Supplementary essays on the cause and prevention of dental caries / by J. Sim Wallace.

THE CAUSE AND PREVENTION OF DENTAL CARIES

SIM WALLACE

SUPPLEMENTARY ESSAYS

ON

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BY THE SAME AUTHOR

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SUPPLEMENTARY ESSAYS

ON

THE CAUSE AND PREVENTION

OF

DENTAL CARIES

BY

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PREFACE

THE following essays appeared originally in the *Transactions of the Students' Society of the National Dental Hospital*, the *Dental Record*, and the *British Dental Journal*. Although separately they have gained a certain currency both at home and abroad, having been criticised, reproduced, translated, and abstracted in several other journals, yet, I think, they may now be advantageously published together, in the hope that they may prove a more or less fitting supplement to my book on the Cause and Prevention of Decay in Teeth.

J. SIM WALLACE.

30A, WIMPOLE STREET,
LONDON, W.
April, 1906.

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INTRODUCTION

The time has now come when a few supplementary considerations on the cause of the prevalence of dental caries may be advantageously presented. Over six years have elapsed since my investigations into the Cause and Prevention of Decay in Teeth was published. Time has thus been given for criticism, clinical evidence and experiment, to have been directed on my hypothesis. Whether these have substantiated it or not, the reader must judge for himself. In my opinion, however, substantial verification has been brought forward both by experiment and clinical evidence, and, with regard to adverse criticism, the following essays may be taken as my reply.

My previous work was largely taken up with a general investigation of known facts and special observations bearing upon the subject, together with the formation of a provisional hypothesis. At the same time an attempt was made to undermine the current theories and supposed facts which most effectually obscured the truth. Happily the old theories and supposed "facts" which were considered of the "first importance" have now been almost completely banished from recent dental literature. Fortunately, too,

clinical evidence has been brought forward by independent observers, and substantial verification of the hypothesis has been obtained. Laboratory tests have also been made, and one of our most distinguished experimentalists has corroborated my main contentions in this way. Lastly, the hypothesis has been verified on the *corpus ville.* Circumstances and design made this essentially a test experiment. And, to conclude, the more or less complete acceptance of the theory by recognised authorities leaves little more to be done beyond disseminating the knowledge to those whom it may concern.

CHAPTER I.

DISCUSSIONS ON THE CAUSE OF THE PREVALENCE OF DENTAL CARIES.*

The alarming prevalence of dental caries has naturally led to a considerable interest being taken in the discovery of the cause, and this has in recent years been the subject of much discussion.

The hypotheses which have been advanced have appeared under diverse names, such as "The Cause of the Early Decay of Teeth," "The Etiology of Dental Caries," "Susceptibility and Immunity to Dental Caries," etc. They have all, however, had the one aim of discovering the cause of the increasing prevalence of the disease in order to check it by the removal, if possible, of the cause.

The subject is apparently complex, and etiological questions are not always easy to set at rest. Much work has been done, and many hypotheses have been propounded, but, unfortunately, the results of the investigators have not infrequently carried absolutely no conviction whatever. Indeed, so much so has this been the case that dentists have been slighted for being unable to give a satisfactory explanation. At least, it seemed rather a rebuke to the

* Paper delivered before the Students' Society, National Dental Hospital, November 11, 1903.

dental profession for the British Medical Association to call upon its own members a few years ago to elucidate a subject which was continually being investigated by dentists themselves.

Simultaneously and independently Dr. Black, a distinguished member of the dental profession in America, strongly urged the elucidation of this subject. Shortly after this the late Mr. Storer Bennett earnestly appealed to the younger members of the dental profession to direct their attention to this matter. In his presidential address to the Odontological Society he said: "There will always be those who will need the dentist's services, and in time to come we shall find that prevention is better than cure; for rest assured of this, the mystery of immunity will be unravelled by someone, and it is my earnest hope that the discovery will be made in England.

"It has been reserved for us dentists in the closing years of the nineteenth century to show what dental caries is, and how it is produced. Is it, then, too much to hope that the earlier years of the twentieth century—nay, I would even say the opening year—may also reveal to one of us the means of its prevention? Or are we in the future to sorrowfully admit that this, the greatest discovery of all, has been made by one who is not a dental practitioner?"

