rays to be degraded into a more easily manageable form of energy, namely heat which is readily dispersed by the evaporation of sweat (see p. 109).

Individuals differ in their capacity to "tan," *i.e.*, to increase

the protective pigment of the skin under the influence of the solar rays, and it has been found that those who do not readily tan are the least satisfactory patients for the sunlight treatment as practised by Rollier and Gauvain. Now, if the penetration of the skin beyond the pigmentary layer by ultra-violet rays is beneficial, these blonde patients should derive the most benefit from the sunlight cure. May not their failure to make headway when undergoing the sunlight treatment be due to their inability to protect themselves against an excess of the ultra-violet rays ?

When the vitamin D in the food does not suffice for the needs of the organism, the deficiency may be supplied by the action of sunlight on the sub-pigmentary ergosterol (see p. 114), and for this, a moderate degree of reflected sunlight (even though the sun may not be " shining ") suffices for all those who are not definitely swarthy. *Those who spend much of their time in the open receive a goodly supply of ultra-violet rays even in cloudy regions of the temperate zone.* An outdoor life favours health partly on account of the purity of the air, partly because of the stimulating effect on the skin of the moving air (unless good cross ventilation can be secured indoors, the confined air remains comparatively stagnant), and no doubt in part by the action of light in generating vitamin D in the skin.

Those who desire to get a physiological dose of these rays need not expose the nude body to the direct rays of the sun : a daily exposure of ten to fifteen minutes, while taking the morning bath in ordinary (reflected) daylight, will help to supply the necessary dose. The modern fashion of exposing, without due precaution, the nude (or nine-tenths nude) body to the direct rays of a powerful sun during a comparatively brief period of the year has no physiological justification. The practice of all and sundry indulging publicly in this form of cure is neither therapeutically nor æsthetically commendable.

CHAPTER III

VITAMINS

Historical

It was in 1881 that Lumin may be said to have opened the first chapter in the investigation of those subtle agencies, now known as vitamins. He found that by feeding animals on a mixture of pure protein, carbohydrate, and fat, together with the necessary minerals, life could not be sustained, thus showing that some necessary constituent of which physiologists were at that time ignorant, was lacking. The physiologist, Voit, had already been working on similar lines.

Identification of Vitamin A (the anti-zerotic[1] vitamin). This important work was allowed to lapse, and was not renewed until 1902, when Eijkman and Röhman studied the effect of various carefully-composed (synthetic) diets on rats and mice. Thus Röhman found a diet consisting of purified casein, albumin, potato-starch, margarine, together with the necessary salts, to be inadequate for mice.

In 1905, C. A. Pekelharm made the *first great advance* : he found that mice fed on bread baked in casein, albumin, rice-flour, lard, and the needful salts, died from starvation in four weeks, while *the addition of a small quantity of milk rendered the diet adequate.* He concluded : " there is an unknown substance in milk which even in small quantities is of paramount importance to nutrition." This was the first step towards the identification of A.

About 1906 Gowland Hopkins carried on important investigations (published in 1912). The synthetic (basal)[2] diet employed by him consisted of protein, carbohydrate, lard, and the necessary salts. This

[1] Vitamin A prevents zerophthalmia. The term " antizerotic " suggested by Leslie Harris is preferable to " growth-promoting," seeing that other vitamins are also growth-promoting.

[2] A *basal* diet, as here understood, is one containing all the necessary constituents for normal nutrition, save some unknown item which it is the object of the experimenter to discover.

proved to be a starvation diet for growing rats. The daily addition of 2 c.c. of milk, however, rendered the diet adequate. Here, again, *the milk contained the unknown essential.*

In 1909 W. Steep found bread soaked in a little milk to be a complete diet for mice, but that, after extracting the contained fat with alcohol and ether, the diet was no longer able to support life. This constituted *a further significant advance* : it clearly showed the unknown constituent to *be associated with the fat portion of milk, i.e., butter-fat.*

Similar experiments were carried out by a number of enthusiastic workers, including Osborne and Mendel, McCullum and Davis, with a view to discovering the *elusive ingredient associated with butter-fat.* The method adopted was to feed growing animals, such as rats and mice, on a basic diet—in this case one adequate for their needs save for the presence of a fat containing the unknown ingredient. In this way it was found that most animal fats, but especially butter-fat, yolk-fat, and cod-liver oil, were rich in the fat-soluble ingredient sought for ; while others, such as lard, and most vegetable fats and oils, were entirely, or almost entirely, devoid of it. Thus it came about that the newly-discovered agent received the name of *fat-soluble A vitamin.* It was subsequently shown (after the identification of vitamins B and C) that the fats (butter, etc.) containing this vitamin contain a second vitamin, to which the name of fat-soluble D has been given.[1]

Absence of vitamin A from the food produces a characteristic affection of the eyes known as zerophthalmia.

Since this date students have been busy throughout the world in the investigation of vitamins. In her monumental history of vitamins, Dr. Ethel Browning enumerates upwards of 3,000 references to monographs treating of vitamins. It is estimated that on the average three new papers are published daily on the subject of vitamins. Dr. Browning's list includes the names of several biochemists who have struggled valiantly, and with a large measure of success, in the attempt to elucidate the intimate chemical structure of the vitamins. Already one of the vitamins (vitamin C) has been built up synthetically—a rare and brilliant achievement.

Identification of Vitamin B_1 (the anti-neuritic vitamin). It had for some time been known that the Japanese troops had suffered from beri-beri

[1] The term *vitamine* was invented by Funk (1913), who wrote a book entitled " Vitamines," a wholly inappropriate term, suggesting a relation to the chemical bodies known as *amines.*

(a disease characterised by widespread inflammation of the nerves) as the result of a diet consisting largely of polished rice.

In 1905 Eijkman, by feeding some fowls on polished rice, produced in them a disease resembling beri-beri. A cure was effected by adding to the diet an extract of the polishings. From this it was concluded that the polishings contained a constituent essential to normal nutrition. Subsequent experiments with basal diets showed that this constituent is more abundant in certain foods (*e.g.*, wheat-germ and yeast) than others, and to it the name of water-soluble B was given. This is a complex of several vitamins of which as many as six have been described. The two best known are the anti-neuritic vitamin B_1, the absence of which causes beri-beri, and the anti-pellagra vitamin B_2 (vitamin G), the absence of which causes pellagra, a disease which between 1907 and 1912 caused 20,000 deaths in the United States.

The Identification of Vitamin C (the anti-scorbutic vitamin). The association of scurvy with the absence of some essential constituent in the food has long been recognised. Perhaps the earliest experiment in vitamins was that of C. Carebb, who in 1737 sought to cure scurvy by means of an "extract of fir spikes." With the resources of modern knowledge it was not difficult to discover the relative anti-scorbutic powers of different foods, and ultimately to identify the agent as an acid (ascorbutic acid) which effects the cure in scurvy. To this the name of water-soluble C was given.

The Identification of Vitamin D (the calcifying vitamin). One of the most fascinating chapters in the history of the vitamins is that which tells of the discovery of vitamin D. This discovery was made independently (1) by the method of basal diet administration and (2) by the ultra-violet irradiation of the mammalian skin.

In 1919 Professor E. Mellanby began a dietetic investigation of rickets. He showed that puppies fed largely on cereals and a small allowance of milk developed rickets, which could be cured by the addition to the diet of butter-fat or cod-liver oil: and, again, that when the diet consisted of bread, separated milk, linseed oil, yeast, orange juice, and the necessary mineral matter, rickets developed and could be cured by butter-fat or cod-liver oil. It was clear that the missing anti-rachitic (calcifying) ingredient was associated with these fats, but not with linseed oil. The question naturally arose whether this illusive ingredient

was identical with the anti-zerotic fat-soluble A. Mellanby seems to have suspected that it might be an independent calcifying vitamin. That such was the case was brilliantly demonstrated by McCullum and his co-workers, who showed that cod-liver oil oxidised from twelve to twenty-four hours lost the potency of fat-soluble A (*e.g.*, the power of curing xerophthalmia in rachitic rats) while retaining its calcifying power. To this calcifying agent the name of fat-soluble D was given.

The existence of vitamin D was at the same time being independently demonstrated by the brilliant irradiation work of investigators such as Racznsky, Huldschinsky, Hess and Lundegen. These investigators succeeded in showing that vitamin D is produced by the action of ultra-violet rays on the sub-pigmental layer of the skin—a great achievement (see p. 114).

While vitamins A, B and C are abundantly present in the vegetable kingdom, vitamin D is very scantily represented in vegetable food.

The cereals, wheat, rye, barley, oats, maize, rice, contain no vitamin D ; on the contrary, Professor E. Mellanby has shown that they, notably oatmeal, yield an *anti-calcifying body*.

So far as foods are concerned, our supply of vitamin D is practically limited to certain animal fats, such as the oil obtained from the liver of cod, herring, mackerel, salmon, and the fat of meat, also butter-fat and yolk-fat. Lard yields little or no D. Most vegetable oils, *e.g.*, olive oil, linseed oil, cotton oil, are similarly deficient in D, but can be made to yield this vitamin by irradiation.

CHAPTER IV

VITAMINS (*continued*)

General Remarks on Vitamins

These subtle agents resemble the hormones in not yielding energy, thus differing from proteins, fats and carbohydrates. We have much to learn concerning their exact mode of action. It is, however, known that vitamin D aids the absorption of calcium (and phosphorus ?) by the alimentary tract, and that in the absence of B_1 the lactic acid produced by muscular contraction does not suffer the normal metamorphosis and tends to accumulate in the body—in the case of the rat the excess of the acid thus generated reduces the pulse rate from 500 to 250 a minute (Leslie Harris and Drury).

Vitamins differ from ferments (enzymes) such as diastase (which converts starch into sugar) in being remarkably stable.

This is well shown by the behaviour of the fat-soluble vitamins, A and D, present in cod-liver oil. On boiling this oil with strong alkalies, 99 per cent. of the oil is converted into soap, while the two vitamins A and D are left intact in the remaining 1 per cent. of unconverted oil ; from this oil they can be distilled at a temperature of 200° C. Thus, as Professor Drummond observes, although these vitamins are " highly volatile," they are " remarkably stable."

It was at first thought that animals were wholly dependent for their vitamin supply upon the vegetable kingdom, but it is now known that the calcifying vitamin D is produced (not only by plants but) in the skin of mammals (including Man) by the action of the ultra-violet rays of the sun, for which reason some deny its claim to rank as a vitamin. Certain mammals and birds can generate the vitamin C.

Vitamins are capable of being stored up in the body to varying extents by different animals, these reserves enabling them to maintain their health for varying periods in the absence of fresh vitamin supplies.

The biochemists have achieved remarkable success in their efforts to isolate individual vitamins and obtain them in the pure form : they have succeeded in obtaining crystals of vitamin D (calciferol), the administration of which by the mouth cures rickets ; crystals claimed to be vitamin B_1 have also been isolated, and the formula ($C_{12}H_{16}N_4OS$) estimated (this is the only vitamin known to contain sulphur) ; not only has vitamin C (ascorbutic acid) been isolated and its structural formula worked out—it has, as we have seen, even been synthesised. Dull indeed is the man who is not stirred by such achievements.

How greatly the various organs and tissues of the body differ in their vitamin requirements is shown by the varying quantity of the vitamins found in them ; for instance, the heart contains proportionately ten times as much B_1 as voluntary muscle.

A striking feature of the vitamins is the small quantity required for normal nutrition : for example, 0·05 milligram of vitamin A, daily, suffices to prevent zerophthalmia in the rat ; a daily dose of no more than $\frac{1}{100.000}$ to $\frac{1}{20.000}$ of a milligram of calciferol suffices to cure rats of rickets.

Some vitamins can be taken for long periods in excess of the normal requirements, apparently without any ill effects ; on the other hand, it has been shown that a slight excess of vitamin D may lead to a deposit of calcium salts in the arteries and viscera (*e.g.*, the kidneys), and that, if the excess is long continued, death may ensue. Inasmuch as this vitamin is produced by the action of sunlight on the sub-pigmentary layer of the skin, its excessive production by solar irradiation has to be guarded against. To this end Nature deposits pigment in the skin in proportion to the degree to which this structure is exposed to the ultra-violet rays of the sun (see p. 99). The tanning of fair-skinned persons

which results from several weeks' exposure to strong sunshine is manifestly protective.

Natural Foods as Sources of Vitamins. We may gather some useful hints regarding the sources of vitamins by studying "natural foods." All the essential vitamins of the mammals are contained in the food they eat. The calcifying vitamin D is also generated by the action of the ultra-violet rays of the sun on mammalian skin, and this, in the case of the herbivora, may be, as we shall see, the chief source of this vitamin (see p. 114).

The carnivora get their supply of vitamins from the animals they prey upon, and to a less extent by means of the solar irradiation of the bare portions of the skin; they also obtain vitamins from the green food they occasionally seek out instinctively. The herbivora derive their vitamins from the plant world, but, the supply of vitamin D from this source being scanty, it would seem that these animals obtain their vitamin D mainly from the solar irradiation of bare, or comparatively bare, portions of the skin. It is significant that a ponderous herbivorous animal, like the ox, can build up its massive skeleton and dentures solely on the simple vegetable fare provided by good pasture and such vitamin D as is generated by solar rays; and this in one-tenth of the time required by the much smaller human being, who has at his disposal a large class of highly nutritious foods. Note too that extant pre-agricultural Man derives much of his vitamin supply not only from his animal food, but also from raw vegetable food and the abundance of solar rays incident to his outdoor life.

We have seen that during Man's evolution from the anthropoid phase his food was comparatively simple, consisting of animal food of various kinds, and of the products of the uncultivated plant world, all of which, prior to the employment of cookery, were consumed in the raw state. In those days he did not concern himself about vitamins, but ate whatever his instincts led him to eat. Remember, too, that he had no milk other than his mother's —no cow's milk, butter, cheese or regular supply of eggs, on

all of which vitamin enthusiasts set so great store. No doubt the liver was highly prized by the primitive hunter for its manifold nutritional virtues (recently brought to light): the hawk will kill a hare for this one dainty, as I have myself observed.

Thus a consideration of Man's pre-agricultural hunting career brings out into clear relief the fact that " natural foods " from the animal and vegetable kingdom, aided by the solar irradiation afforded by an abundant outdoor life, supply Man with all his vitamin requirements.

Man can get his full complement of vitamins, save vitamin D, from his vegetable food alone ; for his supply of this vitamin he is dependent mainly on solar irradiation and animal fats. We may conclude that an abundance of raw vegetable food and outdoor country life go a long way towards supplying him with the necessary complement of vitamins.

CHAPTER V

SUNLIGHT AND RICKETS

The Production of Vitamin D

Sunlight and Rickets. The investigations which led to the discovery of vitamin D centre round the pathology of rickets.

It is now known that rickets in its minor unrecognised forms is much more common than is generally supposed. According to the testimony of Sir George Newman, 87 per cent. of the children of the London poorer classes suffer from some degree of rickets, and similar evidence of its frequency comes from the Continent. In minor cases the only signs by which the disease can be identified may be the defective ossification as revealed by X-rays.

Rickets is a constitutional disease in which the blood and all the tissues are involved. In its acute form the nervous system and the mucous membrane of the bronchi and digestive tract are disordered, and there may be fever and sweating : the child is irritable, restless, liable to local (tetany) and general convulsions, bronchitis, colitis ; but over and above these phenomena, the process of bone formation is profoundly disturbed, notably is calcification deficient.

Whatever the cause of the constitutional symptoms just described, it is certain that the disordered development of bone in rickets is due to a deficiency of vitamin D. By means of X-rays the improvement in the condition of the bones can be followed by the eye from day to day by supplying this vitamin, whether by irradiation, the administration of calciferol, or by means of a diet rich in D, such as butter, egg-yolk or cod-liver oil.

Huntley (1889), in his " Habits and Diets of Natives of Rajputana with Reference to Ætiology and Treatment of Rickets,"

seems to have been the first to direct attention to the influence of sunshine in preventing rickets. In the following year T. A. Palm pointed out that " rickets is unknown where sunlight abounds," *e.g.*, Australia and South Africa.

The recognition of this fact is the first and, some may think, the most significant discovery made in connection with the causation and cure of rickets. Rickets is a disease of darkness. It abounds in dark alleys and smoke-ridden towns from which the ultra-violet, vitamin D generating, radiations of the sun are shut out : it is, as Palm observes, " unknown where sunlight abounds," *even though the vitamin D content of the food be low.* When it occurs in sunny countries it is only under conditions which exclude the entrance of sunlight, as in the overcrowded narrow streets of Palestine, Egypt and Algiers.

In parts of India osteomalacia, a disease allied to rickets, characterised by a widespread softening of the bones, is common among Purdah women ; but rickets is rarely seen among their children who, from infancy onwards, are out in the sunlight all day. Osteomalacia is also common in China, Japan, and Egypt. In Northern China 2 to 5 per cent. of pregnant women are said to die in consequence of this disease. As might be expected, it is most prevalent in the winter months.

Even in temperate, cloudy countries like our own, rickets is comparatively rare among country children who are much in the open, for, as we have seen, the light reflected from the sky, even in the absence of sunshine, plays its part in developing vitamin D in the skin.

In 1912 Racznsky reported that sunlight facilitated calcification in puppies : two puppies born in May of the same litter, and suckled by the same mother, were reared, one in the dark, and one in the light : the one reared in darkness developed rickets ; the other did not.

pass on to the striking discoveries made in connection with the generation of vitamin D in the skin in response to ultra-violet irradiation.

Apparently the first to show that rickets could be cured by artificial ultra-violet irradiation was Huldschinsky (Berlin, 1919–20). He reported the healing of rickets in thirty children after twenty-two to twenty-six treatments spreading over two months. X-ray examination showed a steady improvement in calcification after four weeks, and complete healing after eight.

A. F. Hess (New York), quick to take this hint, irradiated the integument of a hog prior to the slaughtering of the animal, and found that the addition of portions of this irradiated tissue to the rachitic diet of some rachitic rats sufficed to effect a cure! It thus became evident that the curative effect on rickets of ultra-violet rays, whether from sunshine or artificial lamp, is due to the production of a calcifying substance (later known as vitamin D) generated in the skin. Subsequently (1924) Hess and Windus showed that sunlight activates the sterol present in the skin into ergosterol, and this again into vitamin D.

Influence of Ultra-violet Rays on the Blood. Howland and Kramer (1921) were among the first to demonstrate the remarkable influence of ultra-violet rays on the blood. They showed that the sub-normal inorganic (mineral) phosphate of blood serum, characteristic of rickets, is raised in the process of healing by ultra-violet rays—*the first definite evidence that the chemistry of the body is affected by the solar rays.*

Further striking evidence of the influence of the solar rays on the chemical changes taking place within the body was furnished by Hess and Lundegen (1922). They demonstrated, as the result of observations on sixty children, a *seasonable tide of mineral phosphate* in the blood serum, correlated with seasonable variation of ultra-violet rays in the solar spectrum.

"These meteorological observations confirm our opinion that the dominating factor in the phosphatic tide is sunlight, an opinion which was strengthened by the fact that increase in the blood phosphate was brought about even during the winter months (when sunshine is slight)

simply by irradiation of ultra-violet light from an artificial source. In this connection it is also well to bear in mind that rickets and tetany are almost unknown in the tropics."

Shikley (1924) found that, if an isolated piece of imperfectly calcified bone of a rachitic rat is placed in the blood plasma of a normal rat, some calcification of the bone will have taken place within twenty-four hours.

In rickets the calcium and phosphorus content of the blood tends to be sub-normal (John Hopkins, 1917). It has been shown that they are not deposited in bone unless the normal blood level is attained (Calvin, 1924), and that a sub-normal level of these bases can be raised to the normal by the administration of vitamin D (which is known to promote calcification in rickets) whether in the form of calciferol (W. J. Spence, 1934) or irradiation of the skin (Howland and Kramer, 1920, Orr and Holt, 1923).

J. C. Spence (1935), as the result of thirteen months' treatment of a rachitic child with calciferol (vitamin D) without any changes in the diet, obtained an increase in the blood-calcium from 9·0 mg. to 10·5 mg. per 100 c.c., and an increase in the blood-phosphorus from 3·2 mg. to 5·16 mg. per 100 c.c.

Influence of Ultra-violet Rays on the Vitamin D Content of Food. Hess and Windus (1924) showed that linseed oil and cotton oil, both devoid of vitamin D, can by irradiation be rendered anti-rachitic. They further showed that irradiation of the mother favours the storage of this vitamin in the unborn offspring.

Hess (1927) found that the irradiation of nursing women increases the vitamin D in the milk.

McCullum showed that a rickets-producing diet could by irradiation be rendered capable of curing rickets. It has also been shown that the proportion of vitamin D in milk can be increased by irradiation.

H. Chick and Roscoe (1927) observed that pasture-fed cows, when sunshine is plentiful, gave a higher vitamin D content in their milk than stall-fed cows.

G. Bohsted and his co-workers (1927) found that " Pigs bathed in sunlight made better gains and grew denser and stronger bones than pigs fed on the same rations and kept indoors."

All these observations bear out the importance of sunlight, as first emphasised by Huntley and Palm, in preventing rickets.

Calcification of the Teeth in Rickets. While rickets in children seriously disturbs the developmental process in bones (notably as regards their calcification), there is no evidence that children's teeth are similarly affected in this disease.

This is not surprising, seeing that the teeth display a far greater avidity for calcium than the bones. Maxwell Kurshas found that, by feeding rats on a ricket-producing diet, and thereby reducing to one-half the amount of calcium and phosphorus in the bones, the proportion of these elements in the teeth, *including the persistently growing incisors*, remained unaltered. Only when the calcium was *wholly eliminated* from the already severely inadequate diet did the teeth show evidence of deficient calcification.

Even before the discovery of vitamins, G. W. Watson, L.D.S., and J. H. Gibbs, F.R.C.S., made a detailed examination of the teeth of a large number of young rats, " very greatly affected with advanced rachitic changes of the whole bony skeleton." They found no naked-eye or microscopic changes " calling for notice."

We may conclude, then, that while deficiency of vitamin D in children produces rickets, characterised (among other features) by disordered developmental processes of the bony skeleton, there is no evidence that the development of the teeth is affected by rickets, or that the teeth of present or past sufferers from rickets are to any appreciable extent deficient in calcium. They are probably slightly more liable than others to gross hypoplasia, and this is what one might expect ; for the bad hygienic conditions under which rickety children are nurtured are just such as would render these children liable to those temporary illnesses which are apt to induce gross hypoplasia (see p. 180).

That some vitamin D is necessary for the normal development and calcification of the teeth is only what one might expect. M. Mellanby has shown that by feeding young animals, *e.g.*, puppies, on diets deficient in D, the developing teeth are deficiently calcified in proportion to the deficiency of vitamin in the diet ; and that the addition of cod-liver oil (which is rich in D) pro-

motes the calcifying process. This observer has also found that the administration of D stimulates the formation of secondary dentine by the pulp.

Professor E. Mellanby has further shown that cereals tend to hinder calcification ; if, therefore, to a diet deficient in vitamin D a large proportion of anti-calcifying cereal (oatmeal in particular) is added, calcification is still further hindered. On a severe diet of this kind the teeth and the jaws show defective development. Medical Research Council Report, 1929, " Diet and the Teeth " (see Plate 13), by M. Mellanby.

These investigations are of interest as showing the effect of grossly inadequate diet on the development of the jaws and teeth ; it can, however, rarely, if ever, happen that children in this country are nurtured on a diet so extremely inadequate for the normal development of the jaws and teeth as the experimental diets given by M. Mellanby to sub-human animals.

Rickets and Dental Caries. Observations concerning the comparative frequency of dental caries in sufferers, past and present, from rickets, are somewhat conflicting. It is not unlikely that in the rickety class, caries, like hypoplasia, may be slightly more frequent than among others ; but we are safe in concluding that rickets has little or nothing to do with the great prevalence of dental caries among the white population of the British Empire. In the sunny countries of that Empire, where rickets is almost unknown, and where the bones, and *a fortiori* the teeth, are presumably well calcified, dental caries is rampant in the white population, among whom the traditional dietetic customs of the mother country prevail.

CHAPTER VI

THE PREVENTION AND CURE OF RICKETS

It is now known that the defective growth of new bone in rickets is due to a deficiency of vitamin D. This vitamin facilitates the absorption of the ingested calcium and phosphorus, and when deficient the calcium and phosphorus content of the blood-plasma fails to reach the level necessary for the normal formation of new bone. It is especially during the first few years of life that a high level of vitamin D is called for.

We have seen that our supply of vitamin D is derived from two sources—solar irradiation of the skin and foods rich in this vitamin. The greater the amount furnished by irradiation, the less the need of foods rich in D ; and *vice versâ*. It is probable that the naked peoples of tropical regions generate a sufficiency of vitamin D independently of any they may derive from their food. Indeed, the tendency in their case may be for over-production by irradiation, a tendency which needs to be kept within physiological bounds by a copious deposit of cutaneous pigment.

Seeing that white children living in sunny countries, such as Australia, rarely develop rickets, we may conclude that they are only in a small degree dependent upon the vitamin D injested with their food.

Even in comparatively sunless countries such as ours, children leading an open-air country life do not, unless grossly misfed, develop rickets : skyshine alone furnishes its complement of ultra-violet rays capable of providing some degree at least of the

necessary D. Solar rays pour down upon the body from all parts of the firmament—a vast expanse compared with the area of the sun's disc, whence the direct rays reach the body.

It is essentially in town-bred children inhabiting slum areas, where sunshine and skyshine are blanketed by smoke, and where the supply of animal fats is meagre, that rickets abounds.

Yet, even in the complete absence of sunlight, rickets may not occur, provided the child is adequately fed—that the food is not seriously deficient in calcium and phosphorus, that the cereal food is of a kind which compels thorough mastication (and is not therefore likely to be consumed in excess), and that he is amply supplied with butter, dripping, eggs and raw vegetable food, including fruit. Fortunately, a large proportion of poor children in this country are getting their daily portion of milk, while necessitous children are provided with free dinners.

Children suffering from rickets have generally been fed on an excess of farinaceous food, which sets up chronic gastro-intestinal disturbance leading to contamination of the blood by poisons. This excess is mainly due to the consumption of farinaceous food in a soft form which all too readily slips into the stomach, instead of in a form compelling thorough mastication. This fault needs to be corrected.

For the rest, open-air life is desirable; but even without this the necessary vitamin can nowadays be furnished by the routine administration of calciferol, or the application of ultra-violet rays by means of the quartz mercury vapour, or carbon arc, lamp. The administration of ultra-violet irradiation in this way has the advantage that the dose can be regulated with greater precision than by the direct rays of the sun.

The improvement in the condition of the bones can be watched from day to day by means of X-rays.

The accompanying table gives the relative intensity of infra-red and ultra-violet rays emitted by the sun and by different lamps.

	Infra-red	Sunlight	Ultra-violet
Quartz mercury vapour lamp .	52	20	28
Direct sunlight	80	13	7
Carbon arc lamp . . .	85	10	5
Incandescent lamp . . .	93	6	1

It will be seen that the intensity of the infra-red waves yielding heat increases from the mercury vapour lamp to the incandescent lamp, while, in the case of light and ultra-violet waves, the reverse is the case.

The Proportion of Light to Heat

Oil lamp yields 3 per cent. light, 9 per cent. heat.

Electrical incandescent yields 5 per cent. light, 95 per cent. heat.

Firefly yields 100 per cent. light, 0 per cent. heat.

A mercury lamp 2·5 amperes, 50 cm. away, gives twelve times the sun's strength in ultra-violet rays.

CHAPTER I

RACIAL CHANGES THE HUMAN JAWS AND TEETH HAVE UNDERGONE FROM THE ANCESTRAL ANTHROPOID PHASE TO THE ADVENT OF AGRICULTURE

SINCE the ancestral anthropoid phase of Man's progressive evolution a diminution in the size of the jaws and teeth has taken place, accompanied by a change from the *pro*gnathic type (in which the jaws protrude definitely beyond a vertical line drawn from the root of the nose) to the *ortho*gnatic type, in which they keep within that line. A definite degree of *pro*gnathism persists among certain races such as the Negro race and the Australian aborigines, and may occasionally be observed in " white " peoples and those closely affiliated to them.

These changes have taken place contemporaneously with the diminishing work which the teeth and jaws have been called upon to perform. The diminution in the work of the jaws has come about as the result of the following factors :

(1) As Man increased in intelligence, and in manual deftness in gathering vegetable food and conveying it to the mouth, the jaws and teeth were relieved of much of their former strenuous work.

(2) The introduction of cookery, by breaking up the cellulose framework of the coarser vegetable foods, had the two-fold effect of softening them and facilitating their digestibility.

(3) The development of agriculture gave rise, by a process of artificial selection of the foods cultivated, to a diminution in the cellulose constituents of vegetable foods, whereby they were not

only softened, but rendered more nutritious and more digestible. The practice of grinding cereals further relieved the work of the teeth and jaws.

(4) The advent of industrialism and the discovery of steel-roller milling machinery, by means of which the embryo and the outer coarser layers of the grain (= bran) can be removed, and the remaining portion ground into a refined white flour, has widened the scope of the pastrycook and housewife, enabling them to produce all sorts of delectable products of soft consistence, such as spongy bread, scones, sponge-cakes and pultaceous puddings and fancy pastry, all of which could quite easily be dealt with by toothless gums. The production of the more superfine and dainty of these products has been stimulated by the abundance of sugar now available.

Closing Up of the Inter-dental Spaces. Professor Wood Jones, an eminent anthropologist, draws attention to an interesting difference between Man and other primates. In the sub-human primates adjoining teeth do not come into close contact; gaps are left between them, notably in the region of the canines. In Man, however, the diminution in size of the jaws has proceeded more rapidly than in that of the teeth and has led to a closing up of these gaps, which, in the case of the permanent teeth, has brought the mid-regions of their crowns into actual contact. The upper permanent front teeth are occasionally separated by a slight space in well-developed jaws. All the front temporary teeth, upper and lower, are in normal jaws separated by distinct intervals, these intervals lengthening out with the growth of the jaws, especially as the time for the eruption of the first permanent teeth approaches. In this country it frequently happens that the temporary teeth are closely jammed together owing to the jaws being undersized from insufficient use. In such cases there is all the greater reason for the permanent teeth to be overcrowded, *both before and after eruption.*

It will readily be understood that the racial diminution in the size of the jaws and consequent closing up of the teeth allows quite a small diminution in the normal (racial) size of the jaws (such as results from pap-feeding) to give rise to overcrowding of the teeth.

Note that the shortening of the interdental spaces brought about by the racial diminution of our jaws implies *a relatively more rapid diminution of the jaws than of the teeth*, and it is noteworthy in this connection that the jaws and teeth possess a certain independence of development. This is shown by what has happened in the case of the edentulates, which have lost all their teeth while retaining ample jaws.

There is, in my judgment, no reason to suppose that the *racial* (hereditary) *diminution in the size of the human jaws*—though doubtless this has taken place more rapidly than the racial diminution in the size of the teeth—has proceeded *to a degree sufficient to cause overcrowding of the teeth*, as has been assumed by some dental pathologists. Evolution is guiltless of gross bungling; whether progressive or retrogressive, it is essentially a process of adaptation.[1]

[1] I do not accept the view that orthogenesis, *i.e.*, the progressive development through successive generations, of a particular feature (such as the horns of the extinct Irish elk) affords an instance of evolutional bungling. Natural selection does not permit any feature of a species to develop to a harmful degree. We seem justified in concluding that the extinction of such a species as the Irish elk was brought about by *environmental changes* which rendered immense horns disadvantageous.

CHAPTER II

CHANGES IN THE BRITISH JAWS AND TEETH SINCE THE ADVENT OF AGRICULTURE

WE have now to consider more particularly the changes which the British jaws and teeth have undergone since the advent of agriculture.

Mankind can be classified broadly into the round-headed and the long-headed ; the round-head tends to be associated with a broad face, palate, and nasal chambers ; the long-head with a long narrow face, long narrow nose, narrow palate and nasal passages ; but to this rule there are many exceptions.

It would appear that since the advent of agriculture there has been a *racial* (*i.e.*, an inherited) tendency among the people of this country for the face to get longer and narrower and for *both the teeth and jaws* to get smaller. These changes have been accompanied, notably since the advent of industrialism, by an increased tendency to dental irregularity and caries. We have it on the authority of Sir Arthur Keith that

" Misplacement (irregularity) of the teeth, long, narrow dental arches, high vaulted palates and carious teeth, which are so common among Englishmen of to-day, were almost unknown among the British people of the Neolithic and early Bronze periods ; that the conditions made a sporadic appearance " with the approach of the Roman period, but are rarely seen amongst the remains of the Saxon graves, not " assuming anything approaching their present frequency *until the eighteenth century is reached and England entered on her life of industrialism.*" [1] (My italics.)

[1] Miss Smyth found some degree of mal-occlusion in 90 per cent. of Saxon skulls (Bradford-on-Avon) about A.D. 600. Although crowding of the incisors was quite common, it was evidently slight compared with that observed in modern jaws.

Again, a comparison of fifty pre-Norman and fifty eighteenth to nineteenth-century skulls served to strengthen Sir Arthur Keith's " conviction that definite changes of a measurable amount are affecting our teeth, *jaws*, *noses*, *orbits*, *cheeks* and other points in the conformation of our faces." (My italics.)

In a similar strain the same authority writes, " a comparison of skeletal remains found in ancient and modern graves shows minor skeletal changes in at least one-third in modern instances—the narrow bony opening to the nose, with its gib-like nasal spine, its raised and sharp sill so often seen in modern English skulls, is not present in the English of the pre-Roman period ; contracted palate, crowded and defective teeth, deformed jaws, sunken cheek-bones, *do not become common in English graves until we reach the eighteenth century*." [1] (My italics.)

While a steady racial (inherited) change has been taking place in the British jaws since neolithic times, and ample room has been provided for the thirty-two permanent teeth (assuming, of course, that the jaws have been adequately exercised), it must not be supposed that the pronounced changes which have taken place in the facial skeleton of the British since the introduction of industrialism (changes which had begun to show themselves even before that date) are racial in the sense of being heritably stamped upon the race. The markedly contracted jaws characteristic of this period are decidedly too small for the teeth, and are essentially *individual acquisitions of post-natal date, the result of inadequate use of the jaws brought about by an excess of soft food*, notably of spongy, pultaceous, sugary foods, the products of highly milled wheaten flour. Such food not only fails to provide the jaws with the vigorous work for which there is an instinctive craving, but probably also begets a tendency to adenoids and catarrh (*e.g.*, rhinitis) ; these, by hampering normal nasal breathing, further tend to hinder the normal development of the

[1] See also Sir Arthur Keith's Lecture " Concerning certain Structural Changes which are taking place in our Jaws and Teeth," delivered under the auspices of, and published by, The Dental. Board of the United Kingdom. Sir Arthur stresses the influence of the Endocrine Glands in the causation of " contracted palates, irregularities in the eruption of teeth, and mal-growth of the jaws." The influence of inadequate exercise of the jaws which I regard as mainly responsible for these conditions, is not mentioned.

facial skeleton. A diet compelling adequate use of the jaws from infancy onwards favours the development of normally sized jaws, *i.e.*, jaws affording comfortable room for all the teeth. Jaws too small for the teeth are obviously undersized, and we may safely conclude that such jaws are not the outcome of an evolutional process, are not, that is, racial, but are individually

FIG. 2.—Ideal type. Well-developed facial skeleton. Regular, well-grown teeth.

FIG. 3.—Ill-developed facial skeleton. Palatal arch pointed, small under jaw, the teeth show no evidence of efficient attrition and grinding-down.

acquired as the result (apart from disease) of inadequate use; for evolution is an adaptive process, and may be reckoned upon not to suffer the jaws to become racially (heritably) too small to enable the teeth to take up their normal positions.

Thus regarded, *practically all British jaws, both at home and abroad, are undersized in consequence of inadequate exercise during early life*. An eminent dental surgeon of large experience, who has made a special study of mal-occlusion and dental irregularities,

informs me that he has met with but one solitary instance of perfect jaws among the British, and that one in the person of his own son, whose diet he was able to control from infancy onwards.

The defective development of the modern British "jaw" begins to display itself even during the period of the temporary teeth, but becomes increasingly and painfully evident with the eruption of the permanent teeth. This defect in the growth of the jaw bones consequent upon insufficient exercise is not limited to these bones, but involves the entire facial skeleton, causing, in its extreme forms, the hatchet-face so common among the British peoples, under which term I include both the home stock and those who have established themselves overseas and carried on the dietetic customs of the home country.

J. S. Badcock writes concerning the German prisoners in Richmond Military Hospital: "I was surprised to see the exceedingly good development of the men's mouths. I have been looking at mouths for thirty years, and there I saw *far more perfect dentures and better jaws than I had ever seen before*. I was told that these prisoners had petitioned that they might be supplied with less meat and more bread stuffs and vegetables in their dietary, and that the *greatest delicacy that they could receive from home was black bread*." (The italics are mine.)

The reference to black bread is of particular interest, for this, in contrast to our soft, spongy, ill-baked white bread, demands vigorous use of the jaws. The plea for *vegetables* doubtless included *salads*, which are popular with the German people, and tend to stimulate mastication.

Take note that, whereas the teeth do not require to be put to vigorous functional use in order to attain their full development (which is reached before they pierce the gums),[1] the jaws, on the

[1] In the case of the temporary teeth, the roots continue to develop after the crowns have cut the gums. In regard to the statement that the teeth do not require to be put to vigorous functional use in order to attain their full development, I cannot but think that vigorous use of the jaws exercises a favourable influence on the unerupted teeth.

other hand, need to be exercised rigorously from early infancy until the cutting of the wisdom teeth, in order to achieve that full development which shall enable the teeth, during their successive eruptions, to take up their proper places in the gums without any jamming or irregularity.

CHAPTER III

MALFORMED JAWS. MAL-OCCLUSION

If the jaws are malformed, mal-occlusion of the teeth necessarily results. The developmental process by which perfect occlusion (*i.e.*, the proper relation to one another of the upper and lower teeth) is brought about is highly complex, and is correspondingly apt to miscarry ; indeed, ideal occlusion of the permanent teeth is rarely met with in civilised Man ; among the British it is almost unknown.

Mal-occlusion and dental irregularities are encountered in pre-agricultural savages, and in all collections of ancient human skulls, neolithic, and even remotely palæolithic. They may occur even in wild animals. Hellman has found them *e.g.*, in the horse, monkey, orang and chimpanzee, and Sir Frank Colyer (working in the Museum of the Royal College of Surgeons of England) in hoofed animals, carnivora, monkeys and apes, admirable illustrations of which he has published. As might be expected, these abnormalities are more common in domesticated than in wild animals.

In Man they increase with the advent of agriculture, as shown by the examination of ancient Egyptian skulls, and have become disastrously prevalent among certain neo-civilised peoples since the introduction of industrialism (see *e.g.*, Figs. 3, 4, 5, 6, 7, 8).

I have said that ideal occlusion is almost unknown among the British. Obtrusively malformed facial skeletons are very common in this country, so common, indeed, as to be regarded, it would seem, as normal ; and they are faithfully displayed in the portraits and busts of such eminent craftsmen as Sargent and Rodin.

Sir Arthur Keith found gross deformity of the jaws and gross irregularity of the teeth in 25 per cent. of adult British.

Mal-occlusion is now known to be common in children. Normally the temporary teeth should be separated by distinct intervals. If they are jammed closely together, as is all too frequently the case in this country, it is manifest that the jaws are too small for the teeth, and that, at a later stage, there will not be room for the permanent teeth to erupt normally.

FIG. 4.—Protrusion of the palatal arch, retrusion of under jaw, mal-occlusion, no grinding-down from attrition.

D. M. Shaw (1928) found among 334 L.C.C. children excessive overlapping of the upper front teeth (maxillary protrusion). In 9 per cent. this was so pronounced that the lower incisors actually came into contact with the palate; in these cases there was considerable retrusion of the lower jaw.

Evils of Mal-occlusion. Contracted jaws necessitate undue jamming, or irregularity, of the teeth, and consequent mal-occlusion. Many evils result from dental irregularity:

(1) It is difficult, if not impossible, for irregular teeth to be cleansed properly, either by natural or artificial means, especially when an overlapping of adjacent teeth occurs. Dental irregularity is thus a potent cause of oral mal-hygiene and consequent dental caries.

(2) Mal-occlusion prevents normal mastication. Two evils result from this—

(*a*) The normal grinding-down of the cusped teeth does not take place, thus rendering them so much the more apt to retain food in the pits and crevices on their occlusal surfaces and to become carious. A similar inadequate wearing-down of the biting edges of the front teeth prevents that æsthetically desirable moderate shortening of these teeth and evenness of the biting edges.

(*b*) The roots of the teeth are prevented from being vigorously rocked in their sockets, and the socket-membranes and the neighbouring gum margins are bereft of that periodic acceleration of the circulation of blood and lymph within them needful for their normal nutrition.

(*c*) The teeth are apt to become dirty in the cervical regions.

Relative Influence of Ante-natal and Post-natal Conditions in Causing Malformed Jaws. Heredity, of course, plays its part in determining the form of the jaws, and the facial skeleton generally, as in the case of the Hapsburg jaw, but of itself it is only in a minor degree responsible for serious mal-occlusion; as a factor in the causation of the widespread mal-occlusion in this country it may almost be discarded. The normal growth of the jaws after birth is largely dependent upon the pressure strains to which they are subjected during mastication. These not only stimulate their general growth, but profoundly influence their shape during the plastic stage of development, by promoting the growth of bony tissue in certain regions, and causing its removal from others. Under perfect conditions, including breast-feeding, adequate exercise of the jaws from an early age, and abundant outdoor life, jaws affording room for the teeth, with good occlusion, may in a great majority of cases be reckoned upon. Minor deviations from the ideal (rarely achieved, even among savages), will doubtless occur, but not to a degree likely to inter-

fere seriously with good mastication and the normal wearing-down of the grinders and the biting edges of the incisors.

Malformed "freak" jaws, due to the abnormal activity of certain ductless glands, such as those characteristic of cretinism and acromegaly, will always occur from time to time, even under ideal nurtural conditions. I find no grounds for concluding that perverted endocrine secretion is in any appreciable degree responsible for the prevailing undersized jaws of the British.

FIG. 5.—Ill-developed facial skeleton, V-shaped face, mal-occlusion. Irregular teeth.

Mal-occlusion and dental irregularity may be of ante-natal and post-natal origin.

Ante-natal. Mal-occlusions thus occurring may be strictly hereditary, as in the case of the underhung Hapsburg jaw; or induced by some harmful factor, positive or negative, operating upon the unborn child: such we need not consider.

Post-natal. The chief causes of such mal-occlusions are:

(*a*) First and foremost, insufficient exercise of the jaws and teeth (owing to too soft food), resulting in jaws too small for the teeth.

(*b*) Obstruction of the nasal passages brought about by such causes as adenoids combined with chronic *rhinitis*,[1] or by this alone. A considerable number of children of the poor suffer from chronic mucopurulent rhinitis sufficient to cause mouth-breathing, which itself impedes the normal growth of the jaws.

(*c*) General mal-nutrition from semi-starvation, the bony

[1] Inflammation of the lining membrane of the nasal passages.

skeleton of the face (including the jaws) failing to develop to normal dimensions ; in such cases the jaws being sub-normal in size, but the teeth tending to be of the normal size, these will necessarily be overcrowded.

(*d*) Bad habits, such as thumb-sucking and the use of the rubber teat.

All these post-natal causes are essentially acquired, although it may not be possible entirely to eliminate an hereditary factor. Thus some subjects may be hereditarily more inclined to develop adenoids than others.

Causes of mal-occlusion after birth include disturbances of the internal secretions, resulting in such disorders as myxœdema. infantilism, and other types of dwarfism.

CHAPTER IV

MALFORMED JAWS (*continued*)

POST-NATAL REQUIREMENTS FOR NORMAL DEVELOPMENT OF THE JAWS. The post-natal conditions necessary for the normal facial development of the growing human are : (1) a sufficiency of the essential foods ; (2) vigorous exercise of the jaws from early infancy ; (3) free nasal breathing ; (4) normal retention of the temporary teeth ; (5) abstention from the use of the " comforter," thumb sucking and similar injurious habits.

(1) *A Sufficiency of Food containing the Necessary Ingredients.* Failure in this respect leads to stunted growth generally, including that of the jaws. A certain proportion of the people of this country are stunted in growth, through lack of sufficient nourishing food during the growing years. In such the whole skeleton, including the jaws, is stunted. Now, seeing that the teeth under these conditions tend to grow to the normal size, such stunted jaws, even if well exercised, are too small to allow the teeth to erupt without overcrowding and consequent mal-occlusion.

(2) *Vigorous Exercise of the Jaws from Early Infancy Onwards.* The gnawing instinct needs to be given full play by the provision of hard objects for " gum-gnawing," and later, when the first temporary teeth come through, hard foods, such as bickiepegs, which excite the jaws to vigorous action. Quite early the infant is capable of gnawing raw vegetable foodstuffs, such as an apple or celery stalk. It must never be forgotten that, unless *the temporary teeth in the growing jaws are from an early age adequately exercised, neither they, nor the buried permanent teeth, will erupt normally during the successive phases of dentition.* One would

expect this early vigorous exercise of the jaws to favour the development of the buried teeth within them, but this result has not actually been proved to occur.

(3) *Free Nasal Breathing.* Complete nasal blockage for a lengthy period during early life leads to serious deformity of the jaws (in which the whole facial skeleton shares) largely by

FIG. 6.—V-shaped face; narrow jaws, retrusion of the lower jaw; the upper teeth show undue length, in consequence of their being unopposed. This has caused the roots to emerge somewhat from their sockets, and has prevented the normal shortening due to attrition.

FIG. 7.—Shows ill-formed jaws, protrusion of the upper, retrusion of the lower, jaw. Mal-occlusion.

obstructing the entrance of air into the nasal passages, and (among other evil effects) the consequent elimination of the stimulus induced by the to-and-fro respiratory currents of air.

(4) *The Retention of the Temporary Teeth until Normal Shedding Occurs.* Premature loss of these teeth interferes with the normal eruption of the permanent teeth. The retention of the permanent

teeth should also be encouraged, inasmuch as the loss even of a single one tends to disorder the arrangement of the others.

(5) *Abstention from Thumb Sucking, etc.* Some of these habits are referred to below.

These five essentials for the normal development of the jaws will now be dealt with in somewhat greater detail, commencing with the last two.

Defective Jaw Development from Premature Loss of the Temporary Teeth. There should be no difficulty in preventing premature loss of the temporary teeth from caries. If the cereal food is mainly confined to such forms of it as compel adequate mastication, if sweets are withheld, and if cleansing, raw vegetable food is daily consumed, and other nutrient essentials provided—the entire facial skeleton, including the jaws, will develop normally, the teeth will be amply spaced and free from decay, and the shedding of the temporary teeth and eruption of the early permanent teeth will take place normally. It may be added that, under the conditions mentioned, the child will not be likely to develop adenoid growths.

We need to remember that the first permanent (six-year-old) molars begin to erupt when only a few of the temporary teeth have been shed; it is all-important that these permanent teeth be kept free from decay, and that, should they decay, a dentist be consulted. The danger is that the mother may mistake them for temporary teeth, and regard their decay as of little account.

Defective Jaws produced by the Comforter, Thumb Sucking, etc.[1]

The Comforter. The constant pressure of the teat, aided by the tongue, causes the front upper teeth and the front part of the palate to grow forwards. The teat is sometimes smeared with sugar or jam to soothe the child, a practice which favours decay of the upper front teeth. Moreover, the teat is very apt to get dirty.

[1] My observations under this head are taken from the admirable booklet on "The Care of the Teeth," by A. T. Pitts, D.S.O., M.R.C.S., L.R.C.P., L.D.S.

Thumb Sucking The pad of the thumb is "pressed with considerable force" against the back of the upper front teeth, while the lower front teeth are forced backwards, the combined effect being to produce considerable protrusion of the palate and upper front teeth. This habit may continue long after childhood.

Finger Sucking. "If the fingers are placed with the fleshy surface upwards, a protrusion of incisors results." If they are hooked over the lower incisors, these are pulled forward. In either case a gap between the upper and lower incisors results.

Tongue Sucking. "The tongue may be pressed against the upper incisors, or more commonly is protruded between the upper and lower incisors, and rests just between the lips which suck the tip." Result: "The upper incisors are pushed forward, and in addition a space between the upper and lower incisors is produced." This practice is very apt to pass unnoticed.

The child needs constantly to be checked when indulging in these habits. They are probably predisposed to by nurturing children on too soft food, thus cheating the masticatory instinct of its full functional activity; doubtless the instinct derives some compensatory satisfaction by the indulgence of these morbid habits.

In obstinate cases Mr. Pitts finds the use of a small aluminium plate effective in the treatment of these cases.

FIG. 8.—Contracted jaws; bad occlusion, defective attrition and wearing down.

Defective Jaws from Inadequate Diet. The diet needful for the normal growth of the jaws includes, of course, the normal complement of vitamins. Among these, special stress has been laid on the necessity for providing an ample supply of vitamin D. There is no evidence, so far as I know, that the poor development of the British masticatory apparatus is due to a deficiency in vitamin D, as has been suggested. The jaw bones appear to escape from appreciable involvement in rickets. On the other hand, no matter

how plentiful the supply of D, these bones, like the rest of the skeleton, will fail to develop normally—they will not achieve their normal size, capable of affording ample room for all the thirty-two permanent teeth, unless they are adequately exercised : it can very seldom happen that the lack of D is such as to interfere with the development of the jaws.

M. Mellanby has shown that, when the supply of vitamin D to puppies is greatly reduced, the jaws fail to reach their normal dimensions ; both they and the teeth are insufficiently calcified, and the teeth of the lower jaw are overcrowded and irregular. There is, however, no evidence that the children of this country ever suffer from a dearth of D adequate to produce such disastrous effects. Their jaws, as we have seen, are not affected in rickets (see p. 139), a disease which is known to be caused by deficiency of vitamin D ; and it may be regarded as certain that rickets is not in any appreciable degree responsible for the great prevalence of dental decay in this country. Brash draws attention to the escape of the jaw-bones in rickets from the morbid changes observable in other parts of the skeleton in this disease. By way, it would seem, of emphasising the influence of vitamin D on the development of the jaws, as distinct from the influence of vigorous mastication, M. Mellanby adduces the fact that puppies fed on diets rich in vitamin D develop good jaws with regular teeth, *even though the food is soft and the animals are prevented from taking exercise in the open*. This might be taken to imply that vitamin D, rather than exercise of the jaws, is the outstanding factor in bringing about their normal development. The significant fact is, however, cited that these puppies, owing to their highly stimulating food, were very active and spent much of their time in gnawing the wood of their kennels, and had *in fact well-worn teeth*—clearly showing that they put their jaws and teeth to vigorous use.