Let us now direct our attention to a discussion which appeared in *Nature* in 1894. The following extracts will give clear indications of the views held by the several writers, and what is incidental in the discussion may be left on one side. I wish to direct your attention more particularly to the fact that the first four writers lay much

importance on the change in diet which has taken place among civilised peoples.

"Now, it has never been proved that the increasing prevalence of caries is due to weakness of the teeth, owing to comparative disuse, but there is, nevertheless, great probability in the inference, especially as signs of wear and freedom from caries appear to occur together, and *vice versâ*. There is, however, a further point in regard to the existing liability to the attacks of caries, which, I think, can be best explained by a transference of nourishment to other parts governed by the same nerves."*

"It is difficult, however, to understand how nerve strain can have any *direct* effect upon fully formed teeth, and we should, I think, look for the explanation of the cases referred to in some vitiated condition of the fluids of the mouth, caused by the depressed condition of health, so common amongst hospital nurses.

"There is little doubt that an open-air life and healthy surroundings encourage the formation of sound teeth in a sound body; but I cannot but think that the principal cause of caries must be looked for in the food. . . . Structural defects, due to inherited weakness or imperfect nutrition *during the development of the teeth*, combined with the use of soft cooked food, which is long retained in contact with them, and is of a nature eminently suitable for fermentation give us, I think, the principal factors of decay amongst civilised races.

"While allowing the influence of nerve strain in early

* Extract from letter by Arthur Ebbles, *Nature*, May 31.

childhood, and, as a factor in hereditary transmission of defective structure, I fail to see how it can influence teeth already formed."*

Re people in the north isles of Scotland.

"We find here side by side old people with strong teeth free from decay, though possibly worn down like those of an old horse, and several later generations among whom dental caries is quite general and including many girls in their teens who are almost edentulous.

"The habits of the older and younger generations form an equally striking contrast. The former, even as children, were thinly dressed, and did well on three meals daily. Both men and women gathered seaweed for kelp in all weathers, and worked until the tough bannock in their pockets became a tempting meal."†

"The most likely medium of *teeth* caries, however, being induced is the use of hot drinks, soups, tea, and coffee, which primarily may cause a fissure in the enamel by unequal contraction and expansion in the structures of the teeth. Into this fissure, on cooling down, will be kneaded, by mastication, articles of irritating food and drink, which will lead to caries around it."‡

We see from these four letters very clear indications that the writers attribute the cause of the prevalence of dental caries principally to dietetic causes, and although they differ as to *how* the foods affect the teeth, they are all pretty clearly agreed as to the fact.

* Extract from letter by J. H. Mummery, *Nature*, June 7.
† Extract from letter by Jas. Wenyon, *Nature*, June 14.
‡ Extract from letter by W. G. Black, *Nature*, June 14.

The next letter on this subject in *Nature* is from Mr. C. S. Tomes, and may be more critically examined.

He begins with a sweeping indictment on all the previous writers, saying: "None of the writers of the interesting letters which have appeared upon this subject seem to have kept before them a distinction which is of the utmost importance." This seems a somewhat strange reflection on the letters of the able and lucid writers to *Nature*; but the unfortunate part about Mr. Tomes' letter is that he fails to point out that the distinction *is* of the utmost importance—in fact, he only shows that there is no importance in the distinction at all.

He says: "Dental caries is very prevalent, and its increase seems to be very rapid, so that the last few generations show a marked increase—at least, so it is generally believed. But its victims may be divided into two groups—namely, those whose teeth are apparently perfect in their construction, but nevertheless fall a prey to caries; and those whose teeth show to the trained eye clear evidence of structural weakness."