CHAPTER V

MALFORMED JAWS FROM INADEQUATE EXERCISE

MUCH the most potent factor in causing the undersized, misshapen jaws of the British people is insufficient exercise owing to the softness of the diet. In order to secure normal development of the jaws, a sufficiency of food, such as well-baked, crusty wheaten bread, compelling their adequate use, must early be introduced into the dietary.

Anyone who will adopt the plan of nurturing children from a tender age on a sufficiency of food compelling abundant mastication will be surprised how readily they take to it, and at the effect of such food in stimulating the growth of the jaws. One would expect, as I have suggested, the unerupted permanent teeth in some measure to share in this stimulus to healthy growth, although this has not been proved.

We must never lose sight of the connection between undersized jaws and the deficient exercise of them.

Feeble jaws are often encountered among the British while the rest of the skeleton is well developed, the incongruity being manifestly due to inadequate exercise of the jaw-muscles. Bones not adequately exercised do not reach their full development. Certain of the Esquimaux, a race of small stature, are said to have the largest jaws and best teeth of any known race, a manifest result of the vigorous use to which they are put. When, however, they adopt from an early age " the white man's [soft] diet and mode of living," no matter how ample the supply of D, the jaws show " marked deterioration both in size and strength," and the

teeth become irregular. " This occurs in a *startling degree even in one generation.*"

Professor J. C. Brash does not accept " the commonly expressed opinion that the jaws are insufficiently exercised in consequence of the nature of modern diet," maintaining that no more than a moderate degree of exercise is needful for the normal development of the bones. " It requires an altogether exceptional degree of lack of use amounting almost to cessation of use altogether to affect in any degree the growth of the tissues concerned."

" Over and over again it has been pointed out that the common idea that uncivilised peoples use their jaws a great deal more than the highly civilised in masticating food supposed always to be hard and tough, is erroneous " (Four Lectures, etc. Dent. Board U. Kingdom, 1929, p. 195).

" How do we account for the excellent jaw development that may occur in races and in individuals in whom masticatory activity is at a minimum? . . . African tribes have been quoted whose staple food was a jelly-like porridge, which required little mastication ; and yet . . . the facial configuration of these people did not show any lack of muscular development " (pp. 201–2).

There is, however, no evidence that " mastication is at a minimum " among African tribes whose staple food is " mealies." This consists of *coarsely-ground maize*, and those who have watched natives eating this food testify that it calls for deliberate mastication. Conclusive proof that they use their teeth vigorously is further shown by the *extent to which they are worn down*.

That the jaws demand more than a moderate degree of functional activity in order to attain full development is suggested by many considerations : it is *a priori* evident that they are constructed with a view to vigorous exercise. Witness the massiveness of their muscles (Fig. 9), the fact that the teeth are constructed to withstand pressures up to 300 lb., and the exceptional density of the lower jaw-bone which, after the body has been reduced to ashes by fire, alone of all the bones, may retain its shape.

The physiological need of the jaws for vigorous exercise is

further shown by the clamant instinct which the infant displays to gnaw hard objects with its toothless gums, *i.e.*, even before the first teeth have erupted, and by the fact that, if this instinct for functional activity of the jaws is allowed full play by the provision

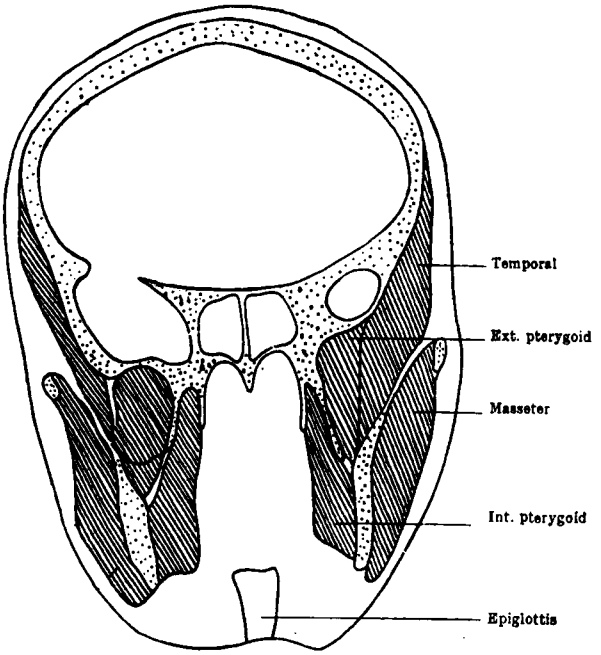


FIG. 9.—A vertical bilateral section through the head, showing the massiveness of the masticatory muscles.

of suitable food until the completion of dental (temporary and permanent) eruption, it will continue to function vigorously so long as any serviceable teeth remain in the jaws.

Finally, there is the unanswerable evidence that, if the jaws from infancy onwards are compelled to work vigorously by having to cope with the right kind of food, they develop suffi-

ciently to accommodate, without jamming, first the twenty temporary teeth, and later the thirty-two permanent teeth.

In short, the undersized British jaws are mainly a consequence of their being cheated of their physiological meed of exercise, by the lack of an adequate proportion of coarse vegetable food, whether in the cooked or raw state. Animal food does not call for much mastication. The carnivora do not masticate their food in the sense of grinding it like the herbivora.

Should We Aim at Securing Jaws of Normal Size? By a normal size is here meant one permitting the full complement of thirty-two permanent teeth to take up their proper positions without jamming.

It might be argued that the achievement of such complete maxillary development not only involves much tiresome chewing, but, in the case of the woman, at least, might detract from the comeliness of the face: I see no point in either of these objections: adequate mastication facilitates digestion and acts beneficially on the teeth and their sockets, while well-developed jaws are surely preferable to hatchet faces and run-away chins. (See Figs. 3, 4, 5, 6, 7.)

It might further be urged that modern diet does not require the same amount of chewing as was required for the coarser vegetable diet of our pre-agricultural ancestors; and that, owing to the increasing refinement of our food, our teeth and jaws are passing through a transition stage destined ultimately to culminate in complete edentulism. (Among the animals classed as *Edentulates* the only entirely toothless ones are the ant-eaters). How long such a process of transition would take, I cannot say—probably some tens of thousands of years—meanwhile the process of adaptation would be likely to involve many undesirable complications.

I conclude that, for practical purposes, we shall do well to aim at developing human jaws which shall afford ample room for all the permanent teeth.

A compromise might indeed be made by aiming, not at com-

plete development of the jaws, but such development as would afford ample space for twenty-eight instead of thirty-two permanent teeth, the reduction being effected by the early extraction of the four first bicuspids, thus allowing the hindmost molars, or wisdom teeth, ample room to move forwards. This practice certainly tends to prevent overcrowding and irregularity—but is it an ideal to be aimed at? The human organism has through the ages evolved elaborate plans for the eruption of thirty-two permanent teeth, giving perfect occlusion ; are we justified in withholding that degree of functional activity of the jaws and teeth needful for the realisation of Nature's intentions ? I do not think so.

FIG. 10.—Defective development of the lower part of the facial skeleton, causing V-shape of the face and emphasising the size of the forehead.

Æsthetic Effect of Small Jaws due to Insufficient Exercise. The defective growth of the jaws influences the form of the entire skull. When the jaws are feebly developed the face viewed from the front tapers from above downwards, emphasising the dimensions of the forehead, and giving rise to a V-shaped (hatchet-shaped) appearance, while the profile view displays a receding chin (see Figs. 3, 5, 6, 7, 10). This type of face, all too common in our country, generally betokens inadequate exercise of the jaws as the result of too soft farinaceous food ; but it also results from persistent blockage of the nasal passages, giving rise to the " mouth-breather's " or " adenoid " facies : in this there is a marked falling-in of the cheeks (owing to contraction of the large " antral " air-spaces), and a narrowing of the palate with resulting

irregularity of the teeth. There are good grounds for attributing adenoid disease itself to an excess of soft farinaceous food (see pp. 151–4).

" Unfortunately beauty is not simply skin deep, since ugliness goes into the bones. . . . In the daily walks of life it may happen that a possible vision of beauty may be conjured up when looking at the graceful lines which may chance to be seen from behind. When, however, the face is seen from the front or the side, severe disappointment may supervene in observing the weak and ill-developed jaws, long, irregular, and projecting teeth, the jib-sail-like nose, the cut-away chin, or some other of the various dento-facial disfigurements which are so prevalent at the present day."

Note.—Regarding the practice of extracting teeth when overcrowded in undersized jaws, some recommend the removal of the four first molars. On this question Wallace writes : " For ease and rapidity for getting the front six teeth in proper alignment, the first four bicuspids are most generally extracted. The extraction of the first permanent molars is, however, justifiable if one or other of them is so badly decayed that a proper restoration of the crown cannot be made." For further remarks on this head consult his work, " Variations in the Form of the Jaws," pp. 133–8.

CHAPTER VI

FREE NASAL BREATHING

Malformed Jaws Caused by Obstruction to Nasal Breathing

Normal development of the jaws, and facial skeleton generally, requires not only that they shall be vigorously exercised from early infancy to the eruption of the wisdom teeth, and that the diet shall be nutritionally adequate: it requires also that the nasal passages shall admit of unimpeded nasal breathing with closed mouth.

Sustained nasal blockage during the early years seriously impedes the growth of the jaws, indeed of the entire facial skeleton. It produces these effects in three separate ways: (*a*) by blocking the openings of the nasal sinuses; (*b*) by eliminating the stimulus provided by the nasal air-currents; and (*c*) by compelling mouth-breathing.

(*a*) The extensive air-sinuses opening into the nasal passages play a prominent part in causing the deformities of the facial skeleton which result from nasal blockage. There are several groups of air-sinuses—the frontal group above the orbits, the two maxillary (antral) sinuses, one below either orbit, the ethmoidal sinus between the orbits, and the sphenoidal sinus behind and somewhat below the ethmoidal. There is free communication between all these sinuses, and between them and the nasal passages. They are all lined with a delicate ciliated mucous membrane, continuous with the nasal mucous membrane, and they all open into the nasal passages. All the nasal air-sinuses thus communicate with the external air.

The sinuses are comparatively small in early childhood, but undergo gradual expansion in the course of development, free communication with the external atmosphere being a condition of their full expansion. The sinuses serve the double function of resonators and of conferring lightness on the bones.

FIG. 11.—Distorted jaws, narrow palatal arch, the teeth show defective attrition. Suggests past nasal obstruction of long standing.

It is only by virtue of their communications with the external atmosphere through the nasal passages that the sinuses are able to retain their full complement of air. Complete blockage of the nasal passages shuts off these communications, and, as the result, the sinus-air is absorbed by the blood, and a negative pressure is established in the sinuses. Under these conditions the sinuses are prevented from undergoing their normal developmental expansion, and a widespread distortion of the neighbouring structures results.

Hence, when nasal blockage is long-continued during early life, there result the pinched nose and small nostrils, the sunken cheeks, the narrow, contracted hard-palate, the narrow upper dental arch, characteristic of the adenoid facies. This phenomenon is less frequently seen to-day than it was thirty years ago, because in the majority of cases of adenoids causing nasal obstruction the growth nowadays is promptly removed.

(*b*) Normally, there pass through the nasal air-passages, each twenty-four hours, some forty thousand air-currents, at times

(as during the extreme breathlessness induced by exertion) with considerable impetus. These rhythmic air-currents no doubt stimulate the nasal mucous membrane and underlying bone, and the lack of this stimulus cannot fail, one would think, to impede the normal growth of the nasal and correlated structures.

(*c*) *Mouth-breathing*. During normal nasal breathing the mouth is kept closed and the tongue is kept in contact with a considerable portion of the palate, and presses against the inner (lingual) sides of the teeth, tending to push the dental arches out laterally ; at the same time the pressure of the closed lips against the front teeth prevents them from being forced forward by the tongue, the total effect being to widen the arches. (Sim Wallace.)

When the nasal passages are blocked, *e.g.*, from adenoids, the mouth is necessarily kept open, the tongue falls away from the palate, and no longer exerts pressure on the lingual aspect of the upper teeth ; on the contrary, external lateral pressure is applied by the tightened cheeks.

Mouth-breathing further tends to interfere with the normal development of the jaws by hampering sustained mastication, as anyone may prove for himself.

Nor must we forget that the habit of mouth-breathing may be contracted even in the absence of nasal obstruction. Provided the nasal air-sinuses are not blocked, and the habit has not been contracted until nearly all the permanent teeth have erupted, mouth-breathing alone may not obtrusively affect the growth of the jaws, especially if mastication is vigorously practised.

Be this as it may, it is of the utmost importance to secure free nasal passages and for everyone to practise nasal breathing habitually throughout life ; for, apart from the beneficial influence of nasal breathing on the development of the jaws, this type of breathing warms, moistens, and filters the inspired air, fitting it for its passage through the larynx, windpipe, and bronchial tubes. Mouth-breathing leads to dryness of these parts, and predisposes them to inflammation. It also causes dryness of

the mouth and an unhealthy condition of the oral mucous membrane.

A dry mouth felt on waking up in the morning—often accompanied by " a nasty taste in the mouth "—is a sure sign that the subject has been sleeping with open mouth. It is to be noted that the retention of the horizontal posture for several hours during sleep tends to produce congestion of the nasal mucous membrane, and thus to favour mouth-breathing.

FIG. 12.—Shows narrow palate and dental arch and little worn teeth. The plump face conceals somewhat the defective bony development, suggestive of past adenoids.

Adenoid growths form in the space immediately behind the nasal passages—the so-called " posterior nasal space." Some writers have been inclined to belittle the influence of these growths, in causing malformation of the jaws, arguing that they may occur without any jaw deformity, and that deformity similar to that often met with in adenoid disease may occur in the absence of the latter.

There is no difficulty in reconciling these apparent anomalies. The so-called " adenoid jaw," in its typical form, does not result unless there be complete, or almost complete, blockage of the nose, including *the openings of the nasal air-sinuses*, into the nasal passages. If a blockage of this kind, involving not only the nasal passages but the air-sinuses, lasts for a considerable time in

early life, when the bones are highly plastic, the development of the upper jaw is of necessity seriously perverted, as also that of the lower jaw, on account of the mal-occlusion resulting from the distortion of the upper dental arch.

If the post-nasal space and nasal passages are ample, a considerable bunch of adenoids may develop with little or no impediment to nasal breathing. On the other hand, given a narrow post-nasal space and narrow nasal passages, a comparatively small mass of adenoids may effectually block the passages, especially if, as frequently happens, there be associated inflammation of the nasal mucous membrane (rhinitis). Indeed, this alone may suffice to obstruct nasal breathing. Neglected slum-bred children may for months together suffer from a muco-purulent nasal discharge with more or less complete nasal blockage. In such, malformation of the jaws may result.

Experimental Evidence. It has been shown in experimental animals that complete blockage of one side of the nose not only hinders development of that side of the upper jaw, but produces asymmetry of the entire skull.

The dependence of the growth of the jaws and other parts upon the normal functioning of the masticatory muscles is shown by the fact that division of one temporal muscle in early life causes asymmetrical development of the facial bones and deviation to one side.

Extraction or grinding-down of the teeth on one side in the rabbit leads to unequal development of the two halves of the skull.

The Causation of Adenoids

This affection is characterised by an overgrowth of lymphoid tissue in the naso-pharynx and tonsils. For convenience we may speak of it as " adenoid disease " or " adenoids."

It is strange that it should be so common with us. Among wild animals it is unknown, and one does not hear of its occurrence in " savages."

I have long held and taught that it is essentially a dietetic

disease, largely due to excess of soft farinaceous food, which induces :—

(1) An overloading of the stomach with imperfectly insalivated cereal and similar highly starchy foods, such as tapioca, semolina and sago, which ferment in the bowel and give rise to a vitiated blood, watery tissues, and a tendency to an increase of lymphoid tissue throughout the body and a diminished resistance to the microbes which give rise to catarrhal affections of the mucous membrane.

FIG. 13.—Ill-developed jaws, mal-occlusion, long teeth, showing no evidence of wearing-down from attrition.

(2) Defective development of the jaws, naso-pharynx, and nasal apparatus, owing to the lack of the powerful stimulus afforded by vigorous mastication to the flow of blood and lymph through these structures. The naso-pharynx and the nasal passages failing to develop to their normal proportions, adenoid growths, should they occur, are so much the more liable to cause blockage of these passages.

The disease appears to be especially common in the white children throughout the British Empire, all of whom adopt the dietetic customs of the Mother country.

At whatever part of the world the British establish themselves, be it in India, Australia, New Zealand, Canada, or in South Africa, they take with them their dietetic customs. It is, indeed, remarkable that while rickets is practically unknown in sunny Australia and New Zealand, adenoid disease and, I may add, dental caries abound. The like is true of South Africa : one of

the most extreme instances of the disease I have encountered was in a child brought up on the Veldt. Yet among the primitive aborigines of these countries living on their natural diet, the disease is unknown.

A striking circumstance relating to the causation of adenoid disease is the appalling increase it has undergone within comparatively recent times. The evidence of this is not far to seek. We have seen that adenoid disease, causing a blocking of the nasal passages, gives rise to a characteristic malformation of the jaws ; now the revelation of our churchyards shows that such jaws were practically unknown 180 years ago in this country. It follows that adenoid disease could not have been prevalent in this country before that time.

What has happened to cause the widespread prevalence of this pest throughout the British Empire ? It cannot be the increase of urban life, for adenoid disease is as common in country-bred as in town-bred children ; it cannot be a slum-bred affection, for it is as common among the well-to-do as among the children of the poor.

I conclude that adenoid disease is essentially a disease affecting children fed on an excess of soft farinaceous food, this mode of feeding being fostered by the abundance of refined wheaten flours and the abandonment of rye- and barley-bread and the coarser forms of wheaten bread ; and an increase of the softer varieties of bread and pastry and pappy milk puddings. To this factor may be added the non-indulgence in raw vegetable food. The masticatory instinct of pap-fed children is not allowed to develop normally, with the evil consequences we have seen. A child may, apart from his soft, super-saccharide diet, be brought up under ideal health conditions : far from the darkness, dirt, and tainted atmospheres of large towns, live out of doors all day, sleep in a well-ventilated room at night, be fed on the most nourishing food, clothed after the most approved fashion, and yet in spite of all these advantages, we may find his throat packed with adenoid growths.

It would appear that the advent of steel-roller milling is largely responsible for the great increase of adenoids within recent years. Its exuberance in this country may be said to be the product of industrialism.

The prevention of adenoid disease consists in the adoption of a regimen somewhat as follows: the restriction of farinaceous foods, including not only cereals, but tapioca, sago, and the like, to well-baked crusty bread, containing (preferably) at least a modicum of wholemeal flour; the total abandonment of sweets and the reduction of sugar generally, *e.g.*, in such forms as jams and treacle; the increase of animal food in the form of meat, fish, butter, dripping, cheese, and the ample daily consumption of raw vegetable food, such as fruit or salad.

If a diet of this kind were fairly tried out in residential schools, surprising results would be obtained. This scheme should include the annual taking of a mould of the teeth and jaws of the youthful inmates.

Appendicitis is in like manner essentially a dietetic disease. It is rarely met with among the patients in mental hospitals. In such a hospital containing one thousand patients there has been no case of this disease among them during the last two years, whereas several cases have occurred among members of the staff. It would seem that people who lead a routine life on a simple diet rarely get appendicitis. I may incidentally point out that the cancer mortality among mental hospital patients is said to be no more than a quarter of that of the community in general.

CHAPTER VII

THE NEED OF CULTIVATING THE MASTICATORY INSTINCT IN CHILDREN [1]

MASTICATION, as distinguished from mere biting with the front teeth, signifies the pounding or grinding of the food by the more posterior teeth, the one by vertical pressure, the other by a horizontal grinding movement of the lower grinding teeth against the upper.

In order to secure the full advantages accruing from the proper use of the jaws and their appendages, it is above all necessary that, during the whole periods of post-natal development, from birth onwards they shall be exercised adequately. In this way (provided free nasal breathing is maintained) the jaws will develop normally, and the masticatory instinct will be established as a permanent function.

During the first months of life the natural function of feeding at the breast provides the infant's jaws, tongue and lips with the exercise they crave for, and compels the infant to do a certain amount of work for his meals. This the bottle fails to do, and in consequence we frequently find bottle-fed children (more than breast-fed children) seeking to satisfy their natural instinct to exercise these structures by sucking their thumbs or other handy objects. The infant's tongue, lips and jaws find their natural exercise at the breast. If bottle-feeding is adopted, care must be taken that the teat of the feeding bottle is such as shall compel the child to do more work for his meals than is implied by gentle

[1] For "The Functions of Mastication" (see p. 220).

suction.[1] The mechanism of bottle-feeding is quite different from that of breast-feeding. The child at the breast does not get his milk by suction: the stimulation of the nipple by the vigorous action of the infant's lips causes the milk to be poured out reflexly. In "milking" the cow the stimulus to the flow is afforded by the hands of the milker; here there is no question of suction. In bottle-feeding the milk is obtained solely by suction. In the case of the pouched mammals (marsupials) it is actively squirted into the mouth of the helpless, prematurely-born offspring.

FIG. 14.—Defective development of jaws from insufficient exercise. Bad occlusion, long teeth, no appreciable wearing-down by attrition.

Directly the instinct to gnaw displays itself, it should be gratified. It may appear as early as the third or fourth month, becoming increasingly clamant as the time for the eruption of the teeth approaches. Though ivory rings, coral baubles and the like are useful in their way, it is better to give the child something which at one and the same time exercises the jaws, excites the gustatory organs, and provides a minimum of nutriment. For this purpose there is nothing better than the "bickiepeg," a small stick of specially prepared well-baked cereal, which the infant can bite at: it may be given as early as the fourth month, and continued until the period of weaning, or even longer.

Unless it is desired to bring the child up on vegetarian lines, a chop bone or "drumstick" from which most of the meat has

[1] Thumb-sucking, as we have seen, should be guarded against, as it tends to cause protrusion of the plastic palate (see p. 139). Equally pernicious is the artificial teat *employed for the purpose of keeping the child quiet*.

been removed, may be given ; from such, a small amount of nutriment may be extracted of a kind acceptable to an infant's palate and stomach ; but such articles are messy and not always available. A piece of leather may be employed for gnawing, but does not awaken the same interest in the child as the " bickiepeg."

The persistent gnawing which ushers in, or should usher in, the appearance of the incisors not only facilitates their eruption, but helps to bring these teeth, and with them the entire dental arches, into correct relation to one another. Unless this important end is achieved thus early, normal occlusion of the permanent teeth is in danger of being jeopardised.

Firm solid food should not be given until the teeth are ready for it, and, as Wallace observes, the order of their appearance serves as a guide in the choice of the kind of food to be given. The lower incisors come through first (fifth to eighth month) ; then follow the upper incisors (seventh to tenth month) ; the lower lateral incisors appear soon after (tenth to twelfth month). The incisor teeth enable the child to *bite* but not to *chew*, for which function the molars and, when the permanent teeth erupt, the pre-molars (bicuspids) are necessary.

As soon as the teeth are cut the instinct to chew has, among primitive peoples, abundant scope in the shape of coarse vegetable foods in the raw state ; but with us moderns, subsisting as we do so largely on vegetable food softened by long cultivation and careful preparation, this instinct is apt to be cheated of its full expression and tends to die out. Nevertheless, it dies a hard death and long continues to assert itself ; witness the tendency of children to bite their pencils and penholders, to chew small pieces of india-rubber, or what not, for hours together. I have known a child to gnaw through a bone penholder. May not the grinding of the teeth during sleep be a manifestation of a thwarted natural instinct ?

The instinct to chew for chewing's sake manifests itself all the world over, and is not confined to children. The schoolboy's

practice of chewing india-rubber finds a parallel in gum-chewing so popular among modern Americans. Gum-chewing has long been practised by the Redskins ; the primitive Australians down to this day chew gums of various kinds. The custom also of chewing such substances as betel, so common in the islands of the Pacific and the Malay Archipelago, is a further expression of the masticatory instinct. No doubt the attraction of betel, as of tobacco-chewing, depends in great measure upon its stimulating properties, but it must not be forgotten that the mere mechanical act of chewing accelerates the circulation, a fact which helps to explain the universal tendency of mankind to chew hard substances even if devoid of nutrient value.

FIG. 15.—Narrow jaws, pointed palatal arch, retrusion of the lower jaw. Teeth show no evidence of wearing-down by attrition ; mal-occlusion.

Cultivation of the Instinct to Masticate. Seeing how many advantages follow from proper mastication, *i.e.*, a vigorous use of the jaws and teeth, it is obvious that the masticatory instinct should be cultivated from an early age : the teeth should be exercised directly they appear, by giving the infant hard objects to bite. By the end of the second year, or shortly after, when all the temporary teeth should be cut, the normal child, so far as its teeth are concerned, *is capable of coping with any ordinary adult food*. Pappy food thenceforth should be greatly reduced, if not wholly abandoned, *cereal food being mainly confined to well-baked crusty bread* with butter (and perhaps a little grated cheese). " Dripping " has much the same nutritive value as butter. Raw fruits, such as apples, and raw salad food, such as celery, possess the double virtue of exercising the jaws and cleaning the teeth ; they are greatly appreciated by small children. Only

by providing children with acceptable food, which they must perforce masticate thoroughly, is it possible to cultivate their masticatory instinct. It is useless to tell small children not to bolt their food when it is of a consistence which does not compel vigorous mastication.

There is only one way to develop the masticatory instinct in a child—by giving him food which enforces mastication. It is mere waste of words to tell him to chew his food properly; to blame him for bolting it is as unjust as it is foolish: the blame, if any there be, attaches not to the child, but to those responsible for his irrational food. Equally useless is it to tell the child to watch and imitate (*sic*) the masticatory movements of someone else. All that is necessary is, from an early age, to provide an adequate supply of foods which compel substantial mastication.

FIG. 16.—The facial skeleton appears well developed, but the teeth are irregular and occlusion is defective; in consequence the teeth are not evenly worn down.

Many mothers are under the mistaken impression that, if the very young child is given firm, solid food, he will be likely to choke, but of this there is no danger, if he is early accustomed to cope with food of this kind. It is only when, by pap-feeding, his normal masticatory instinct has been kept in abeyance, and the habit of bolting his food has been acquired, that any danger is to be apprehended on that score. Even then it is but remote, and can readily be overcome by judicious handling. Once a child is ready for farinaceous food as part of his staple dietary, it should

be given in the form of well-baked crusty bread. This, spread generously with butter or dripping, constitutes a very acceptable and wholesome food for the child. His jaws and teeth are capable of coping with much tougher fare than puddings and sponge-cake. If brought up on these lines his teeth will be able to deal with hard foods, even nuts, without any danger of being damaged, for if a squirrel or diminutive monkey can crack nuts with impunity, why not the human child? I am not advocating nuts for children: my object is to emphasise the fact that the teeth and jaws of quite small children, nurtured on the right kind of food, are much stronger than many give them credit for. Manifestly they are not intended to deal with pappy foods for which toothless gums are admirably fitted.

As regards meat, fish and bird, these do not require mastication in the sense of grinding: they excite rather a pounding than a grinding action. Sim Wallace advises that meat should be given to small children in the form of thin slices rather than mince: "Flat pieces, about one inch square, generally *necessitate* a certain amount of mastication, but when finely minced, little or no mastication is called forth." The younger the child, the more underdone should the meat be.

When all the temporary teeth are through (at or shortly after the second year), the child *may be given any such foods as go to make a simple physiological meal for an adult;* without condiments, and always avoiding farinaceous foods which do not compel adequate mastication. We must divest ourselves of the obsession that the child, because its jaws and teeth are small, must need be fed on soft foods alone. The enamel is harder and denser than many of the harder metals, and is meant to minimise the effects of attrition incurred by chewing hard foods.

Causes of Defective Mastication. (1) Soft food. Here soft farinaceous food is the chief offender.

(2) Defects in the masticatory apparatus. Such are dental irregularities (which prevent proper occlusion), and dental decay.

At least nine-tenths of contracted jaws and irregular teeth are due to lack of exercise.

(3) Idiosyncrasy. Some are temperamentally more disposed to hurry over their meals than others. Such differences are encountered even in (sub-human) animals, horses, for instance.

(4) Circumstances of life. In this hurrying age people (of what temperament soever) tend to hurry over their meals. The busy man rushes through his breakfast to be in time for the train, instead of getting up betimes and spending what should be the most enjoyable time of the day over a leisurely breakfast; and, as likely as not, hastily swallows his lunch in his office or at a bar; tradesmen are apt to take their meals in snatches—but less so now that they are vouchsafed a midday respite—and the busy doctor is often obliged to content himself with a hurried snack.

Under these circumstances it is not surprising that a habit of bolting the food should be acquired. A meal should be regarded as an end in itself. It should be taken leisurely and in agreeable company: in these respects the poor housewife is often at a sad disadvantage.

CHAPTER VIII

NEED OF FOOD COMPELLING ADEQUATE MASTICATION

Hard and Soft Foods [1]

The Need of Foods Compelling Efficient Mastication. We have seen that in order to get well-developed jaws, it is necessary, from an early age, to provide them with an adequate supply of food compelling vigorous mastication. A primary need in the upbringing of our children is the early abandonment of pap-feeding, and the introduction into their dietary of a sufficiency of foods compelling efficient mastication. I have long, and I may add painfully, realised the urgency of this need. The benefits accruing from the efficient use of the masticatory apparatus, and the fostering of the masticatory instinct, from the period of weaning onwards, are many.

Efficient mastication during the early years :

(1) Secures the normal development of the jaws, nasal chambers and accessory sinuses,[2] indeed of the entire facial skeleton ; thus providing ample space for all the teeth to erupt without jamming or irregularity, and affording full opportunity for the grinding down of the cusped teeth and the biting edges of the incisors.

Inefficient mastication during the growing years fails to secure any of these benefits. In consequence of the inadequate masticatory stimulus, the jaws remain subnormal in size, and the

[1] See, in connection with this chapter, Part III, Chapter XIX, p. 223 *et seq.*, and Chapter XX.

[2] See Part III, Chap. V.

teeth are prevented from taking up their normal positions, ensuring normal occlusion and attrition.[1] Æsthetic disadvantages ensue in the shape of the hatchet type of face, and the long, irregular, obtrusive front teeth so frequently met with in this country (Figs. 2—8).

(2) Causes the roots of the teeth to move freely in their sockets, thus quickening the flow of blood and lymph in the bony sockets, their lining membranes and the surrounding gum-tissues, thereby promoting the normal nutrition and development of these structures, and enabling them to offer effective resistance to the invasion of pyogenic (pus-producing) organisms.

(3) Brings into activity the normal mouth-cleansing mechanisms by stimulating the flow of saliva, by promoting the friction of detergent foods against the teeth and the gums, and by calling into activity the cleansing action of the tongue, lips and cheeks.

All these advantages are secured by nurturing children from an early age on a sufficiency of food compelling vigorous mastication (such as well-baked crusty bread and raw vegetable food). On the other hand, a dietary which is in the main soft fails to call forth adequate mastication : it fails to ensure the normal development of the jaws and the regular arrangement of the teeth, giving good occlusion ; it fails to bring about a vigorous swaying movement of the teeth in their sockets, it fails to furbish the teeth, and to evoke a normal degree of wearing down of their occlusal surfaces, finally a soft dietary fails to rouse into normal activity the mouth-cleansing mechanisms and thus tends to leave the mouth dirty and to promote the deposition of tartar.

In one or other of these ways, soft foods are a potent source of dental caries and pyorrhœa.

[1] The term " occlusion " in dental language signifies the correct adaptation of the upper to the lower teeth. Normally they should be accurately adapted to one another. If the occlusion departs widely from the normal type, the lateral grinding action of the lower teeth against the upper is prevented, and the teeth fail to be ground-down to a normal degree by attrition.

Hard and Soft Foods. It is to be observed that animal food demands of the jaws and teeth a different treatment from that suitable for vegetable food. The carnivora use their powerful jaws and teeth for biting (seizing), rending and pounding (crushing); they do not masticate in the sense of grinding, their inter-

FIG. 17.—Ample dental arches and ample wearing down of the teeth.

locking teeth preventing free lateral movement of the lower jaw. *Per contra*, raw vegetable food requires biting, pounding, and varying degrees of grinding, in which the lower cusped teeth are firmly pressed against the opposing upper teeth, and moved from side to side, the powerful grinding movement taking place from the side on which most of the food happens to be at any one

moment towards the opposite side. This grinding movement is most characteristically seen in the ruminants, such as the sheep, the goat and the ox ; these animals, after regurgitating a portion of the undigested food, subject it to the grinding action of the cusped teeth ; and the rhythmic grinding movements are repeated forty or fifty times before the regurgitated morsel is swallowed, the animal no doubt enjoying meanwhile the delicate savour of the juices expressed from the dense cellulose framework of the fresh fodder.

Before the discovery of cookery our ancestors used their jaws and teeth vigorously for biting, pounding and grinding the coarser varieties of vegetable foods, such as roots and stalks. Note that the biting off of a morsel of tough food held in the hands may necessitate a strong retraction of the head against the resistance offered by the hands. This entails a temporary strain, or series of strains, on the biting teeth and surrounding bone. Note also that such *temporary* strains do not alter the shape of the jaws (causing protrusion of the palate and front teeth) as happens in consequence of more persistent strains, such as are caused by thumb-sucking.

This primitive type of biting is nowadays but seldom resorted to, owing to the softening of vegetable food produced by cultivation and cookery, and the use of the knife and fork.

Raw salad foods (celery, lettuce, radish and fruits—apples nuts, etc.), and such fare as sugar cane, provide some work for the jaws and teeth, and are to be encouraged ; but, owing to the combined effects of cultivation, cookery, milling and other artificial processes, in softening our cereal foods, vegetables and fruit, the work of the jaws and teeth has grown less and less, and to a degree which, in this country at least, is much to be regretted from the standpoint of mouth cleanliness.

The Effect of Boiling, Baking and Roasting on the Consistence of Vegetable Foods. All vegetable foods except the luscious fruits are softened by being *boiled*. This is true not only of potatoes,

carrots and other " roots," but also of green foods which, in the raw state, are pre-eminently crisp, juicy and mouth-cleansing. It is also true of the cereals, as exemplified by rice puddings, suet pudding and porridge. Such boiled vegetable (as distinguished from animal) foods make no serious demands on the jaws and teeth; they receive little more than a perfunctory crushing in the mouth, and enter the stomach almost wholly unmixed with saliva. Furthermore, the ease with which they are swallowed often leads to their excessive consumption; especially does this objection apply to cereals: one of the worst forms in which, from the standpoint of oral hygiene, these foods can be consumed, is that of boiled puddings; equally bad is porridge as prepared in English hotels.

FIG. 18.—Profile suggests good facial skeleton development, with regular well-worn teeth.

Certain vegetable foods are softened by *baking* and *roasting*, as distinguished from boiling; such are potatoes, chestnuts and a variety of pastry-cook productions, and seductive tarts, cakes and other palate-tickling dainties which melt as it were in the mouth, without being subjected to more than a pretence of chewing. Needless to say, food of this kind affords little or no work for the jaws and teeth.

So much for the softening effect of cookery on vegetable foods. While all vegetable foods are softened by boiling and most by baking and roasting, some tend to be hardened by the latter methods. These include the cereals, of all vegetable foods the

most valuable. In this country the chief cereal foods are wheat, rice and oats. Wheat, the prince of cereals, by reason of its delicate flavour and rich content of gluten (which enables it to be made into the familiar loaf of leavened bread), constitutes for us the staple national food. Unfortunately, we consume it chiefly in the form of ill-baked, spongy bread, scones, buns, and the like, and of mushy puddings and dainty forms of pastry and cakes, not one of which affords the jaws and teeth of the developing human the vigorous exercise for which they crave. On the other hand, well-baked bread is capable of providing a tough, leathery crust calling for abundant mastication ; and it is indeed remarkable that well-baked bread is one of the few cooked vegetable foods possessing this virtue. Oatmeal cakes, and coarse varieties of wheaten biscuits also stimulate mastication, but these are only occasional foods.

It is chiefly in the form of well-baked crusty bread that wheaten flour should be consumed by the developing human, among the British at least. Compare a well-baked crust of wheaten bread amply spread with butter (or dripping) with a dollop of suet pudding : they both have precisely the same nutritive value, consisting as they do of wheaten flour (rich in vitamin B) and animal fat (rich in vitamins A and D) ; but while the one ensures efficient mastication, stirring the entire masticatory apparatus into vigorous activity—causing the teeth to dance in their sockets, the salivary glands to pour out their secretions abundantly, the food to undergo adequate preparation for its entrance into the stomach, the mouth-cleansing mechanisms to be incited to full functional activity, leaving the mouth clean—the suet pudding fails lamentably in all these respects and, moreover, tends to promote an excessive consumption of cereal food.

CHAPTER IX

DENTAL ATTRITION

Attrition (Friction) causing Wearing Down of the Teeth. If the teeth are normally arranged and capable, as they then will be, of normal occlusion, and if a sufficiency of food which compels adequate mastication is consumed, the cusps of the molars and bicuspids and the biting edges of the front teeth are gradually worn down. This is a normal process. Note that adequate attrition of the teeth implies good occlusion. If the teeth are irregular so that the opposing surfaces of the two sets cannot come into accurate contact with one another during mastication, as is generally the case with the British, a true grinding process is not possible, and they may remain but little ground down throughout life. This is what happens in the vast majority of our countrymen.

Among the Esquimaux, who use their teeth for other purposes than chewing their tough foods, the teeth are considerably worn down, even in the young subjects, while in older subjects they may be worn to the gums, actually laying bare the pulp. Fossil remains of prehistoric man give similar evidence of extreme dental wearing down from attrition.

As the grinding-down process approaches the dentine, that part of the dentine nearest the enamel hardens, and as the wearing away of the dentine itself proceeds, new " adventitious " dentine is formed under the old dentine by the pulp, the cavity of which is encroached upon by the new dentine. In this way the life of the tooth may be prolonged for several years.

With the edge-to-edge bite of the front teeth, occasionally

met with, even among Europeans, considerable wearing away of these teeth may occur, even, as I myself have observed, nearly to the gums. In these cases the attrition obviously involves the direct friction of the opposing teeth against one another ; and I doubt not that the wearing down of the cusps is due more to the

FIG. 19.—The teeth are regular and well placed, but show no evidence of wearing down by attrition ; the transverse line indicates the normal degree to which they probably would have been worn down had they been adequately exercised.

FIG. 20.—Good palatal arch and facial skeleton generally ; teeth regular and well worn.

friction of the teeth against one another than (as seems to be the general belief) to the friction of coarse or gritty food against them.

A certain degree of wearing down of the cusps—especially when they are unduly long—is advantageous, because, with short cusps, the grinding teeth are so much the less apt to foster on their cusped surfaces particles of fermentable food, a potent

source of dental decay. If a *person over twenty shows no wearing down of these cusps, we may be sure he does not chew his food thoroughly.*

In subjects with long cusps which show no likelihood of being worn down by efficient mastication, the dentist may consider the advisability of grinding them down artificially, thereby diminishing the tendency to the lodgment of food in the pits and crevices at their bases; and perhaps conferring the further advantage of facilitating the normal grinding down of the cusped teeth rendered difficult by the presence of long cusps. This operation requires, of course, skilled discrimination on the part of the operator.

FIG. 21.—Shows well-developed jaws and regular, well-ground teeth.

A moderate wearing down of the biting edges of the upper front teeth, whereby these collectively are made to form a continuous, even curve, and unsightly long teeth are shortened, is a decided æsthetic gain (see Figs. 19, 20, 21). This even curve and this shortening of the front teeth as the result of attrition are frequently to be seen among Continental peoples, but are rarely met with in this country.

Long Teeth. Our Continental neighbours are wont to depict us as having obtrusively long teeth. A person thus characterised is said to be "long in the tooth." The chief cause of this is an unduly soft diet which fails to excite vigorous mastication. In consequence, the occlusal surfaces of the grinders and biting edges of the incisors are only slightly worn down; further, the roots of the teeth not being firmly pressed down and swayed to and fro in their sockets (thus stimulating the circulation in the socket walls and lining membranes and maintaining a firm con-

nection between the teeth and their sockets), are apt to loosen, and the roots gradually to emerge from their sockets ; this, in the case of the front teeth, causes them to appear unduly long and unsightly.

When this condition of long front teeth is pronounced, the lips are protruded, and lose their normal contour, and the mouth has the appearance of being overcrowded with teeth, a glaring evidence of our faulty dietetic customs (Figs. 5, 6).

CHAPTER X

THE STRUCTURE OF THE TEETH

I MUST confess to having little sympathy with the attempt to teach children the structure and function of their bodies. A little learning is a dangerous thing, and the less people concern themselves about their bodies, save in the way of obeying the laws of health, the better.

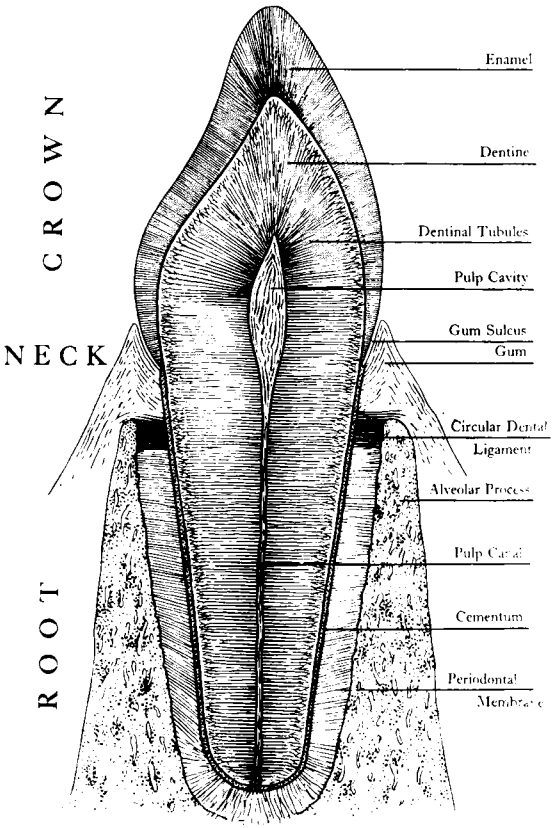
The canons of health are very simple, capable, indeed, of being set forth in a very small compass. There is no need to bewilder children with high-sounding words and would-be scientific explanations. We must, above all, avoid the fatal error of supposing that, in order to learn how to live healthily, it is necessary to be versed in the mysteries of anatomy and physiology.

Even medical men, enjoying as they do all the advantages of special training, can acquire but a limited knowledge of physiology, a science still in the embryo stage, and by attempting to teach it to children we shall only be addling their brains and obscuring the simple truths we wish to inculcate. It is better that children and, for a matter of that, hypochondrically disposed adults should remain in blissful ignorance of the structure and function of their bodies.

Our teeth do not, however, come under this ban. A knowledge of their anatomy and physiology is of practical value, especially in view of the appalling condition of the teeth of our people, mainly the result of ignorance. I therefore venture to ask the reader to be at some pains to understand the following account of the anatomy and physiology of the teeth (see Fig. 22).

A human tooth consists of a crown and root, or roots (the third

molars, or wisdom teeth, have three roots, the first and second molars two roots ; all the other teeth have a single root). The



[*By courtesy Faber and Faber.*

FIG. 22.—Semi-diagrammatic section of tooth and neighbouring parts.

root is embedded in a bony socket, while the crown is exposed to view. The bulk of the tooth consists of *dentine* or ivory. The crown is capped by *enamel*, the densest and hardest of all animal

tissues, and the root is covered by a thin layer of *cementum*. Within the crown, embedded in the dentine, is a cavity containing the *pulp*, the most highly vitalised part of the tooth, furnished as it is with lymphatics,[1] blood-vessels and nerves, which collectively gain entrance to the pulp-cavity by a canal which traverses the entire length of the root.

The Enamel. This consists of closely packed prisms composed of mineral matter. The prisms, each enveloped in a keratine (organic) sheath, radiate from the dentine to the surface of the crown. Individual prisms are bound together by the *cement*. Enamel is to all intents and purposes a dead tissue. It is devoid of blood-vessels and nerves, and although some have contended that the intervals between the enamel prisms and their keratine sheaths constitute lymphatics, the view that an active lymphatic circulation takes place in the enamel can definitely be discarded: take note that once the crown of a tooth has pierced the gum-tissue, its enamel cap is *incapable of being calcified or decalcified viâ the dentine and the pulp*. Those who hug the notion that the enamel is a living tissue seek to persuade themselves that it can offer a vital resistance to decay; there is not one tittle of evidence of this: the enamel of a living tooth is no more capable of resisting decay (*i.e.*, the corrosive action of "fermentation acid") than that of a dead tooth.

Though the enamel is devoid of nerves, it is yet capable, by means of mechanical stimuli conveyed to the pulp, of a considerable degree of tactile discrimination, by means of which, and aided by the tactile sensibility of the tongue, injurious objects can be detected and ejected from the mouth.

On the occlusal surfaces of the molars and bicuspids the enamel is heaped up in the form of *cusps*, which, be it noted, are much more prominent in some persons than in others. Where the

[1] The lymphatics are the tubes which drain off the lymph (*i.e.*, the fluid in which the tissue cells are bathed) and convey it into the large veins.

cusps meet at their bases, fissures and pits are frequent. Here food is apt to lodge, and decay to occur in consequence.

The enamel is of extreme density and hardness, containing a mere trace of organic matter (1 in 0·01). *This density confers no immunity to caries :* its essential object is not to protect against decay, but to *minimise the wearing-away effect of friction :* hence the development of cusps on the occlusal surfaces of the grinding teeth (molars and bicuspids).

As showing how little the degree of calcification and density of the enamel has to do with the initiation of caries, consider the significant fact that the polished dentinal surface left exposed after the covering enamel has been entirely worn away by friction is practically immune to caries. This is because such a smooth surface does not harbour food. On the other hand, the much more highly mineralised enamel is very prone to caries when, as in the case of the molars, it presents abundant retention areas, in which fermentable food is apt to lodge. The inherent liability of a tooth to decay depends not upon its intimate structure, but upon the degree to which it presents retention areas, and for all practical purposes may be said to bear no relation to the degree of its mineralisation (see p. 202 *et seq.*). It is important that the reader should grasp the significance of this statement.

There need be no fear of damaging the enamel, if free from decay, by crushing hard food, such as nuts : sound enamel is capable of sustaining, without fracture, a force of 300 lb., suddenly applied by powerful masticatory muscles. Those accustomed to exercise these muscles vigorously are capable of exerting a pressure of this amount ; while those whose habitual diet does not call for vigorous mastication may not be able to exert a pressure exceeding 50 lb. In such, the socket membranes are apt to be tender, and the teeth and gums intolerant of hard food.

The enamel of all mammals above the marsupials (pouched mammals) presents much the same structure ; and there appears

to be no difference in respect of density and hardness between the enamel of civilised and pre-agricultural Man.

In rodents (gnawing mammals), the enamel continues to grow from the deeper parts as it is worn away superficially. In the rabbit all the teeth are thus endowed ; in the rat the incisors only.

The enamel is, I repeat, virtually a dead structure ; it consists, save for a bare trace of organic matter (thought to be dead keratine), of pure mineral salts (chiefly carbonates and phosphates of calcium). It has neither blood-vessels nor nerves. Constructed as the enamel is, it is inconceivable that an *active* lymphatic circulation can take place in the spaces between the prisms and their keratine sheaths. There is no evidence that the enamel of an erupted tooth can be influenced in the way of calcification or decalcification by the blood circulating in the dental pulp.

How entirely this structure is cut off from the blood is shown by the fact that in morbid hyper-activity of the parathyroid glands causing decalcification of the bones to a dangerous degree, the calcium salts of the enamel remain undiminished. This might be taken to imply an extreme avidity of the enamel for calcium—which no doubt exists—but it is more likely, as I think, to be due to the isolation of the enamel from the general circulation, this isolation preventing the absorption of enamel salts into the blood.

Shut off, as it is, from the general circulation, it is not possible, by increasing supplies of vitamin D, to increase the calcium in the enamel of an erupted tooth *viâ* the blood in the pulp. Pattison, however, claims to have shown that the calcium content of the saliva can be augmented by a diet rich in vitamin D, and it is conceivable that the saliva, thus enriched, might deposit calcium salts in an area of the enamel which had begun to be decalcified by fermentation acid, and that the deposit might in this way arrest caries at its initial phase.

The Dentine. Unlike the enamel, the dentine is a definitely living structure. Lining the pulp-cavity are cells (odontoplasts) which send out radiating branches throughout the dentine. The outer layers of these branches apparently become calcified. Thus

are formed the *dentinal tubes*, consisting of calcified walls containing living protoplasm springing from the odontoplasts. Between these tubes is a homogeneous calcified matrix. The dentine contains lymphatics which communicate with those of the pulp ; it has no blood-vessels or clearly defined nerves, but is nevertheless highly sensitive, as those who have experienced the dentist's drill can testify. The dentinal lymphatics take on the double function of blood-vessels and lymphatics ; by their means the living dentine is nourished, and (unlike the enamel) can in a *slight degree be calcified and decalcified viâ* the pulp. That the dentine can be calcified after eruption of the tooth is shown by the development of secondary dentine under the primary dentine by the pulp in response to attrition and to caries, and by the fact that the degree of calcification of this secondary dentine varies with the supply of vitamin D. (M. Mellanby.) Fish has shown that, unlike enamel, the dentine may suffer some degree of decalcification as the result of parathyroid hyperactivity.

Defectively calcified areas occur in the dentine, known as *interglobular spaces*. They are by some thought to be abnormal ; but unless abundantly present it is doubtful whether they should be thus regarded.

The Cementum. This consists of a thin layer of calcified tissue covering the roots, and occasionally overlapping the enamel. It increases in thickness with advancing age, when bony outgrowths are apt to develop in it. The cementum is essential to the life of the roots : in its absence the tooth loosens and is shed ; so long as the cementum is intact, the root may remain firm in its socket even after the whole crown has decayed ; if an artificial crown is fixed on such a root, the crowned tooth may do good service for years.

Tooth Socket. This consists of the bony socket (alveolus) and its lining (periodontal) membrane. *Each tooth forms its own socket membrane, and it is from the socket membranes that the bony sockets are formed*. The bony sockets fuse together, collectively

constituting the alveolar ridges (upper and lower), which gradually amalgamate with the bony tissue of the jaw proper. Thus *the tooth* (consisting of enamel, dentine, pulp, cementum), *the socket membrane, and the bony socket, together constitute a single dental entity*, largely independent of the jaw bone proper. This independence is shown by the fact that when a tooth is removed the bony socket and lining membrane are absorbed ; hence, after all the teeth have been lost, the alveolar ridges disappear and, on closing the jaws, the atrophied, toothless gums meet, the chin and nose approximating an inch or more beyond the former limit.

It is important to bear in mind that the teeth are not immobile in relation to their sockets. On the contrary, during vigorous mastication they execute a lively dance, sinking, rising, swaying in their sockets. These movements *are necessary for the full development and sustained health of the sockets*. In those brought up on soft food, the socket walls tend to be unduly thin, and many even show perforations externally. The movements of the dental roots within the sockets are also necessary from the standpoint of mouth cleanliness, in that, by stimulating the circulation in the socket membranes and the gum margins, they promote the health of these structures and tend to ward off pyorrhœa.

The Gum Sulcus. The gum margin extends round the entire neck of the tooth, adhering to the lower part of the enamel, and leaving a circum-dental sulcus or fossa (*vide* Fig. 22), which extends almost to the lower limit of the enamel, but may reach as far as the cementum.

The neck of the tooth is a danger zone, in that food particles and bacteria are apt to stagnate in this region. The gum sulcus plays a useful part in antagonising this evil : phagocytes are extruded into the sulcus from the blood capillaries, and act as scavengers of bacteria and other protein substances which tend to accumulate in and about this danger zone.

CHAPTER XI

MALFORMED TEETH (HYPOPLASIA)

THE term *hypoplasia* in dental language signifies some defect in the development of the teeth.

Hypoplasia of the Dentine. Little need be said on this head, seeing that the dentine is not involved in the initiation of caries, which always begins on the exterior of the tooth, *i.e.*, on the outer surface of the enamel, or (more rarely), the cementum, near the lower margin of the enamel.

Areas of deficient calcification—the so-called *interglobular spaces*—are frequently met with in human dentine but, unless very pronounced, are not to be regarded as abnormal: they occur in the teeth of sub-human animals, savages and fossil human skulls. Caries is said to spread more rapidly in these deficiently calcified areas than in the more calcified portions of the dentine.

Hypoplasia of the Enamel. The interest of this subject lies in the fact that ordinary caries begins in the enamel. We have to consider the question whether hypoplastic enamel favours the occurrence of caries.

Two main types of hypoplastic enamel have been described—the grosser forms which are obtrusively obvious on casual observation, and the minor forms (described by M. Mellanby), which require close scrutiny for their detection, or even the employment of a lens, probe or microscope. There is no sharp differentiation between these two forms of hypoplasia.

The Grosser Forms of Hypoplasia. A few words must suffice on this head. The grosser forms are rarely met with in the temporary teeth; in the permanent teeth they occur in about

10 per cent. of persons. It is now generally accepted that they result from some temporary illness which affects the blood in such wise as temporarily to interfere with dental development. Surprising as it may seem, grossly hypoplastic teeth are only very slightly more liable to decay than normal teeth.

The Minor Hypoplasias. M. Mellanby finds minor hypoplasias, as affecting both the enamel and dentine, in the majority of British teeth, notably in children's teeth. In the following account I leave the dentine out of consideration, as this structure takes no part in the *initiation* of caries, which is the great problem confronting us.

These minor hypoplasias are attributed by M. Mellanby to defective calcification (the result of deficiency of vitamin D, aided perhaps by excess of the anti-calcifying cereal factor), and are regarded by her, on the evidence of statistical findings, to be more liable to decay than ideally normal teeth ; it is assumed by this school that dental caries is mainly the result of structural dental defect in which defective calcification plays a prominent part.

There is overwhelming evidence, as I have repeatedly urged in this book, that the intimate structure and the degree of calcification of the teeth have little or nothing to do with the disastrous prevalence of dental decay among British people. The inherent liability of a tooth to decay depends essentially upon the degree to which it affords retentive areas for the lodgement of fermentable food : a polished dentine never decays ; a rough (much more highly calcified) enamel is frequently found to decay. How then are we to explain M. Mellanby's findings, namely, that (*a*) minor hypoplasias occur in the majority of British teeth, and that (*b*) teeth thus affected are more liable to decay than others ? Normal enamel is described by this observer as white, glistening and polished, showing no plainly visible irregular surface, whereas a tooth affected with minor hypoplasia is " apt to be discoloured, rough, and to show slight irregularities, pits and troughs."

Are we, however, justified in assuming that these features are wholly the result of innate dental defect? May they not largely be due to lack of detergent food, and the consequent absence, or feeble action, of those agencies which tend to wear down normal enamel irregularities and to polish the enamel surface?

Dental histologists tell us that all enamel until it has been polished by the friction of opposing teeth and detergent foods has a slightly rough surface. Thus C. S. Tomes in his "Dental Anatomy" writes: "The external surface of human enamel is finely striated, the course of the striæ being transverse to the long axis of the tooth" (3rd edition, p. 49). Longitudinal ridges are also present on the front teeth. Teeth which are not polished by detergent food retain a roughish or striated surface. Such teeth, Sim Wallace tells us, are "apt to become carious, not because of any inherent imperfection, but because the detergent food which should have stimulated mastication and kept them clean, has been withheld from them." I had myself arrived at the same conclusion.

It is noteworthy that M. Mellanby, in treating of the minor hypoplasias mentions their associations with enamel roughness, as also long cusps (which furnish retention areas and so predispose to caries), both of which conditions are manifestly the result of inadequate attrition.

There would thus appear to be a twofold reason why children nurtured on a soft diet should suffer from caries more than others. Soft foods (1) fail to rub away natural retention areas on the enamel surface, while at the same time they (2) tend to leave the mouth dirty, thus predisposing the teeth to caries. "Smooth, polished glistening enamel" points to a diet of a detergent kind, which not only leads to a grinding-down of cusps and furbishing of rough enamel surfaces, but tends in many ways to maintain a high level of oral hygiene. This explanation disposes of an apparently weighty argument in favour of the structural hypothesis.

It would seem, then, that the "minor hypoplasias" and the

decay to which teeth thus affected are liable, are the result, in great measure at least, not of the deficiency of D, but of inadequate attrition and *defective oral hygiene consequent upon a soft non-detergent diet.*

The jaws and teeth of children in this country seldom enjoy the physiological exercise, and the high level of oral hygiene, of which they stand in need.

Let us consider an imaginary case in which these requisites are achieved. When the new-born babe is put to the breast the whole of the infant's masticatory machinery is thrown into full functional activity, involving a quickened flow of blood in the jaws and the buried embryo teeth within them (Fig. 23). Preparatory to the eruption of the temporary teeth the child develops the instinct to gnaw hard objects, an instinct which should freely be indulged during the rest of the lactation period. Thereafter, until the twenty temporary teeth have all erupted (twenty-fourth to the thirtieth month), the child should be provided with food of increasing firmness and detergent quality. With his twenty erupted temporary teeth well ground and polished, and equipped with well-developed jaws, the child will be able to cope, so far as mastication is concerned, with any ordinary adult food—a truth not sufficiently realised.

Thenceforward, until the thirty-two permanent teeth are cut, the food should be of a kind calculated (*a*) to promote sufficient exercise of the jaws to secure their full development, and (*b*) to maintain a high level of oral hygiene.

A question of interest already touched upon arises here. Is the development of the unerupted, buried teeth (temporary and permanent) favoured by the vigorous use of the jaws and the erupted teeth? One would expect vigorous mastication to exercise a beneficial influence on the unerupted teeth by stimulating the circulation in their pulps, and by favouring the growth of the jaw bones, and thus providing ample room for the growth of the unerupted teeth, as well as for their proper spacing after eruption.

Whether or not the *unerupted* teeth of inadequately exercised jaws are placed at a disadvantage as regards their development, as one would expect them to be, certain it is that, *after eruption*, the teeth of inadequately used and consequently ill-developed jaws, fare worse than those of vigorously used and consequently well-developed jaws. In small jaws the teeth are perforce irregular and subjected to all those disadvantages elsewhere set forth.

CHAPTER XII

THE ERUPTION OF THE TEETH

The Temporary Teeth. The calcification of all the temporary teeth is well advanced at birth. Each half of the two jaws contains five of these teeth, making twenty in all. Proceeding from the mid-line, they are as follows : two incisors, one canine (eye-tooth), two molars.

The first to appear are the lower incisors : these are followed after a few months by the upper incisors ; the first molars come next (twelfth to the fourteenth month) ; next the canines (fourteenth to the twentieth month) ; and finally the second molars (twentieth to the thirtieth month).

When the crowns come through the roots are only in part formed, and are not completed until after about two years.

It is a great mistake to suppose that the temporary teeth are adapted for soft and pappy foods only. Even before the completion of the first year they are capable of gnawing hard foods, and after the first two or three years they are quite able to cope with the ordinary civilised diet of adults. How comes it then that a more powerful permanent set has been provided ? Doubtless because, in pre-agricultural times, especially before the adoption of cookery, strong teeth and jaws were required for dealing with coarse, tough, raw vegetable foods, such as roots and stalks.

Hard and detergent foods are good for the temporary teeth, they promote mastication and consequent attrition, whereby the cusps, as well as the roughness and irregularities of other parts of the enamel (normally present on eruption), are worn down.

This reduction of " retention areas " (where food is apt to linger) diminishes the tendency to caries.

Such foods, given during the period of the temporary teeth, are not only beneficial for them, but probably also for the developing buried permanent teeth. We need to remember that up to the sixth year, *when the first permanent molars erupt behind the temporary molars*, all the developing permanent teeth lie buried in the jaw bones (Fig. 23). Hard, detergent foods compel vigorous

[*By courtesy W. Heinemann (Medical Books), Ltd.*

FIG. 23.—Drawing by Frank Harrison, showing normal dentition at seven years. The temporary teeth represented by capital letters, the permanent teeth by numerals.

chewing. This (1) promotes the growth of the jaws, making room (*a*) for the developing permanent teeth still buried in the jaws, and (*b*) enabling them, after eruption, to take up their normal positions in the gums without undue jamming or irregularity. The vigorous use of the temporary teeth probably also (2) promotes the normal development of the buried permanent teeth by stimulating the flow of blood within the sockets (see Fig. 23).

The normal growth of the jaws is indicated by the gradual spacing-out (separation) of the temporary teeth, which should begin about the end of the third year. In a large proportion of

British children the temporary teeth are crowded too closely together, owing to the defective growth of the jaws from insufficient exercise.

Note should be taken of the fact that the eruption at the *sixth year of the first permanent molars, behind the second (most posterior) temporary molars*, often leads the mother to regard them as temporary teeth, the decay of which (should it occur) is of comparatively little importance; whereas the preservation of sound "six-year-old" permanent molars is of the highest importance, as influencing the eruption of the other molar teeth.

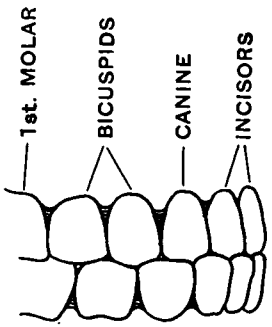


FIG. 24.—Showing how in occlusion each tooth meets two opponents.

Permanent Teeth. The shedding of the temporary teeth is brought about by the upward movement of the permanent teeth which replace them. The near approach of these to the roots of the temporary teeth initiates a process of root absorption which continues until the crowns alone remain and are shed.

The date of eruption of the permanent teeth is somewhat as follows: at the sixth year, it may be even before the lower incisors are shed, the first permanent molars take up their positions behind the second temporary molars. The permanent incisors appear from the sixth to eighth year (the lower before the upper); the permanent canines and first pre-molars at the tenth year; the second pre-molars and second molars at the twelfth year; the third molars from the sixteenth to twenty-fifth year (the lower before the upper).

The dental arches of the permanent teeth are larger and stronger than those of the temporary teeth. The upper arch is more ample than the lower, the upper teeth on occlusion slightly overlapping the lower. It is noteworthy that neighbouring permanent

teeth come into contact at their mid-regions, *so that food is prevented from being driven down the whole length of the inter-dental spaces ;* note also that, on occlusion of the upper and lower teeth, the individual teeth of one set do not meet precisely the corresponding teeth of the other set, but that each tooth (excepting the hindermost teeth) comes into contact with two opponents ; in this way, the maximum grinding power is obtained (see Fig. 24). It follows that, when one tooth is lost, a portion of two other opposing teeth is rendered functionless. The hindmost teeth come into occlusal contact with a single fellow.

CHAPTER XIII

DECAY OF THE TEETH

Historical

Parmly (1818) enunciated the important principle that dental caries does not arise from an innate tendency of a tooth to decay, but from uncleanliness of the mouth. He insisted that the process begins on the surface of the tooth and spreads inwards. He pointed out with rare precision that it generally commences " in the interstices and irregularities of the teeth, in the form of a small dark spot on the enamel, which, eating it away, passes inwards, and occasions a small, more rapid decay of the bone (dentine), till the tooth is entirely destroyed. It has been a great mistake with authors of this subject that caries commences internally." Here Parmly clearly states that dental caries is due to some agent associated with a dirty mouth (now more precisely defined as fermenting carbohydrate), that this collects in the interstices and irregularities of the teeth (retention areas), and bores its way through the enamel into the dentine. There we have in a nutshell the essential pathology of dental caries : given a correct application of it—*i.e.*, the attainment of perfect oral hygiene—and caries cannot take place.

William Robertson (1835) maintained that " corrosive matter " (acid) is formed by particles of food which are liable to lodge in certain situations (retention areas) about the teeth, thus initiating " decay." In 1839 he wrote : " The only cause capable of explaining the partial operation and the particular situation of decay is the corrosive or chemical action of the solid particles of food, which have been retained and undergone a process of putrefaction or fermentation, in the several parts of the teeth best adapted for their reception (retention areas)."

Both Parmly and Robertson advocated the toothbrush as a means of prevention.

The views of these two pioneers excited little enthusiasm : they did not explain, so it was contended, the supposed hereditary nature of caries, or its greater prevalence in some countries than in others.

Macitot (1866) showed that certain sugars on fermenting produce acid, capable of decalcifying tooth enamel and dentine.

Miller (1890), following up the work of his predecessors, defined dental decay as a " chemico-parasitic process," thus recognising the part played

by bacteria in initiating acid fermentation. On this view he advocated the use of antiseptics as a preventive measure, and for many years the use of the toothbrush and antiseptics became the vogue—but failed to check the ravages of the disease.

Black (1895). Before Parmly it was assumed that a tooth decays because of its inherent weakness ; this hypothesis was again advanced by J. Tomes in 1848 : he attributed the greater prevalence of caries among civilised than uncivilised peoples to the presence in the former of structural defects in the enamel : insufficient calcification was put forward as one of the predisposing causes of caries. Black claimed to prove the inadequacy of this view by showing that the molars, which are far more frequently attacked by caries than the incisors, are more highly calcified than they, a finding which was confirmed by Sir Charles Tomes. Black emphasised Parmly's teaching : dental decay, he said, is due to the oral environment of the tooth : a *clean tooth never decays*.

Leon Williams (1897) studied the subject microscopically. He found that " defects " which had been regarded as points of least resistance were common in savages and the anthropoid apes, but he attached little importance to them as influencing the occurrence of caries.

This was how the problem stood at the end of the last century.

Several difficulties, however, remained to be cleared up. The fermentation theory did not account for all the phenomena of caries. It did not, *e.g.*, " explain satisfactorily . . . why some teeth did not decay while others in the same mouth did," or why of two brothers brought up on precisely the same diet, containing an abundance of carbohydrates, the teeth of the one might be sound, while those of the other were ravaged by caries ; or again, " why children living in cane-sugar plantations and chewing quantities of sugar cane showed beautiful regular teeth free from decay."

Sim Wallace (1900) may be said to have put the finishing touch to what may be termed the essential pathology and causation of dental caries. He showed that the hereditary theory which postulated an innate hereditary tendency of the teeth to decay in consequence of some defect in their intimate structure could be definitely discarded as explaining the great prevalence of caries among the civilised. He pointed out that the food in this country is of a kind tending to leave the mouth dirty, that it is largely of a soft, non-detergent character which fails to excite mastication, and to bring into play the physiological self-cleansing mechanisms of the mouth : these he described in detail. He showed

how certain food-constituents, such as acids and aromatic bodies (accessory food factors as it were) played their part in establishing oral hygiene. Again, he drew attention to the influence of the configuration and position within the mouth of individual teeth, in determining the relative frequency with which they are attacked by caries.

Thus the matter stood at the opening of the present century. It was thought by many earnest students that all essential truths concerning the causation and pathology of dental caries had at length been established on a solid basis, and that, in order greatly to reduce the shocking prevalence of this pest, it was only necessary to put into practice the knowledge at our disposal.

This was not to be. As a result of laborious experiments [1] carried out on animals and institutional children between 1918 and 1934, a reactionary school arose, proclaiming that " the experimental method has completely revolutionised our knowledge of the cause and treatment, preventive and curative, of dental caries."

This new reactionary school has revived the older " nutrition " view (as we may term it), the view, namely, that the essential cause of caries lies, *not* in the environmental agencies operating upon the exterior of the teeth within the mouth in the shape of mal-oral hygiene, but in the teeth themselves : the teeth by the reactionary nutrition school are regarded as living structures opposing a vital resistance to decay, a resistance estimated by the capacity of the living pulp to form secondary dentine.

Lowered resistance is ascribed by this school, not to the configuration of the tooth being such as to favour the retention of the food in certain areas, but to defect, largely due to dearth of vitamin D, involving the intimate dental structure and degree of calcification.

It is contended by this school that the vast majority of British teeth, as tested by the naked eye, lens, probe and microscope, show defective structure, the result of a deficiency in vitamin D, that these defective teeth are more prone to caries than others, and that " probably the expenditure of a few thousand pounds would provide yearly sufficient D to ensure the proper formation of the teeth of every future member of the community."

In short, attention is concentrated upon the tooth as chiefly responsible for decay, and the part played by oral hygiene is almost entirely left out of the picture.

This new teaching has had the effect of directing attention away from the paramount importance of oral hygiene, and mothers, and others

[1] " Diet and the Teeth," by May Mellanby, Medical Research Council, 1929, 1930, 1934.

responsible for the nurture of children, have been dosing them systematically with cod-liver oil in order to promote the development of teeth resistant to caries, often it would seem with the result of setting up "acidosis."

The conclusions of this neo-nutrition school will be discussed in the following pages. Meanwhile, let it be said that I find no evidence of the great prevalence of caries among the British being the result of a deficiency in vitamin D. On the contrary, all available evidence, as I shall seek to show, points to the conclusion that this disastrous prevalence is essentially due to an excess of soft non-detergent food which not only fails to effect normal development of the jaws and normal arrangement of the teeth (giving normal occlusion), but tends to leave the mouth dirty—*i.e.*, in a condition which favours the production of decay.

CHAPTER XIV

DECAY OF THE TEETH (*continued*)

General Remarks

The British have the worst teeth in the world. Their condition beggars description. It should excite in us a feeling of shame and humiliation, and a fixed determination to mend our ways and remedy the evil.

Savages have sound teeth and take a pride in keeping them clean. They would turn in disgust from the loathsome mouths which our dentists and doctors are compelled to examine. The poorest Hindoo mendicant, when he begs for a morsel of food, asks for water with which to rinse his mouth. To have sound, clean teeth is part of his religion, to have bad teeth a degradation from which he shrinks.

We need to rouse our children from this indifference to the state of their teeth. The child, from his earliest years, should learn to take an interest in his teeth. He should be made to realise that good teeth are an adornment, and useful servants requiring watchful care. He should be taught that even the loss of a single tooth, which many a schoolboy would be willing to sacrifice for the opportunity of a half-holiday, is no light matter, and that a casual, off-hand attitude is not one to be adopted towards a friend capable of rendering good service to the end of life.

The public need to be taught that nine-tenths of the dental caries in this country is preventable.

Extent of Dental Disease

The evil effects of dental diseases include :

(1) Irregularities.

(2) Loss of teeth from extraction or shedding.
(3) Caries.
(4) Diseases of the root apices.
(5) Pyorrhœa alveolaris.

(1) Irregularities are chiefly due to misshapen jaws, the result of insufficient exercise. Owing to our faulty dietetic customs, a normally developed jaw is rarely to be found in this country.

(2) At a modest computation not less than 100 million teeth have been extracted from the jaws of our present population.

While it is natural for the temporary teeth to fall out, the shedding of the permanent teeth is not, as is generally supposed, altogether a natural senile process: except perhaps in extreme old age; it is mainly due to disease, in the shape of pyorrhœa. If the sockets remain healthy, the teeth, far from loosening with advancing years, tend, at least prior to advanced senility, to become more and more firmly fixed within them.

(3) Caries affects both the temporary and the permanent teeth. Less than 1 per cent. of our children pass through their first dentition without suffering from dental caries. The number of decayed teeth in our population probably exceeds 200 million, without taking account of the large number which have been extracted.

(4) Apical disease (abscess) of the roots generally results from dental caries. At a low estimate there are probably as many as 20 million teeth thus affected among us.

(5) Nearly all our countrymen suffer from some degree of pyorrhœa alveolaris after the age of thirty, many even before their twentieth year.

Consequences of Dental Caries

(1) Malodorous breath.
(2) Unsightliness.
(3) Pain.
(4) Reflex disturbances.

(5) Defective mastication.
(6) Secondary local disease.
(7) Blood poisoning.
(8) Economic loss.

(1) Apart from unhealthy blood conditions, malodorous breath is caused by caries, and even more perhaps by pyorrhœa.

(2) Good teeth are an adornment; they are more attractive than the most costly clothes. On the other hand, teeth that are irregular, protruding, lengthy, discoloured, diseased, are unsightly. We should miss no opportunity of impressing upon children with good teeth the need of taking care of them. Young women of the poorer class should be made to realise that not the most beautiful hat money can buy can compare, æsthetically, with a good set of teeth. It is quite common to see in young women of this class numerous beginnings of dental decay, as to which they appear to be utterly indifferent; yet sooner or later they have to submit to the trouble, inconvenience, expense and unsightliness of artificial teeth; for it is idle to pretend that artificial teeth in the young do not detract from the comeliness of the face. Yet, surprising as it may seem, some young women seem to take great pride in displaying their artificial teeth: a girl of some fifteen summers once informed me that her mother had sold a pig to provide her with a set of false teeth, a circumstance which added greatly to her self-importance.

Unduly long front teeth are the reverse of attractive. A considerable proportion of our adult population are unduly "long in the tooth." Three factors contribute to the production of long teeth: (*a*) Mal-occlusion, (*b*) pyorrhœa (both of which cause the teeth to "rise in their sockets"), and (*c*) inadequate wearing down of the occlusal surfaces of the grinders and the biting edges of the front teeth.

(*a*) Mal-occlusion. When the teeth fail to take up their normal positions on eruption, the upper and lower sets are not properly adjusted to one another, and not being able to meet accurately

during mastication, opposing teeth are prevented from exerting the normal degree of pressure on one another ; in consequence they gradually emerge from their sockets, causing a longer and longer portion to project beyond the gums : an apparent lengthening of the teeth is the result.

(*b*) Pyorrhœa. An even more effective cause of long teeth is a loosening of the roots in their sockets in consequence of inflammation of the socket membranes and corrosion of the bony sockets. If not checked, this condition ultimately leads to shedding of the teeth.

(*c*) Feeble attrition. A third factor is feeble attrition (and consequent inadequate wearing down of the occlusal surfaces of the grinders and the biting edges of the front teeth), either from defective occlusion or lack of foods compelling vigorous mastication.

These long teeth are ugly in themselves ; they give the mouth the appearance of being overcrowded with teeth ; and they distort the lips by thrusting them forwards, so that often it is only with difficulty that they can be made to meet over the teeth (see Figs. 4, 5, 6, 7, 8, 9, 15).

If the upper and lower teeth are normally opposed, and if the food is, as it should be, of a kind compelling their vigorous use, the roots remain deep in their sockets, a considerable wearing down of the crowns takes place, giving rise, in the case of the front teeth, to an even biting edge of the dental arcs.

(3) The pains associated with bad teeth include spontaneous pains felt in and around the teeth, " referred " or " sympathetic " pains (*i.e.*, pains felt in distant parts) ; pain inflicted in the dental chair, and the anticipatory pain induced by fear of it.

(4) Reflex disorders include headache and disurbances of vision.

(5) The evils resulting from defective mastication are dealt with in Part III, Chapter V and Chapter VIII.

(6) Secondary local diseases are those set up in the immediate

neighbourhood of a diseased tooth. An abscess forming at the root apex may burst in various directions, including one or other of the large antral air-cavities bilaterally situated below the orbits. The irritation of a diseased tooth may set up malignant disease of the jaw, while that of a sharp tooth, or an ill-fitting plate, may induce ulceration, or even cancer, of the tongue.

(7) Oral sepsis resulting from caries, root-disease, or pyorrhœa, is a potent cause of blood poisoning. The diseases which have been attributed to blood poisoning thus resulting are too numerous to be mentioned in this place.

(8) In so far as dental disease incapacitates a person from work it incurs economic loss. Nor must we leave out of account the large army of dentists, dental mechanics, and manufacturers of dental appliances, numbering not less than a hundred thousand all told in Great Britain alone, who, were adequate preventive measures taken, could largely be dispensed with, and their high level of ability devoted to other ends.

CHAPTER XV

THE IMMEDIATE CAUSES OF DENTAL DECAY

DENTAL decay starts from the surface of the tooth, *i.e.*, in the outermost layer of the enamel (or, more rarely, cementum), and advances inwards to the dentine and the pulp. It is initiated by the corrosive action of an acid (or acids) generated within the mouth by the fermentation of food. We may speak of this corroding agent as " fermentation acid."

The acid attacks the enamel through the medium of adhering " plaques " yielding corrosive acid. These constitute *acid plaques*. Such a plaque consists of a small mass of fermentable carbohydrate food swarming with bacteria. A significant feature of the acid plaque is its impermeability to alkaline saliva, which, were the plaque thus permeable, would neutralise any acid that might be generated in the plaque and render it innocuous. This impermeability is thought to be due to a gummy substance generated by " manitic " fermentation.

Another variety of plaque requiring our attention is the *alkaline plaque* consisting of protein material (*e.g.*, that contained in food, cast-off epithelium and mucin) undergoing alkaline putrefactive change. Note that when carbohydrate ferments, it produces a *corrosive acid*, and that when protein putrefies it produces *non-corrosive alkaline substances*. In each case specific microbes are at work. When, in the living mouth, putrefactive changes giving an alkaline reaction predominate over acid fermentation changes, we have *the dirty mouth with little or no*

decay. Thus a certain type of mouth-dirtiness is consistent with the co-existence of non-carious teeth.[1]

Plaques tend to form in retention areas beyond the reach of the tongue, lips and cheeks—and even the toothbrush. Among the more frequent of such retention areas are the pits and crevices on the grinding surfaces of the molars, the interdental spaces, and the necks of the teeth, especially when the gums have receded. *Plaques never form, and decay never begins, on a dental surface kept constantly polished, be it enamel, or dentine left bare and polished after the overlying enamel has been worn away*. On such polished surfaces decay cannot originate. When, as occasionally happens, decay begins on the lingual or labial surface of the enamel, it is because the conditions of the mouth have allowed it to become dirty. The minor hypoplasias described by M. Mellanby, themselves largely originating in mal-oral hygiene, afford retentive areas and thus predispose to caries (see p. 180). Such are roughness, unevenness, slight indentations, long cusps, which normally tend to be worn down by detergent foods calculated to promote vigorous mastication.

Owing to unknown constitutional conditions some people seem less liable than others to harbour in their mouths the organisms responsible for caries, and this fact has to be taken into account in considering the causation of caries. A person with carious teeth may unaccountably develop an immunity to caries, his carious teeth showing a tendency to heal up ; but this is a comparatively rare event, and has little practical bearing on dentistry (see note, p. 201).

Micro-organisms Responsible for Dental Decay. The *bacillus acidophilus*, which can be identified in many human mouths, induces acid fermentation of sugar, and is chiefly, if not entirely, responsible for the decalcification which the teeth undergo during the carious process. Many other bacteria are found in the mouth, but it is not certainly known how far they are individually involved in the decalcifying process.

Under a perfect system of oral hygiene plaques containing fermentable material and the *bacillus acidophilus* are not allowed to remain in pro-

[1] This somewhat rare co-existence of a chronically dirty mouth with sound teeth is often brought forward by the nutrition school as a convincing argument against the teaching of the oral-hygienists.

longed contact with the enamel or exposed cementum. With normal occlusion, well-spaced teeth and adequately ground-down cusps, and a sufficiency of detergent foods, it is possible to achieve a high degree of oral hygiene, affording a minimum opportunity for plaques to lodge in retentive areas. When such areas are abundant, as in the case of prominent cusps and irregular teeth, a high level of oral hygiene is correspondingly difficult of attainment, and caries is correspondingly apt to occur.

No doubt the liability of the mouth to harbour harmful organisms tends to vary with the general health, but radiant health is not incompatible with rampant caries, if the diet is one calculated to leave the teeth dirty and to promote acid fermentation.

The chocolate experiment mentioned on p. 212 admirably indicates the sites where plaques are apt to form and decay to originate, also the relative frequency of caries on the different surfaces of the different types of teeth (see p. 236).

Caries of the Enamel. The process of enamel decay is essentially one of decalcification. The super-mineralised, lifeless enamel (containing the barest trace of organic matter) reacts to acid much as a block of marble might: the unprotected, naked enamel, when attacked by the acid generated within an adhering plaque, is wholly at the mercy of the acid, which bites into it, seizing upon such of the calcium as lies within its range of action, thereby inducing corrosion.

After the enamel of a newly-erupted tooth has been slightly worn away, its surface presents an irregular mosaic formed by the cross-sections of enamel prisms abutting on the surface, separated from one another by the interprismatic cement. This mosaic pavement may be regarded, for all practical purposes, as so much inanimate mineral matter whose naked surface is entirely at the mercy of any fermentation-acid (above a certain concentration) that may chance to be brought into immediate protracted contact with it. What follows is determined by chemical affinity pure and simple; of vital reaction there is no question.

There is no evidence that the enamel is capable, as has been

contended, of opposing a specific vital resistance to fermentation-acid ; the fallacy of this view is shown by the fact that the enamel of a living tooth is just as liable to decay as that of a dead one. The nutrition school of dental pathologists would appear to assume that the degree of resistance of enamel to acid increases with the degree to which it is calcified : there is no evidence of this (see p. 202 *et seq.*) ; the tendency of enamel to decay depends not upon its degree of calcification, but upon the degree to which it offers a convenient lodging-place (retention area) for a plaque : we have already seen that a rough *enamel* surface is many times more likely to decay than the polished surface of the much less mineralised dentine which has been exposed by attrition.

Calcification of the Dentine and Resistance to Caries. As the corroding process induced by fermentation-acid proceeds in the enamel, the subjacent dentine undergoes hypercalcification and hardening, and when, by the corrosion of the enamel, the way is opened for the passage of bacteria into the dentine, this tissue becomes involved in the carious process, while the surrounding non-carious area undergoes (apparently a protective) hyper-calcification.

Unlike the enamel, which at most is endued, in its deepest portion adjoining the dentine, with the faintest semblance of vitality, the dentine is very much alive. While decay of enamel is little more than decalcification, the minute trace of organic matter being simply washed away as corrosion proceeds, dentine contains about one-third of organic matter, so that decay of this tissue involves not only the process of decalcification, but the disintegration of organic tissue by specific microbic activity. As might be expected, the disruption of the dentine is a far more rapid process than that of the enamel, and tends to undermine the enamel cap, the overlying portion of which in consequence takes on a characteristic appearance.

Besides the quasi-defensive changes which occur in the primary

dentine surrounding the carious area, secondary dentine is formed by the pulp under the primary dentine.[1]

M. Mellanby has found that, by providing institutional children with a diet rich in vitamin D, the secondary dentine which forms as the result of caries tends to increase in quantity and degree of calcification, and that the decayed dentine tends to harden and may even heal up, the irregular, hardened exposed portion in some cases being gradually worn down, leaving a smooth polished surface. One must conclude therefore that dentine, being a living structure, is capable of offering some degree of resistance to caries, and that in some cases this resistance may be increased by the administration of vitamin D. The children whose teeth (in M. Mellanby's investigation) responded so readily to vitamin D, were evidently suffering from a dearth of this vitamin. When a patient shows evidence of being in want of vitamin D, that want should of course be supplied, by sunlight, suitable food, cod-liver oil, and the like ; but when the practical dentist has to deal with a case of dental caries, he will rarely find it advisable to have recourse to these means alone, trusting, *i.e.*, to the offchance of spontaneous healing taking place : where feasible, he resorts to the time-honoured practice of removing the carious material and inserting a filling.

Some writers show a tendency to exaggerate the importance of arrested caries, as though it were quite a common occurrence, the furthering of which is likely to become an outstanding feature in practical dentistry. This is unlikely. The end to be sought is prevention, and the best way of preventing dental caries is to secure perfect oral hygiene.

[1] It sometimes happens that decay affecting, it may be, several teeth, ceases to progress, a result which Fish attributes to some occult constitutional change which renders the micro-organisms concerned in dental caries unable to establish themselves any longer in the patient's mouth (see p. 202 and p. 206, note).

CHAPTER XVI

DENTAL CALCIFICATION AND LIABILITY TO CARIES

Calcification of the Enamel and Resistance to Caries. The nutrition school would seem to hold that the more completely the teeth are calcified, the less is their tendency to decay.

Throughout the Reports of the Medical Research Council,[1] repeated reference is made to the importance of securing good calcification of the teeth, and to the frequent occurrence of defective dental calcification through lack of an adequate supply of vitamin D, and it is urged that, inasmuch as vitamin D favours the calcification of the developing teeth, a rich supply of this vitamin, whether by means of food rich in D or by abundance of sunshine, will increase the resistance of the enamel to caries.

There is, however, no evidence that the degree of enamel calcification influences its resistance to the fermentation-acid which induces caries. One would not, on *a priori* grounds, expect it to have any such effect. How, one may ask, can a little more or less calcium in the enamel influence its behaviour towards this acid? Speaking generally, all enamels, when exposed to acid, show much the same degree of calcification, and react in much the same way to acid. The calcification hypothesis does not accord with experience :—

(1) It is found that fragments of enamel taken from different teeth of the same person, or from the teeth of different persons, or from the teeth of different species of mammals, and tested outside the body *in vitro*, behave similarly in the presence of acids, fermentation-acid among others.

[1] " Diet and the Teeth," by May Mellanby, Reports of the Medical Research Council, 1929, 1930, 1934.

(2) The like is true whether the fragments are taken from hypoplastic or normal enamel, from teeth recently extracted, or from fossil teeth which have lain buried in the earth for thousands of years.

(3) In imitation of what occurs in the mouth, dental caries can be produced *in vitro* by maintaining a mixture of saliva and fermentable saccharide at a certain temperature and degree of acidity : if a tooth recently extracted is immersed in such a mixture, and all necessary precautions are taken, corrosion occurs just as happens within the mouth, and no difference is observed between the reaction of different enamels : it is found that a dog's tooth, *the enamel of which is defectively calcified, in consequence of an inadequately calcifying experimental diet, corrodes no more rapidly than one which is normally calcified.*

(4) Molar teeth, though even less calcified than the incisors, are much more frequently attacked by caries than the latter.

(5) " Mottled " teeth (due to the presence of fluorine in the water), the enamel prisms of which are deficiently calcified in their superficially placed regions, are not specially liable to caries.

(6) As a further argument against the view that degree of calcification influences the tendency of enamel to become carious, attention may be drawn to the disastrous prevalence of dental caries among the white population of sunny countries, such as Australia, New Zealand and South Africa, where the ample supply of vitamin D, produced by the action of the solar rays on the human skin, secures such effective skeletal calcification that rickets is almost unknown in those countries. Such being the case, it would be strange indeed if the teeth of these people failed to secure equally good calcification, the more so in view of the fact that the teeth display an even greater avidity for calcium salts than the bones.

(7) Not less significant is the fact that dentine, although much less calcified than the enamel, is, when exposed by the wearing away of the enamel and polished by attrition, even less liable than enamel to become carious in the human mouth ; for, unlike certain areas of the enamel (*e.g.*, the grinding surfaces of the molars), such polished dentine is devoid of irregularities (pits, fissures, etc.) calculated to trap the food.

(8) I have seen a whole set of teeth which, although they had been for many years denuded of their enamel by a too rigorous use of a hard toothbrush, leaving the dentine exposed, were surprisingly free from caries.

(9) Further, in certain animals portions of naked dentine normally show on the occlusal surface of the teeth.

The fact is, Nature, in making enamel the hardest, densest, most highly mineralised of all tissues, exhibiting a supremely high degree of calcification, has not been concerned with strengthening its resistance to caries—special mouth-cleansing

mechanisms have been evolved against this evil—*the end in view has been the prevention of an excess of attritional wearing-down of the teeth*, brought about by the normal vigorous use of the teeth.

The facts just brought forward render it evident that the tendency of a tooth to become carious has nothing to do with the degree of enamel calcification. It follows that if, as has been contended, the exhibition of vitamin D lessens the tendency for caries to develop in the enamel, this effect cannot be explained on the hypothesis of augmented calcification.

I have dwelt on the subject of enamel resistance to acid, because it is the action of fermentation-acid on the enamel (occasionally the cementum) surface which initiates the drama of dental caries. I have insisted that in our endeavour to prevent caries, it is essentially upon the checking of this initial process that we must concentrate. In opposition to this teaching, the nutrition school concentrates upon the up-building of " well calcified teeth capable of opposing a maximum resistance to caries," by the provision of food containing an ample supply of calcium, phosphorus, and vitamin D (such as milk, yolk of egg, butter, beef suet, cod-liver oil), and not allowing the stomach to be overburdened by cereal food, to which we may credit some anti-calcifying effect. This is so far sound advice (although perhaps too great stress is laid upon the need of cod-liver oil), but these measures do not influence the resistance of the teeth to caries, though they may favour oral hygiene. The urgency of the need for stringent oral hygienic measures is not emphasised by leaders of the nutrition school, in which respect they are grievously at fault, for the available evidence clearly shows that it is essentially upon oral hygiene that we need to concentrate in our efforts to prevent dental caries.

CHAPTER XVII

DEFICIENCY OF VITAMIN D AND DENTAL CARIES

IT is claimed by the nutrition school of dental pathologists that the alarming prevalence of dental caries among us is essentially due to a deficiency of the calcifying vitamin D in our diet; it is assumed that, in consequence of this, our teeth are structurally defective, notably in respect of calcification, and correspondingly liable to decay. No stress is laid on the paramount importance of securing oral hygiene, the full meaning of which this school has strangely failed to realise. According to the nutrition school our efforts in fighting dental caries should be concentrated on the up-building of good teeth capable of resisting caries, by providing the developing human with plenty of vitamin D in the shape of milk, eggs, butter, fish-fats, such as cod-liver oil, or the systematic administration of vitamin D in the form of calciferol or ultra-violet rays. We are told that the care of the teeth costs the country millions of public money annually, and that "a few thousand pounds would supply sufficient vitamin D to ensure perfect formation of the teeth of every future member of the community, if given from or before birth." This is the *ex cathedra* pronouncement of the nutrition school, the inference being that if such a scheme were carried out a great decline in the incidence of dental caries would ensue.

I can find no evidence, *a priori* or *a posteriori*, in support of this emphatic belief in the ability of vitamin D to diminish, in any

appreciable degree, the *incidence* of dental caries.[1] As shown in the previous chapter, the liability of a tooth to decay bears no relation to its degree of calcification : a smooth dentinal surface is practically proof against caries, while the more highly calcified enamel covering the occlusal surface of the molars is very liable to decay. The inherent liability of a tooth to decay depends essentially upon the degree to which it affords facilities for the lodgement of fermentable carbohydrates, and is wholly unrelated to its degree of calcification.

Nor does the amount of vitamin in our food bear any relation to the prevalence of dental caries among us. The well-to-do, amply supplied with foods rich in D, were, before they began to take special care of their teeth, even more affected by dental decay than the very poor.

Then there is the striking (surely convincing) evidence of the British population of sunny Australia, New Zealand and South Africa, where, owing to the immense available supply of ultra-violet rays, and the abundant production of vitamin D in the skin, rickets is practically unknown—yet dental decay is rampant.

It has been estimated that, by reason of its altitude and the long daily duration and intensity of the sunshine, Johannesberg receives on the daily average ten times the amount of sunshine received by a similar area in England. Now, of 600 white children belonging to the Government schools, examined by Friel and Middleton Shaw, 93·35 per cent. showed dental caries, the

[1] M. Mellanby and colleagues undertook investigations on institutional children first (1924, 1926) at Sheffield, and later (1928) at Birmingham, with the object of discovering the influence of a diet rich in vitamin D on the initiation of fresh caries, and the spread of caries already existing. They found that such a diet both lessened the number of new teeth attacked by caries, and caused a lessening in the spread of the carious patches already existing. How far the latter effect was due to an extra quantity of vitamin D circulating in the dental pulp, and how far to improved oral hygiene, it is difficult to judge, but it is certain that the lessening in the number of new carious teeth could not have been brought about by the blood circulating in the dental pulp, since the superficial portion of the enamel, where caries begins, is wholly outside the range of the blood within the dental pulp ; conceivably the effect was wrought by a change in the composition of the saliva.

average for all being 4·82 carious teeth (*British Dental Journal*, April, 1931).

The same story comes from Australia and New Zealand. We read that while rickets is practically unknown there, the teeth are ravaged by caries.

Again, three careful observers tell of the disastrous prevalence of caries in sunny Hawaii—and this in spite of the children being liberally supplied with cod-liver oil, eggs and milk (both human and fresh unpasteurised cow's milk), as well as the juice of the orange and tomato (*Dental Cosmos*, July, 1933).

There is no force in the argument that the white peoples of sunny countries protect themselves from the sun's rays by staying indoors, and covering the skin. The eloquent fact remains that sufficient D is provided to secure well-calcified bones, and if so, why not well-calcified teeth also, which evince an even greater avidity for calcium than the bones ?

Such importance does the nutrition school attach to the need of providing children with an abundance of vitamin D by the mouth, in order to build up teeth offering a maximum resistance to caries, that its followers urge the habitual recourse to cod-liver oil even for children at the breast. The effect of this teaching has been to divert attention from the prime essential for dental health, namely, the construction of a dietary for children which shall at one and the same time afford ample exercise for the jaws and teeth and leave the mouth clean (oral hygiene). It is remarkable that the increased consumption of cod-liver oil in consequence of the " up-building of good teeth " teaching, has actually synchronised with a rise in the incidence of caries in this country.

The Effect of Anti-calcifying Cereal Food on Dental Caries. Apart from the question whether cereal food has any anti-calcifying effect on our teeth, few are likely to dissent from the contention that the food of our children contains an excess of cereals (bread, rice, oatmeal, etc.) and too little animal food, vegetables and fruit.

So much is certain, but the excess is, I doubt not, the result of giving cereals in a variety of soft forms which fail to compel efficient mastication. Were the cereal food confined to forms which compel vigorous mastication (*e.g.*, well-baked crusty bread), there would be little fear of excessive cereal consumption, while the jaws would be stimulated to normal development and the teeth properly placed in the gums. As regards the deficiency of animal food in our children's diet, the nutrition school stresses the need for more milk, butter, cheese, eggs, fat fish, cod-liver oil, on account of their richness of vitamin D. All these are quite good substitutes for the animal food of the primitive hunter. So much may be granted, but we must guard ourselves against exaggerating the importance of cow's milk, butter, cheese, and eggs, of which Man knew nothing before the introduction of agriculture. They are *convenient substitutes for the* hunter's animal fare, neither more nor less, and are of special service in countries enjoying little sunshine, and especially for children who get little meat or fish, and are prevented from leading an open-air country life.

As to the anti-calcifying ingredient of cereal food I know of no evidence that it plays any appreciable part in the pathology of dental caries.

In addition to the evidence cited on pp. 206–7 regarding the inefficacy of vitamin D in antagonising dental caries, the following investigations (taken from *Public Health*, 1935, September, p. 422) may be cited :—

Michigan Research Group. Of 169 orphanage children, nearly 80 per cent. were entirely free from caries ; in only 5–6 per cent. was the amount obtrusive. Not only was the caloric value of the diet below the standard, but the Ca., P., and vitamin D content also. Little milk was given, no butter. Meat (a small amount) and vegetables, often raw, were supplied daily ; 40 per cent. of the daily energy-yielding food consisted of starch ; " cookies " and sweet foods were confined to Sundays ; dessert consisted of raw apples ; no sweets, no sugar on the table, and only a minimum used to sweeten foods. Manifestly these children received little vitamin D in their food ; on the other hand, the dietetic conditions favoured oral hygiene.

(*For second investigation, see note, p.* 217.)

CHAPTER XVIII

THE INHERENT LIABILITY OF A TOOTH TO DECAY

Susceptibility to Caries. Arrest of Caries

We have seen that the inherent liability (susceptibility) of the enamel to decay has little or nothing to do with the intimate structure, degree of calcification, or " vital resistance," the enamel of a living tooth being just as liable to decay as that of a dead tooth. Its inherent liability to decay depends upon the degree to which it presents " retention " areas—areas, namely, calculated to trap and retain particles of food. Take careful note that *decay never begins on a clean, smooth enamel surface*, such as the labial surfaces of the incisors, kept permanently clean by friction of the lips and detergent foods ; nor, provided the gums are healthy, on the smooth lingual surfaces of the enamel, cleansed by the constant movements of the tongue ; nor, for a matter of that, on exposed dentine smooth and polished by attrition.

Retention areas may be considered under three heads : (*a*) natural configuration ; (*b*) distorted configuration from defective development (hypoplasia) ; and (*c*) distorted configuration from caries.

(*a*) *Natural Configuration*. The retention areas of normal teeth depend upon the peculiar configuration of the enamel caps. The extent to which such areas occur varies in the different types of teeth in the same individual, and in the same types of teeth in different individuals.

Contrast the molars (grinders) with the lower incisors : the

molar teeth are large, they are furnished on their grinding surfaces with heaped-up masses of enamel, known as " cusps," presenting, at the junction of their bases, pits and crevices apt to retain food ; consequently, of all teeth, they are the most likely to decay. On the other hand, the lower incisors are small, simple in form, and narrow laterally, giving rise to narrow interdental spaces ; these teeth thus offer a comparatively small surface for the initiation of caries, added to which they are devoid of pits and crevices. Consequently, of all teeth the lower incisors are the least liable to decay, notwithstanding that they are even less calcified than the molars.[1]

The canines occupy an intermediate position between the molars and the lower incisors as regards the possession of retention points and liability to decay.

We need to remember that the grooves round the necks of the teeth constitute, with the encircling gum-margins, retention areas where soft non-detergent foods are apt to stagnate. The tendency for such stagnation to occur increases when, in later life, the gum-margin begins to recede from the teeth : decay at the cervical region then becomes increasingly frequent. Note that such retention areas, as well as the interdental spaces, are external to the teeth, and do not come under the category of *inherent* liability of a tooth to decay.

The longer the cusps of the molars and bicuspids, the more apt are they to lead to the retention of food and to promote decay. If, however, the jaws are well formed, if occlusion is perfect, and if the food is of a kind necessitating adequate mastication, the cusps of the molars and bicuspids will gradually be worn down by attrition. Such wearing down is due more to the friction of enamel against enamel than of food against enamel.

[1] The close proximity of the sub-lingual ducts secreting alkaline saliva may help to protect the lower incisors from caries. Probably for the same reason, these teeth are very apt, quite early in life, to be coated with tartar, which favours pyorrhœa : the central lower incisors are the earliest teeth to be shed from this cause.

The degree to which the enamel is worn is a measure of the efficiency of mastication. In a large proportion of our population the permanent teeth are but little worn down, owing to the combined effect of mal-occlusion and soft food. Notably is this true of the cusps: hence the frequency of caries in the molars and bicuspids, for the less the cusps are worn down, the more liable is food to be retained at their bases. The wearing-down process *should begin soon after eruption*. It is well seen in the temporary teeth, which generally present more efficient occlusion than the permanent teeth.

When prominent cusps have not undergone the normal process of flattening by attrition, the question of having recourse to artificial attrition comes up for consideration. Some dentists advocate forestalling decay in long-cusped teeth by inserting fillings in the fissures and crevices at the bases of the cusps, where caries is so apt to occur.

(*b*) *Retention Areas from Hypoplasia.* This term signifies a defect in the development of a tooth. Hypoplasia modifies the natural configuration of the tooth and predisposes to decay in the same way as the natural configuration, *i.e.*, by affording retention areas where food can lodge, rather than by defect in intimate structure or degree of calcification.

(*c*) *Retention Areas from Caries.* An ugly feature of dental decay is its tendency to progress until the affected tooth is destroyed. This is because, once a minute cavity is formed by the decay of the enamel, it constitutes a retention area for the accumulation of food, one which increases as the carious process advances and involves the dentine.

Summary. In brief, the inherent tendency of a tooth to be attacked by caries is in direct proportion to its capacity, in virtue of its configuration, to harbour food, and bears no relation to the intimate structure of the tooth.

A Practical Method of Indicating Retention Areas. Nothing

more strikingly shows the part played by food stagnation in the causation of dental caries than the way in which the disease picks out the retention areas of individual teeth, where fermentable saccharide food tends to lodge, be it in the retention areas of the tooth itself, on an adjoining (interdental) surface, or at the gum-margin, especially when this has receded—the three great seats of election. *These are not areas of diminished resistance, but areas peculiarly exposed to the attack of the enemy.* Anyone can identify these retention areas for himself by examining a mouth immediately after some chocolates have been eaten : he will find the seats of election precisely marked out, and he will be able to measure the relative retentive capacity of the different retention areas by the time taken by the individual dark patches to clear up. We may speak of this as the " chocolate test."

The Intimate Microscopic Structure or Degree of Calcification of the Enamel takes Little or No Part in Predisposing to Decay. The enamel, as already emphasised, plays a passive part in decay ; it can offer no resistance to fermentation-acid. On the other hand, the dentine, as we have seen, puts up some degree of resistance to decay, one which is aided by an adequate proportion of vitamin D in the blood. Dentinal resistance, however, is of little or no import in connection with practical dentistry.

Note.—The exemption of dogs from caries when fed on saccharide food is largely due to the configuration of their teeth, which is such that the food glides off readily from the polished enamel surfaces ; it may also in part be due to an unsuitability of the dog's mouth for the growth of the organisms responsible for the production of the corroding fermentation-acid.

The Term " Susceptibility of the Teeth " as applied to Caries. By the nutrition school the teeth are regarded as varying in their " susceptibility " to caries. " It is contended that the teeth of the civilised, especially those living in temperate zones, are very susceptible to caries." This susceptibility is not regarded as being related to the normal configuration of the teeth—*i.e.*, the

degree to which they present retention areas liable to retain particles of fermentable food—but to defective intimate structure. The living tooth is assumed to be the seat of " metabolic, nutritional, vital " activities capable of opposing an active resistance *sui generis* to decay, and strong, healthy *living* teeth are assumed to offer a maximum of such resistance. On this view our chief concern, from the standpoint of prevention, should be not—so the argument runs—the achievement of perfect mouth cleanliness (efforts in this direction having, it is contended, signally failed), but the building-up of perfect living teeth. Throughout, the contention appears to be : provide plenty of vitamin D, secure a sufficiency of calcium and phosphorus, avoid an excess of anti-calcifying cereals—and the teeth will tend to remain caries-free, and we need not greatly concern ourselves about keeping the mouth clean, for " perfect teeth are found among those who have never used a toothbrush."

Susceptibility of the Enamel to Caries. The terms susceptibility and resistance to caries, more particularly when applied to the enamel where caries begins, labour under the disadvantage of suggesting an innate tendency of the teeth to take on the process of decay spontaneously. What, however, apart from configuration, does the term " innate tendency of a tooth to decay " mean ? Neither more nor less than the degree to which the lifeless enamel offers resistance to fermentation-acid.[1] When, however, we come to test the reaction of different types of enamel to acid, we find that they all react in precisely the same way. (The like is true of the cementum where, more rarely, caries may begin.) So far, then, as the initiation of caries is concerned (the event which, above all others, we wish to prevent in our efforts to stamp out dental caries) our great aim must be to concentrate on oral hygiene : *all teeth* (apart from their configuration, which

[1] Unless we postulate with MacPhee the existence in the enamel of circulating lymph capable of immunising a *contagium vivum*, a highly problematical assumption.

is responsible for the existence of retention areas) *are equally susceptible to caries.*

Susceptibility of the Dentine to Caries. So far as the *initiation* of dental caries is concerned, the dentine, buried as it is beneath the enamel, does not come into consideration. The dentine and pulp differ sharply from the enamel in being actively living tissues, and when the carious process extends to the dentine, this structure, aided by the pulp, does its limited best to check the morbid process, sometimes more effectually than others, so that it is correct to speak of the dentine as offering resistance to decay. This resistance, as M. Mellanby has shown, may be influenced by the amount of vitamin D circulating in the blood.

So much may be conceded, but this does not justify us in taking the resistance opposed by the living dentine to caries as a criterion of the resistance of the tooth as a whole. Some qualification, therefore, is needed of the contention that the resistance of the living tooth " is indicated (measured) by the presence and the character of the secondary dentine . . . well-developed secondary dentine indicates good resistance, fully calcified, poor resistance," for this rarely does more than delay the ultimate destruction of the tooth. The resistance here referred to is that of the dentine *after the great event in the drama has occurred, i.e.*, the corrosion of the enamel which is wholly incapable of offering resistance to the disintegration of fermentation-acid, *i.e.*, to the initiation of caries.

In short, such vitality and vital resistance to decay as the tooth possesses belong to the dentine (aided by the pulp) alone ; the dentine cannot prevent the initiation of caries, nor is its resistance of a kind which the dentist can rely on to effect a cure. We are brought back to the fundamental importance of oral hygiene : keep the teeth clean, prevent fermentation-acid from attacking the enamel, once decay has begun insert a filling, put no faith in the remote chance that the resistance of the living dentine will effect a cure.

In 1912 Beust revived the original view that the immunity to caries " observed in some teeth resides within the tooth itself " ; attributing the immunity to the formation of antibodies within the teeth.[1] No mention is made of the possible influence of such factors as the presence or absence of retention areas, the position of the teeth in the mouth, and the absence of opposing teeth (see p. 235 *et seq.*).

Fish (1926) suggested the possible existence in the blood of substances conferring protection against dental caries.

Graham MacPhee (1936) claims to have produced experimental evidence in support of this view. He hints at the existence of a *contagium vivum* in the shape of an ultra-microscopic *virus* which travels along " the extremely minute vascular channels," and at the possibility that we may some day be able to " measure the individual's immunity from dental caries " (" Studies in Ætiology of Dental Caries," 1936).

These investigations are of interest, but it is difficult to conceive how antibodies circulating in the dental pulp can find their way to the superficial layers of the enamel where caries begins, or how, having reached that region, they can prevent a decalcifying acid from corroding the enamel. Be this as it may, the antibody immunity here postulated has no practical significance. What we find as a matter of experience is this —if children are nurtured on a system which ensures perfect oral hygiene, their teeth do not decay, whereas if they are nurtured under conditions which do not ensure a high level of oral hygiene we may expect caries to occur.

Broderick, while admitting that fermenting carbohydrate is the exciting cause of dental caries, contends that this factor is only operative in the presence of a predisposing cause, which he regards as the more important of the two, on the ground that it is the more readily dealt with. This predisposing factor he assumes to consist in a lowered alkalinity, or actual acidity, of the saliva, due to an accumulation of acid in the system, a condition which, when pronounced, is known as acidosis.

Broderick maintains that a highly alkaline saliva tends to go with sound teeth, a low alkalinity, or actual acidity, with dental decay. It is argued that, given the immunity to dental caries conferred by a highly alkaline saliva, oral hygiene is unnecessary ; and that, on the other hand, with the susceptibility to caries induced by low salivary alkalinity or actual acidity, oral hygiene is of no avail : " no matter how carefully stagnating foodstuffs are removed from the teeth, the incidence of caries will not be affected "—an argument which appears to be self-contradictory ; for if the necessary exciting cause of caries is removed, how can caries be induced ? (To which Broderick would probably retort " perfect hygiene is not possible," therein differing from the school of oral hygienists.)

[1] Antibodies are chemical substances which counteract the injurious effects of pathogenic micro-organisms and their products.

In order to put this hypothesis to a scientific test, it would be necessary daily for a series of years to test, in a number of subjects, the average salivary reaction (which may vary from day to day, from hour to hour), and to compare the results with the dental records in respect of caries.

It seems, on the face of it, in the highest degree improbable that the appalling prevalence of dental caries among the British is essentially dependent upon a sub-normal alkalinity of the saliva. On the other hand, it is no mere probability but a proved fact that, if fermenting carbohydrate is prevented from being persistently maintained in contact with a tooth, by a system of adequate oral hygiene, dental caries does not occur.

As to acidosis—should this occur, it is, as a matter of course, treated by the medical man quite apart from the presence or absence of dental caries.

Arrested Caries. Sometimes dental caries undergoes spontaneous arrest. Some dental pathologists maintain that the small patch of decalcified enamel, which constitutes the first stage of the carious process, may be re-calcified by the deposit of calcium salt from the saliva. Caries affecting several teeth is known to undergo, at times, spontaneous arrest as the result of changed oral conditions of which we have no certain knowledge. M. Mellanby reports the arrest of dental caries in children (associated with the formation of richly-calcified secondary dentine), brought about by an increased provision of vitamin D (see note, p. 206).

Cases of arrested caries are, however, exceptional, and have little or no bearing on practical dentistry. In the vast majority of cases, a decayed tooth, left untreated, continues to decay until it is entirely destroyed. This is largely on account of the difficulty of maintaining a clean carious surface—a manifestly impossible achievement in the case of a cavity with overhanging enamel walls. When, however, these have been extensively destroyed, and perhaps somewhat worn down by attrition, thus freely exposing a carious dentinal surface, the conditions are more favourable for cleansing the surface and the arrest of the carious process.

That the cleansing of a carious area favours such arrest is shown by the fact that, when a small patch of caries has affected opposing surfaces of adjacent teeth, extraction of one of the affected teeth, by affording opportunity for cleansing the carious surface of the other, may check the carious process.

Investigation of Marshall Day and H. J. Sedwick. The work was carried out on public school children (Rochester, U.S.A.) averaging *æt.* 13. The experimental group numbered 147, the controls 171. Three detailed inspections were made at intervals of six months, radiography being employed in the first and final examinations. Six tablets, all seemingly alike, were given daily to each of the children, but those supplied to the experimental group each contained vitamins A and D equivalent to three teaspoonsful of cod-liver oil reinforced with viosterol, whereas those given to the control group lacked the vitamin addition. No beneficial dental effects were discoverable in the experimental group.

(*For first investigation, see p.* 208.)

CHAPTER XIX

ORAL HYGIENE

Mouth-Cleansing Foods

The aim of oral hygiene is cleanliness of the mouth. The oral hygienist, in his endeavour to prevent dental caries, concentrates his efforts on mouth-cleanliness ; he maintains that the intimate structure of the enamel cap may, for all practical purposes, be said to have no influence on the liability of a tooth to decay, and that the inherent liability of a tooth to decay depends essentially upon the degree to which the enamel cap, by virtue of its configuration, affords opportunity for the lodgement of fermentable food.

In order to prevent decay of the teeth we must adopt measures calculated to keep the mouth and teeth clean between meals, so that no opportunity shall be given for the development of fermentation-acid—the corroding action of which, all enamels, whatever their intimate structure or degree of calcification, are equally impotent to resist. The maintenance of clean enamel is much the most important factor in the prevention of caries.

To Black we owe the aphorism : " *a clean tooth never decays,*" but it was reserved for Sim Wallace, at the beginning of the present century, to work out the principles of oral hygiene, and to show how nature had throughout the ages evolved special mechanisms for keeping the enamel caps clean. In wild animals living on " natural " foods, *i.e.*, raw animal and raw uncultivated vegetable foods, these mechanisms suffice to keep the mouth and teeth clean, but among neo-civilised peoples living on highly artificialised, soft, farinaceous foods, and consuming an abundance

of sugar, they do not suffice, unless the principles of oral hygiene are appreciated and conscientiously put into practice.

For the following brief account of oral hygiene, I am mainly indebted to the writings of Sim Wallace. It will be convenient to treat the subject under the following heads :—

The Need of Efficient Mastication.
The Muscular Mechanisms Concerned in Oral Hygiene.
The Secretions of the Mouth.
The Cleansing Action of Phagocytes and Proteolytic Bacteria.
Types of Food in Relation to Oral Hygiene : Mouth-Cleansers, Mouth-Soilers.
Oral Hygiene as Influenced by the Proper Spacing of the Meals and the Proper Sequence of the Individual Courses of a Meal.

The Need of Efficient Mastication. A first requisite for ensuring cleanliness of the mouth and teeth is the possession of well-developed jaws, which shall enable the teeth to erupt without being too closely jammed together, or forced into irregular positions. An irregular arrangement of the teeth is incompatible with perfect oral hygiene ; the correct placing of the teeth is essential to normal occlusion, and without this, normal mastication (which implies the unhampered capacity both for *pounding* and *grinding* the food) is not possible. Contracted jaws, leading as they do to irregularity of the teeth, thus jeopardise all the many benefits which accrue from efficient mastication : the teeth themselves are deprived of the benefit of the normal grinding down of prominent cusps, and burnishing of the roughness and irregularities normally present on the circumferential surfaces of the enamel (retention areas being to this extent reduced) ; and the sockets are bereft of the stimulus afforded by the vigorous rocking of the dental roots attendant upon normal mastication, an essential condition for the normal growth of the socket-bone and the maintenance of a healthy socket-membrane (*i.e.*, freedom from pyorrhœa).

In order to secure normally developed jaws and tooth-sockets, the child should, if possible, be breast-fed. Especially important is it to secure normal eruption of the teeth first to erupt, namely, the incisors, for upon this depends the normal eruption of the other temporary teeth, a pre-requisite to the normal eruption of the permanent teeth.

Normal development of the jaws requires that the diet shall contain a sufficiency of food which compels vigorous mastication. We need to remember that mastication, as distinguished from mere biting, consists of *pounding* and *grinding* the food, the one by a vertical movement, the other by a lateral movement of the lower jaw ; grinding is employed for the coarser forms of vegetable food only.

Vigorous mastication stimulates the flow of saliva and mucin, secretions which play a necessary part in cleansing the mouth and teeth. It causes the roots of the teeth to move in their sockets both vertically and horizontally, thus promoting the nutrition of the socket-membranes, the bony sockets, and the gum-margins. Furthermore, efficient mastication ensures (*a*) adequate friction of detergent foods against the teeth, thus cleansing and polishing them, and (*b*) the friction of the occlusal surfaces of the teeth against one another, and consequent wearing-down of the cusps of the grinders and the biting edges of the incisors.

The Muscular Mechanisms Concerned in Oral Hygiene. Besides the muscles which move the lower jaw those of the tongue, lips and cheeks are concerned in mastication. These muscles are employed in moving the food within the mouth : thus the tongue and the cheeks convey the food from one side of the mouth to the other, enabling it to come alternately under the action of the teeth of one and the other side, so that both sides shall take an equal share in the work of mastication. While the food is being masticated on one side, the grinding movement of the lower jaw takes place towards the opposite side. The tongue, lips and cheeks all play their part in conducting the food to the back of the mouth

preparatory to swallowing it. In the intervals of mastication during a meal, and for some little time immediately after, these muscles act as mouth-cleansers, removing particles of food from the teeth, gums and outlying regions of the mouth. The cleansing of inaccessible areas, such as the pits on the grinding surfaces of the molars, and the spaces between the teeth, is mainly effected by the flushing of the abundant flow of saliva induced by vigorous mastication. The cleansing action of the tongue on the teeth is most efficient in respect of their lingual aspects where caries rarely occurs (provided the gum-margins are healthy), an eloquent testimony to the influence of *cleanliness in keeping the teeth free from caries*. Similarly caries rarely begins in the two thirds, as measured from the biting edge, of the labial surfaces of the front teeth, those areas, namely, which are kept clean by the constant movement of the lips. That portion of the enamel of these teeth nearest the gum-edge comes but little under the cleansing action of the lips. Hence caries from marmalade (and the like) is not rare in this region of the upper front teeth, while tartar deposit in the corresponding region of the lower front teeth is quite common.[1]

The Oral Secretions. Two secretions are yielded by the mouth —saliva and mucin, the two being intimately mixed together.

Saliva is an alkaline fluid containing, besides mucin, certain salts and a ferment, ptyalin, capable of digesting starch. It is secreted to the amount of about 2 pints in the twenty-four hours. The secretion is most abundant during mastication ; between meals it is just sufficient to keep the mouth and throat moist, thus facilitating speech ; during sleep it is still further diminished, so that sleeping with the mouth open causes excessive dryness of the mouth and is apt to produce " a nasty taste in the mouth." The flow of saliva is increased by acid foods, sugar, and bitter substances ; also by the smell or taste of appetising foods.

[1] See further on this subject, p. 235, under the heading, " Relative Frequency of Decay Occurring on the Different Surfaces of the Teeth."

Certain of the salivary salts may be deposited on the enamel in the form of dense *tartar*, which should not be allowed to collect, because it tends to set up pyorrhœa. It has been suggested that the calcium salts of saliva may be deposited on parts of the enamel which have been softened by fermentation-acid.[1]

Saliva mixed with mucin forms a *ropy fluid*, *i.e.*, one capable of smearing (adhering to) surfaces (*e.g.*, enamel) with which it comes into contact. One of the functions of this ropy saliva appears to be to gather up particles of food from the outlying regions of the mouth and from the recesses about the enamel-caps over which it forms a film. Under the influence of acid food, such as raw fruits and salads, the ropy adhesive film curdles and becomes flocculent, when it is so much the more easily removed by the combined action of friction and the flushing of watery saliva. The intimate insalivation of the food with ropy saliva brought about by vigorous mastication is said to help digestion in the stomach by enabling the gastric juices to reach individual particles of the food. The more vigorous the mastication, the greater the flow of saliva. The entrance of saliva into the stomach may further promote gastric digestion by virtue of its alkalinity.

The Cleansing Action of Phagocytes and Proteolytic Bacteria. While the saliva provides ptyalin, the chief function of which would appear to be to liquefy particles of starch left in the mouth after a meal (Sim Wallace), no secretion is provided for the digestion of protein food similarly needing liquefaction within the mouth. Disintegration and liquefaction of this protein, as well as the protein of mucin and desquamated epithelium, is effected by (*a*) phagocytes from the blood ; and (*b*) proteolytic bacteria.

(*a*) Cells endowed with phagocytic powers are met with in the saliva. It is thought that they pass from the blood into the gum-sulci surrounding the necks of the teeth, and that their

[1] According to Patison, vitamin D may increase the calcium salts in the saliva. This might conceivably favour the deposition of calcium salts on the enamel.

function is to cleanse a region of the teeth very apt to become dirty.

(*b*) Proteolytic bacteria dissolve mucin (which is a protein), desquamated epithelium, and protein particles of food, by a putrefactive process ; note that, unlike the fermentation-producing bacteria, these putrefactive bacteria give rise to an alkaline reaction.

From the standpoint of oral hygiene we may, with Wallace, classify foods into those which cleanse the mouth (mouth-cleansers), and those which tend to leave it dirty (mouth-soilers).

Mouth-cleansing Foods. These include *accessory foods acting chemically* and *detergent foods acting mechanically*. Regarding the former class it is necessary to point out that, at the end of the last century, students of dietetics focused their attention all too exclusively on what they termed nutritious foods. Wallace pointed out that a normal diet also contained accessory foods, *i.e.*, foods other than those, such as proteins, fats and sugar, which yield energy. Such accessory foods are all of the cleansing variety.

Man shows his desire for foods of this nature by his love of condiments—pickles, piquant sauces and the like. Long before he learnt to brew alcohol, he gathered stimulating herbs and berries and mixed them with his food. All the most primitive tribes of the world resort to substances of this kind. As an instance I may cite the practice among the Australian aborigines of chewing pitchery, a vegetable substance to gather which they travel long distances, and that of chewing betel, so common among the savages of the Pacific Islands.

The chemical accessory foods include acid, pungent, aromatic and bitter substances, the effect of which is to stimulate the flow of saliva and mucin and thus to aid in the cleansing of the teeth and oral mucous membrane. Notably is this true of raw acid fruits and salads.

Wallace includes under accessory foods roughage or ballast, which acts mechanically, and which has been too much neglected. It consists of fibrous food containing an abundance of undigestible cellulose which promotes mastication and stimulates the intestinal tract. Monkeys deprived of a due complement of cellulose are apt to develop serious digestive disorders.

Next, as to detergent foods, those which by reason of their fibrous (fibrillar) texture promote mastication and the associated mouth-cleansing activities.[1] By their friction against the teeth in the act of mastication they exercise a detergent effect, removing from the enamel the mucous film charged with food particles and bacteria, leaving a clean, polished surface ; in this they are helped by the copious salivary flow excited by the vigorous mastication.

Detergent foods may be either animal or vegetable.

All flesh foods—meat, fish, poultry, fat (which facilitates the removal of food particles from the mouth)—are detergent.

All raw vegetable foods tend to leave the mouth clean—fruits (apples, pears, oranges, plums, nuts, etc.), and raw salad foods (lettuce, watercress, cucumber, onions, tomatoes, celery, radishes, carrots, peas, heart of cabbage, etc.).

Such raw acid foods stimulate the flow of alkaline saliva and exercise a detergent effect upon the teeth, and they tend to beget a pleasant sense of cleanliness in the mouth. As mouth-cleansers they are best taken at the end of a meal. One of the most effective cleansers is a raw apple : an infant may be allowed to bite at an apple directly its incisors are through. Why cheat a fully erupted tooth of its proper function ?

" Contrast apple with cake, or chocolate pudding composed chiefly of starchy flour and sticky sugar. Observe how they clog the crevices of the teeth, especially of the hindermost molars ; note the absence of the mop to promote the flushing of the saliva between the teeth, note the absence of the clean, fresh feeling which should be present at the end of a meal ; note, in addition, the somewhat viscid, or clammy sweetness which lingers in the mouth ; look carefully at the crevices in the hinder

[1] See also Part I, Chapter XIII.

teeth, and note not only that they are dirty, but that the carbohydrates left are rapidly fermentable " (Sim Wallace).

Among *cooked* vegetable foods only the baked varieties are mouth-cleansing ; well-baked crusty bread, made of flour not too finely milled, is mouth-cleansing. Typical English loaves, consisting as they do of a maximum of doughy crumb, and a minimum of ill-baked crust, are to be condemned. Loaves should be bun-, spindle- or cylinder-shaped, thus ensuring a maximum of crust, and they should be well baked. Such bread compels thorough mastication, and can be eaten with impunity and relish, hot from the oven. With a liberal supply of fresh butter, what more acceptable ?

Well-baked wheaten bread is the ideal form of cereal food. Oatmeal made into solid forms is good, but lacks (some may think) the delicate flavour of wheaten bread. Wheat is the prince of cereals : apart from its delicate flavour, it alone among the cereals is sufficiently rich in gluten to make good leavened bread.

CHAPTER XX

ORAL HYGIENE (*continued*)

Mouth-Soiling Foods

Modern foods derived from the vegetable kingdom are apt to be unduly soft and non-detergent; by cultivation much of the pristine coarseness of "roots" and grain has been got rid of, the roller-milling of grain has led to a variety of refined flours, and again, many forms of vegetable foods are softened by cooking; the total effect has been not only to reduce the work of the jaws and teeth, but also to diminish the detergent, cleansing effect upon the teeth of foods derived from the vegetable kingdom. In our own country, especially, there is a regrettable lack of cleansing detergent vegetable foods which compel vigorous chewing. Wallace emphasises "the incongruity of bringing up children on a pappy milk diet, *though their teeth might be better* adapted for a tough diet than those of many adults" (my italics).

Mouth-soiling Foods. These are all of the vegetable order.[1] They include all boiled cereal foods such as suet pudding, roly-poly, and milky puddings made of rice and such non-cereal foods as sago and tapioca. To these must be added oatmeal porridge as usually prepared in modern hotels. The chief offenders in this country are foods made of highly refined wheaten flour, such as spongy bread, buns, scones, puddings, rich cakes and tarts. The addition of sugar to foods composed of highly-refined flour increases their stickiness and their tendency to cling to the teeth.

[1] See also Part I, Chapter XIII.

The most pernicious mouth-soiling foods are those containing an abundance of concentrated sugar—jams, marmalade, treacle, golden syrup, honey, and sweets (especially those of a consistence rendering them liable to be jammed into retention areas, such as the intervals between the teeth and the pits and crevices on occlusal surfaces of the cusped teeth).

Loaf sugar by itself is readily dissolved in the mouth, and does not necessarily leave it dirty. The chewing of sugar cane by native workers in sugar plantations does not cause the teeth to decay. This is not surprising, seeing that a whole foot of the cane yields but little sugar, which is, moreover, in a well-diluted form, and is still further diluted by the copious flow of saliva induced by the vigorous chewing needed to extract the juice. Thus diluted no sugar is left lingering in the mouth.

Sugar as a Mouth-soiler and Cause of Caries. The evidence that sugar is a potent cause of dental caries is overwhelming, and the public should be made to realise this. There must be no misunderstanding about so important a truth. As early as 1530 —four centuries ago—a book on " Diseases of the Teeth " (Zeeny Artzei) was published against " Sweet Foods Easily Retained in the Dental Spaces." More than two centuries later Pfaff (1736) and Ovelgrum (1771) commented on the frequency of bad teeth among confectioners.

In proof of the causal relation between sugar and caries, the following authorities may be cited (for the italics employed, I am responsible).

F. Breese tells of a patient who came to him in 1916 " for a final inspection before leaving for France (to meet there a little later with his death). For many years he had been a regular visitor, and on this occasion, after doing what was required, I counted the number of fillings in his mouth which reached the unique figure of seventy-six. I said to him, ' you have often told me, in reply to my questions, that you are fond of sweets . . . tell me how fond of them you really are.' Poor fellow, he actually blushed, and he said, ' you know I don't drink, and I don't smoke, but I always have a packet of sweets in my pocket, and I am at them all day long '."

The same authority instances the case of a chimpanzee who refused to go through his stage tricks on account of toothache. The animal being anæsthetised " a widespread condition of caries was found," and Mr. Breese " was referred to the pockets of the animal's keeper which were bulging with sugar. It appeared that the patient had to be continually bribed with sugar at all stages of the practice and public performance, with the result of extensive caries."

Breese comments upon the comparative freedom from caries under the Old Poor Law *régime*. On entrance the dental troubles of the children were rectified. Thereafter they " had little opportunity of cultivating the sweet-eating habit. . . . Contrast this state of things with what one finds in the London elementary school children ; think of the melancholy state of the teeth we constantly find in little children of four and five years of age, *where every copper they can obtain is spent in cheap sweets*, where there is very generally also no care to send the child to bed with a clean mouth and teeth."

F. S. Dunn found dental decay, tartar, and infected gums prevalent in children belonging to institutions where the dietary contained an abundance of soft starchy food, and was deficient in the more cleansing kind. On the other hand, in a school for the deaf and dumb, where the children were supplied with detergent food, and fruit given daily after each meal, the condition of the children's teeth was excellent.

Cory Mann cites the case of a boys' school where the diet was of low caloric value and deficient in A, C, D. The boys were not allowed *to spend their money on sweets*, but only on fruit. Caries was practically absent.

Bunting (America) and his colleagues found that the feeding of a large group of his children for one year on a well-balanced diet from which *practically all sugar and candy had been eliminated*, resulted in a marked reduction in the incidence of caries and of the growth of *Bacillus acidophilus*.

The late Dr. James Wheatley, the Medical Officer of Health for Shropshire, examined some 30,000 children. He divided them into four classes according to the amount of sweets they were reported to eat, and it was found that the extent of caries detected bore a direct ratio to the amount of sweets consumed : *caries was five times more numerous in the class consuming sweets than in the class consuming no sweets*. This enthusiastic worker succeeded in increasing the number of school entrants with perfect teeth from 0·5 to 4·9 per cent. in ten years. Commenting upon Wheatley's crusade, Wallace writes : " In England there had been a reduction in the number of carious teeth in school children of considerably more than 10,000,000 teeth."

During the war, *when sugar was relatively scarce*, when bread was unusually coarse, and when crusts were eaten instead of being cut off and thrown away, the incidence of caries underwent a marked reduction.

We learn from Cambridge Borough Report that between 1917 and 1924 the percentage of caries met with in the five-year-old group of children in the borough fell steadily from 35 to 12, and from 1922 to 1929 it had risen to 21, in spite of " the increase of cod-liver oil."

The Lure of the Sweetstuff Shop. The sweetstuff shop has the same lure for children as the public house has for many of their elders. When nothing else will induce an ultra-shy child of the poorer class to come to you, the sight of a penny held up rarely fails to act as a charm ; overcoming all scruples, the child (perhaps barely able to walk), slowly draws near, puts out its hand to receive the magic copper, and toddles off to the nearest sweetstuff shop.

Sugar, when occurring in natural combinations, is good. Nowhere in nature, not even in honey, is it met with in the pure, concentrated form, while, as I have said, we in Great Britain annually consume 95 lb. of pure sugar per head. When we consider that all the starch we digest enters the blood as sugar, it becomes evident that the additional 95 lb. of sugar annually consumed must sometimes tax our stores of insulin.

We need to remember that pure sugar is not an essential food, but a luxury ; man evolved to the status of *homo sapiens*, endowed with the gift of language and abstract thought, without having once so much as tasted it.

Beyond all reasonable doubt the promiscuous indulgence in sweets is responsible for millions of decayed teeth. In considering the pros and cons of sweetstuffs, we need to balance the transient gustatory pleasure they afford against the harm they do by spoiling the appetite for healthy fare and by damaging the teeth. No sacrifice should be spared to rear a race of healthy children ; and with this object in view we should not allow children the luxury of sweets except under the strictest precautions. The ideal would be—total prohibition.

Carbohydrates and Dental Caries. In spite of evidence such as I have cited, the nutrition school still remains refractory con-

cerning the part played by carbohydrates in causing the great extent of dental caries among us. It is argued that " the commonly accepted doctrine that the high incidence of caries is mainly due to the extensive use of carbohydrates, and especially fermentable carbohydrates in the diet . . . cannot at the present time be regarded as established on a basis of scientific evidence ; all practical rules for ' oral hygiene ' based on this doctrine must therefore be tentative in character ; their value, if any, can only be established by controlled observation." [1]

This experiment has, however, been made over and over again : the diet may be varied in an infinite number of ways, but if it contains no carbohydrates, caries will not be initiated. A sufferer from diabetes when limited to a diet devoid of carbohydrates ceases to develop new carious foci : here the sole variable is carbohydrate food. Equally convincing is the freedom from caries of Esquimaux peoples, who consume little or no carbohydrates, but who, when they come into touch with civilised conditions and indulge in neo-civilised diet, containing abundance *of carbohydrates in forms tending to leave the mouth dirty*, very soon suffer from dental caries.

M. Mellanby stresses the fact that carbohydrate can be consumed plentifully without setting up caries. This is no doubt true under conditions tending to leave the mouth clean. Its truth is evident from the fact that Man has evolved on a diet which from pre-mammalian times has included a liberal supply of carbohydrate food. Again, extant pre-agricultural peoples consume carbohydrates in plenty and yet suffer very little from caries, but these people achieve a far higher level of oral hygiene than we : they subsist largely on " natural " foods. The same investigator cites, as tending to show that the oral hygienist exaggerates the *rôle* of carbohydrate in the causation of dental caries, several instances of civilised and semi-civilised peoples in

[1] " Diet and the Teeth." By May Mellanby, Medical Research Council, 1930, p. 52.

different parts of the world who indulge freely in carbohydrates, and yet suffer comparatively little from caries, but in all these cases it is not difficult to show that the diet, as recorded, is compatible with a comparatively high level of oral hygiene.

Let any one from early years consume a diet requiring little mastication and consisting largely of refined white flour sweetened with sugar, and in addition let him indulge freely in tenacious sweets and sparingly in such cleansing foods as raw fruit and salads—and it is certain that caries will develop to a disastrous extent, no matter how plentiful the supply of milk, butter, eggs, cod-liver oil or sunshine.

The view of the nutrition school that the relative frequency of dental caries among different peoples is determined essentially by intimate dental structure, and little, if at all, by the degree of oral hygiene achieved in no wise accords with available evidence. There must be no mistake on this question.

Oral Hygiene as Influenced by the Proper Spacing of the Meals, and the Proper Sequence of the Individual Courses of a Meal. A factor influencing oral hygiene is the length of time between consecutive meals. The mouth-cleansing mechanisms continue to operate for some time after a meal, gradually disposing of the particles of food left behind in the mouth, thus leaving the mouth clean for the succeeding meal. If the meals follow one another too soon, or if snacks of food or sweets are taken between meals, the mouth is not afforded an opportunity for normal auto-cleansing.

The factor of appetite also has to be considered in spacing the meals. The interval between meals should be long enough to allow a healthy appetite to develop. That hunger is the best sauce is true in more senses than one. Not only does a keen appetite heighten the relish of food, but as the great physiologist Pavlov has shown, the eating food with appetite and relish favours the secretion of appropriate digestive juices.[1]

[1] I am told that in London slumland the majority of children have little appetite for breakfast. Some have a cup of tea only, and bring to school a

Classification of British Vegetable Foods Considered Oral-hygienically

Rough Table of British Foods

Vegetables.		Fruit.		Salads.	Cereals and Starch (Farinaceous).				Sugar.
Greens	Cabbage Spinach etc.	*Cooked :* Jam Stewed Baked	*Uncooked :* Oranges Apples Plums Bananas etc. *Dried :* Figs ? Dates Raisins Prunes Nuts	*Uncooked :* Tomatoes Onions Cucumber Celery Olives Radish Endive Lettuce *Cooked :* Beetroot Celery etc.	Bread Scones Buns Sponge-cake Tea-cake Fancy cakes	*Boiled or Steamed Puddings :* Suet Batter Currant *Baked :* Batter Pancakes	Bread and milk Porridge Arrowroot Gruel *Milky Puddings :* Rice Semolina Sago Tapioca Vermicelli	Rusks Biscuits Pastry Shortbread Cake	Loaf Moist Treacle Syrup Honey Sweets
Roots	Potatoes Carrots Turnips Onions								
Pulses	Peas Beans Lentils								
Stalks	Celery Seakale								
Unfavourable to mastication.		Cleansing to teeth.			Spongy.	Pultaceous.	Pappy.	Powdery.	Sticky.
					Consumed abundantly by the British. For the most part spongy, pappy, pultaceous, or sticky.				

Again, the proper sequence of food in a meal is of importance from the standpoint of oral hygiene. The meal should never terminate with food (such as roly-poly) which leaves the mouth dirty, but always with a detergent, cleansing food, in which class raw salad and fruit stand supreme.

Of all foods, salads and raw fruits are the most cleansing.

In regard to the table, p. 232, it is doubtful whether dried figs, dates, raisins and prunes can be said to exercise a cleansing effect on the teeth. In any case, these foods are only moderately consumed in the dried state by the British people.

piece of cake to eat at play-time (10.30 a.m.). These children often have " supper " late, not going to bed until ten or eleven o'clock, and they sleep in overcrowded ill-ventilated rooms.

CHAPTER XXI

OTHER FACTORS CONCERNING ORAL HYGIENE

Individual Differences Respecting the Mouth-cleansing Function. Considerable individual differences are met with in regard to the efficiency of the mouth-cleansing function. These differences may be grouped under three headings—anatomical, physiological and temperamental.

Anatomical. Some may have good occlusion and teeth presenting a minimum of retention areas: in such, the teeth are easily cleansed. In others, the teeth may be overcrowded, irregular, and possessed of long cusps and a maximum of retention areas; in such, the teeth, even with the utmost care, cannot be cleansed effectively.

Physiological. Differences may exist in regard to the efficiency of the salivary and mucous glands, and the resistance which the mouth offers to pathogenic micro-organisms. Considerable constitutional differences may exist in these respects: the better the general health the more likely are the mouth-cleansing mechanisms to function efficiently.

Temperamental. Some, as the result, it may be, of temperament, nurture, or habit, masticate their food efficiently, bringing their entire mouth-cleansing machinery into full operation during and immediately after meals; others hurry over their meals and fail to bring that machinery into use; in such the mouth is apt to be left dirty between meals.

Wallace cites the case of two brothers, A and B, about the same age. A, *æt.* 18½, had large, broad, well-formed teeth, and the *cusps of the molars and bicuspids were well-worn in spite of his youth*, showing good

occlusion and good habits of mastication. No caries was present, and the cultures failed to yield *Bacillus acidophilus*. In this case the mouth-cleansing mechanisms had free scope to function normally. In the case of B, *æt.* 20, the molars and bicuspids displayed long (unworn-down) cusps (and presumably defective occlusion), clear evidence of inefficient mastication and consequent inadequate functioning of the mouth-cleansing apparatus. In contrast to A, considerable caries was present, and cultures gave evidence of *Bacillus acidophilus*.

Many years ago Breese showed that, " in a large group of children living under the same conditions and eating the same food, on inspection after meals, the amount of food lodging about the teeth differed greatly in different children, but was fairly constant for each individual child . . . some children were blessed with something in the nature of a self-cleansing mouth, while others were not." He further showed that it was children with the least clean mouths after meals that had the most caries, and moreover, that the sites of the caries corresponded with the sites where the food lodged. He also found that foods varied in their liability to lodge, apples being among the least liable.

Position of the Teeth in the Mouth as Influencing the Incidence of Decay. From the standpoint of mouth-cleanliness, the front teeth are better placed than the back. The tongue has a wider range of movement, and the lower jaw a wider lateral swing, in front than behind—features which give the front teeth an advantage in the way of cleanliness.

Food is somewhat more apt to accumulate about the necks of the lower teeth than the upper.

The propinquity of the openings of the sublingual gland ducts to the lower incisors helps to explain the tendency for tartar to form on these teeth, and their comparative freedom from caries.

Macitot gives the comparative frequency of caries in the upper and lower incisors and canines.

The Relative Frequency of Caries in the Different Types of Teeth. The molar teeth are the most liable to caries ; of these the third molars, or wisdom teeth, are the most liable. The incisors are the least liable, the canines somewhat more liable.

Relative Frequency of Decay Occurring on the Different Surfaces of the Teeth, and of the Different Types of Teeth. This has been carefully investigated by C. B. Marshall Day and H. Tabe

Sedwick (*Dental Cosmos*, May, 1935), and with results which strikingly confirm the teaching of the oral-hygiene school.

Investigations were made on 433 children having an average age of thirteen, only one of whom was free from caries.

The following table, compiled from the author's paper, summarises their findings, and shows, in a most striking way, that the regions of enamel *selected for the initiation of caries bear no relation to enamel structure, but are determined by the situations at which fermentable food is most apt to linger*. There is no evidence whatever that the sites of election are sites of subnormal resistance of enamel to acid. This evidence supplements that afforded by the chocolate test (see p. 212).

		Cavities	Cavities
On the *Occlusal* surfaces of molars and bicuspids		4,873	4,873
On the *Inter-dental* surfaces . . .		2,222	2,222
			= 7,095
On the *Lingual* surfaces . .	Upper **783** Lower 31	814	
On the *Buccal* surfaces . .	Upper 70 Lower **532**	602	
On the *Labial* surfaces . .	Upper 10 Lower 0	10	Cavities = 1,448
On the *Incisal* (biting) surfaces .	Upper 14 Lower 2	16	
On the *Cervical* surface . .	6	6	

The comparatively large number of cases of caries on the lingual surfaces of the upper, as compared with the lower teeth, is probably to be explained, partly at least, by the peculiar conformation (frequently met with) of the lingual aspect of the lateral incisors, one, *i.e.*, calculated to retain the food. The large excess of caries on the buccal surfaces of the lower teeth (those facing the cheeks),

pertains to the molars and bicuspids, and is explicable by the fact that the upper teeth in this region, somewhat overlapping as they do their opponents on the buccal side, tend during mastication to force the food downwards on the buccal side towards the gum margin, where non-detergent food is apt to lodge. As regards the front teeth, which come under the cleansing action of the lips, the upper incisors are more prone than the lower to decay on the labial surface at the gum-margin, because the lips are apt to fail in cleansing the upper incisors effectually at the gum-margin.

Unopposed Teeth. Such teeth are at a great disadvantage both as regards caries and pyorrhœa. Normally, all the teeth are subjected to pressure strains—the front teeth in the act of biting (greatly lessened since the introduction of knives and forks), the back teeth during mastication, *i.e.*, by pounding and grinding. The great importance of these periodic strains, as regards the health of the teeth and their sockets, as well as the gums, is apt to be overlooked: they stimulate the circulation in the socket-membranes, the socket-bone, and the gums, and at the same time promote the flow of saliva. Disuse of a tooth from lack of an opponent causes it to become dirty, especially at the neck, and gradually to emerge from its socket; sooner or later the gum-margin and socket-membrane inflame, the tooth in course of time loosens and finally is shed.

One-sided Mastication. This may result from tenderness of a tooth (*e.g.*, from decay) on one side, or from absence of opposing teeth on one side: the usual results of disuse follow. In unilateral disuse, the tongue tends (through lack of friction) to be coated on the disused side.

Irregularity of the Teeth as Influencing Dental Caries. Teeth properly placed in the gums—an ideal which can only be achieved in fully-developed jaw-bones—provide the anatomical conditions most favourable to oral hygiene, inasmuch as normally arranged teeth enable the mouth-cleansing mechanisms to operate to the best advantage. If the jaws are not big enough to permit this ideal,

the teeth are in consequence too closely jammed together to allow the inter-dental spaces to be cleansed efficiently; or they may even be thrown out of their normal alignment, causing (perhaps) one tooth to overlap another, and rendering adequate cleansing of the teeth still more difficult.

Such conditions not only make it difficult to clean the teeth properly by artificial means (the tooth-brush, tooth-pick and silk thread), but they hamper the normal functioning of the mouth-cleansing mechanisms: irregular teeth are incompatible with normal occlusion, without which normal mastication is not possible. Vigorous mastication favours oral hygiene in two ways —by inducing a free flow of tooth-cleansing saliva, and by providing adequate friction of the teeth by means of detergent cleansing foods, both of which advantages are in some degree sacrificed if the teeth are irregular and occlusion defective.

CHAPTER XXII

THE MAINTENANCE OF CLEAN TEETH

THE child should be brought up on a diet calculated, by the efficient mastication it promotes, to ensure normal development of the jaws and a normal arrangement of the teeth. Efficient mastication implies that the cereal food should be mainly in the form of well-baked crusty bread, or some such bread as rivita, rather than mushy puddings or spongy scones, buns and the like. The last food consumed at each meal should be of a kind tending to leave the mouth clean, such as fruit or salad. No food or sweets should be eaten between meals. The occlusal surfaces of the cusped teeth—molars and pre-molars—should be brushed with a moderately hard tooth-brush thoroughly every night before getting into bed, with the object of dislodging all food from the pits and crevices on these surfaces. By this simple process thousands of teeth might be saved from decay.

Were these conditions fulfilled, there would be little need to adopt any further measures for preventing caries: it would become comparatively rare, and a great fall in the incidence of pyorrhœa would likewise ensue. This statement applies more particularly to early life. In later life there is a progressive tendency for the mouth to get dirty, and special care should be taken to keep it clean; with advancing years we may note, *e.g.*, a tendency for the tongue to be coated, for the gums to recede, and for tartar to collect about the teeth. Nevertheless, tartar may be deposited in quite young subjects.

While, then, if the precautions mentioned are strictly observed, the teeth and mouth will probably remain healthy until early

middle life, it is well, even before this period, to adopt special means to keep the enamel clean. Every day each tooth should individually be cleansed with the help of a hand glass and a good light. A quill, or some pliant instrument of the kind should be employed for dislodging food from between the teeth, this operation being punctuated by frequent rinsings of the mouth with tepid water to which a small quantity of common salt may be added. In addition, a small pledget of cotton wool fixed to a suitable holder may be gently rubbed between the necks of the teeth.

If there is any tendency for tartar to collect round the necks, the affected teeth should be rubbed with a small twig or slip of wood teased out at one end. If tartar continues to accumulate, the dentist should be consulted.

In the young the gum-margin hugs the teeth somewhat closely, leaving but a potential fossa round the necks, and whatever protein finds its ways into this fossa is disposed of by phagocytes, which are said to migrate from the blood for the purpose. When tartar forms it tends to separate the gum-margin from the tooth, spreading down into the socket.

A fairly soft tooth-brush should be used for the labial and lingual surfaces of the teeth, but it is especially the grinding surfaces of the cusped teeth which require the brush, for it is there that the food is so apt to lodge and caries so apt to occur. If the tooth-brush is employed for the outer surfaces (labial and buccal), the movement should be vertical and away from the gum : never should it be transverse ; forcible transverse rubbing tends to wear away the enamel and (eventually) dentine at the gum-edge, especially of the left upper canine and its neighbours (in the right-handed). Teeth have been known to be cut through in this way. For the inner (lingual) surfaces of the teeth the brush should be used in any convenient direction.

For polishing the outer surfaces of the teeth a piece of lint or the plain finger can be used. Dentifrices are rarely called for.

An efficient and harmless cleanser is soap; tobacco ash, used only occasionally and cautiously, is useful for removing slight discolorations due to deposit.

If the teeth are properly cleaned at night, it may not be necessary to do more than rinse the mouth well out in the morning until the water used in the rinsings remains clear. Mouth-rinsing, so far as this is feasible, should be practised after each meal. This post-prandial rinsing might be a routine practice in schools where fruit or salad has not been the last item in the meal. The use of the tooth-brush over the grinding surfaces of the cusped teeth (grinders) every night, would alone, as I have said, lead to great reduction in the incidence of caries.

In health the gum-tissue is pink, thin, hard, and firmly adherent to the enamel; but when the food is of the non-detergent kind, tending to leave the necks of the teeth dirty, inflammation of the gum-margins, recession of the gums, and pyorrhœa are apt to occur.

Gum-brushing. Systematic gum-brushing as a means of keeping the gums healthy, is an admirable practice for those who do not adequately stimulate their gums by detergent foods.

"Brushing can make the gums healthy. If the gums are healthy the teeth will mostly take care of themselves. Few gums are healthy, the reason being that they are not brushed by a sufficiency of detergent foods compelling vigorous mastication. Gums *must* have friction. Every square inch of them, behind and before, should be vigorously brushed with a moderately hard tooth-brush, using a fairly light hand, at least once a day and preferably oftener. Every square inch of the gums, before and behind, should be brushed in this manner with at least fifteen double strokes, *i.e.*, backwards and forwards. . . . The brush should be frequently dipped and actively shaken during the process in saline water. A heaped-up eggspoonful of common salt in half a tumbler of water will suffice. . . . Friction is a

most important part of the treatment of chronic congestion of the gums. Friction is essential when a gum is healthy, to keep it so and to prevent pyorrhœa.

" Gums should be pale pink, hard, tight, attached to the neck of the teeth with a very small amount of free edge and free from tenderness. Friction will induce all these signs and symptoms of health.

" No inter-dental tartar should be present under the edge of the gum. Friction on the gum will prevent its deposit. With proper friction of the gum from childhood up there will be no such thing as pyorrhœa." (Sir Harry Baldwin.)

The friction here so strongly advocated is a substitute for the friction induced by detergent food, notably by raw vegetable food, such as raw fruit and salads. Sir Harry Baldwin, who, to the great regret of many friends, contracted fatal typhoid fever abroad soon after his retirement, strikingly illustrated in his own person the benefit to be derived from the routine practice of gum-brushing, for, although past sixty years of age, he had perfect teeth and gums answering to his ideal description of them.

CHAPTER XXIII

THE TEACHING OF ORAL HYGIENE

DOUBTLESS the systematic dental inspection of school children does some good, but this practice is essentially a shutting of the stable door after the horse has fled. We need to teach mothers the principles of oral hygiene, for which purpose an army of lecturers is required to disseminate the truth—to explain in a simple, graphic way how decay of the teeth can be prevented. To this end I am hopeful the present work may contribute.

Our best chance of success is through the mothers. Once they can be got to realise how, by the observance of a few common-sense principles, decay of the teeth can be prevented, they will be so much the more likely to feed their children on rational lines.

From an early age, say from the eighth year, school children should have the practical facts concerning the care of the teeth systematically drilled into them, so that it shall become a religion with them to keep their mouths clean. They should be made to realise that decaying teeth, pus-exuding gums, and a malodorous breath, are things to be ashamed of.

So far as my experience goes, the work of dental propaganda has not yet been effectively undertaken in the elementary schools. It is indeed rare to come across a child who has any serious knowledge of the subject, or who seems to take the slightest interest in it.

In order to avoid dental decay we need :

(1) To secure well-developed jaws by substituting for spongy and mushy cereal food well-baked crusty bread, which compels adequate mastication.

(2) To give plenty of raw vegetable food in the shape of fruit and salads, preferably at the end of meals; and

(3) To prohibit sweets between meals, if not altogether.

If the jaws and teeth have been properly exercised by a normal amount of mastication, the temporary teeth will show considerable wearing down before they are shed, and as regards the permanent teeth, the edges of the front teeth and the cusps of the back teeth will, as early as the late teens, show definite signs of frictional wear; but in this country the permanent teeth rarely show a physiological degree of wearing down.

Exercise of the teeth and cleanliness of the mouth are the two great desiderata to be aimed at—no matter how nourishing the food, how rich in milk, butter, eggs, and cod-liver oil, no matter how abundant the outdoor life and sunshine, we may expect caries to develop in the child brought up on food which fails to exercise the teeth properly and which tends to leave the mouth dirty. It is all so simple.

CHAPTER XXIV

PYORRHŒA ALVEOLARIS

I DO not propose to enter in detail into this so common affection, since much of what I have written on dental decay applies to it also. Strictly, the term pyorrhœa alveolaris signifies purulent inflammation of the socket-membrane, but the term is made to include any inflammation of this membrane, whether associated or not with the obvious formation of pus.

The main cause of pyorrhœa is mal-hygiene of the mouth, and the best way to prevent it is to put the principles of oral hygiene into operation. Of the individual factors in causation the two chief are : (1) insufficient exercise of the teeth, and (2) stagnation of food about the necks of the teeth. J. G. Turner describes it as a " dirt " disease, " due to the accumulation round the necks of the teeth of sticky food." Other factors are : (3) morbid states of the blood, and (4) the formation of tartar.

(1) Vigorous mastication, by causing the roots of the teeth to move within their sockets, thereby stimulating the circulation in the socket-membrane and gum-sulcus, tends to fortify these tissues against bacterial invasion.

(2) The stagnation of food about the necks of the teeth is favoured by soft, sticky farinaceous foods (especially when mixed with sugar) which fail to excite vigorous mastication and the oral hygiene mechanisms dependent upon it. It is not possible to keep the necks of the teeth clean, so long as the teeth are closely jammed together ; the neck of each tooth should be cleansed in its entire circumference : there should be sufficient space to allow 3-ply worsted to pass easily between them. To this end it

may be necessary to extract certain teeth at the age of 14–16. (J. G. Turner.)

The limitation of farinaceous foods to well-baked crusty bread or rivita and the free consumption of such cleansing foods as raw salads and fresh fruit would do much to lessen the frequency of pyorrhœa. For those who indulge unduly in soft non-cleansing foods, systematic gum-brushing should be practised (see p. 241).

(3) Many kinds of unhealthy blood favour inflammation of the tissues. The healthier the blood the less likely is a person to suffer from pyorrhœa.

(4) The deposit of tartar about the necks of the teeth tends to injure the gum tissue and set up inflammation therein, and cause recession of the gum-margin, which favours the stagnation of food in this region. The tartar deposit may spread along the root of the tooth separating it from its investing membrane.

We are thus provided with certain common-sense measures for the prevention of pyorrhœa.

(1) Eat a sufficiency of foods compelling adequate exercise of the teeth.

(2) Eat a sufficiency of foods which tend to leave the mouth clean.

(3) Lead a life calculated to keep the blood healthy.

(4) Should tartar form, consult your dentist.

Sooner or later pyorrhœa leads to absorption of the bony socket, the tooth loosens and ultimately is shed. The shedding of the teeth among the aged is mainly due to pyorrhœa.

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