Here we have "the distinction which is of the utmost importance," and what does it amount to? Only this, that the two classes of teeth referred to fall a prey to caries. Now, it is difficult to see the utmost importance of this distinction. After some remarks on heredity, to which we shall return, Mr. Tomes appears to describe the class of teeth which show clear evidence of structural weakness. He approaches the subject as follows: "But it is quite common to meet with instances of healthy parents with good teeth having a family of children, also

apparently healthy and well grown, whose teeth, although to the casual observer normal in shape, size, and general aspect, are, to the eye of the dentist, doomed to early destruction, and speedily undergo it. These teeth have an appearance somewhat difficult to describe: they have a glassy look, are more translucent than they should be, are softer, and are believed, though the proof is not complete, to be somewhat deficient in lime salts."

Let us analyse the appearance described. It has long been pointed out that the amount of wearing down of the teeth is in general in an inverse ratio to the amount of caries, and this fact has been referred to by Mr. Ebbles and Mr. Wenyon in the letters quoted. As the enamel covers the tooth the part first worn down is the enamel. Now, teeth with much enamel present appearances which indicate the presence of that enamel. That is to say, they have a glassy look, and are more translucent than teeth with the enamel worn off. When soft foods are consumed, instead of the coarse and fibrous or tough foods, the teeth do not get worn down, and the food, lodging in the relatively deep crevices of the teeth, speedily gives rise to caries. It is, moreover, not altogether clear that soft enamel is more subject to caries than hard enamel for the following reason: If the enamel is soft the cusps especially will become worn down rather quickly, and the original fissures of the teeth soon become level with, or more prominent than, the surrounding dentine, and thus the crevices which were at first most liable to lodge food, and bacteria and their products, become less liable to lodge food, and consequently less susceptible to caries. With

regard to the deficiency in lime salts, this, of course, has been completely disproved.

Now let us revert to Mr. Tomes on heredity. He says: "As the latter class (those whose teeth show to the trained eye clear evidence of structural weakness) present a problem in heredity, and for various reasons are likely to be more interesting to readers of *Nature* than the former, I will dismiss them with a few words." It is somewhat difficult to see why the subject should be dismissed with a few words because of its interest. It is still more difficult to learn from Mr. Tomes' remarks why they present a problem in heredity, as he seems to think the cause of this kind of tooth is tc be found in some cause acting at or about the time of birth.

Mr. Tomes then goes on to say, "There is good reason for supposing that the proximate cause (of caries) is to be found in the vitiation of the oral secretions, as caries often occurs in an extreme degree after diseases of the digestive tract, and examples such as those quoted by Mr. Wenyon are probably to be explained as due to dyspepsia induced by the unhealthy way of living."

This seems somewhat extraordinary reasoning, as Mr. Tomes has just said that it is quite common to find children apparently healthy and well grown whose teeth are doomed to early destruction. Unless we believe that the digestive tract is unhealthy in people who have no signs or symptoms of such troubles, we cannot accept this argument, but, over and above this, as all the previous writers to *Nature* have pointed out, the frequent association of foods unsuitable either for the teeth or the digestive

tract would easily account for the frequent association of the unhealthy state of the teeth and the digestive tract. It is perhaps more in accordance with experience to say that the dyspepsia is frequently due to the bad teeth than *vice versâ*. But, to cut a long story short, there is *no* good reason for supposing that the proximate cause is to be found in the vitiation of the oral secretions, or presumably Mr. Tomes would have mentioned the good reasons somewhere or another.

Mr. Tomes is not, apparently, content with first throwing cold water on the previous writers and confusing the question with invisible important distinctions and more confusion on heredity, but he gives them the final douche by informing them that "there is a considerable amount of literature on the subject which seems to have escaped them," and also mentioning that "the question, interesting and important as it is, is not so simple a matter as some of your correspondents would imagine."

Let us now proceed to a discussion which appeared in the *Lancet* in 1900. It commenced with a criticism of my book, and took a form somewhat similar to the letter just criticised. It was as follows:

"In a recent publication Dr. Sim Wallace has advanced an ingenious theory to account for the increasing prevalence of dental caries. His views are as follows: 'The cause of the prevalence of dental caries is that the natural food-stuffs are to a large extent ridded of their accompanying fibrous parts and prepared and consumed in a manner which renders them liable to lodge and undergo acid fermentation in the mouth, while from this same cause

and the induced conditions the micro-organisms of the mouth lodge and multiply and augment the rapidity and intensity of the acid fermentation.' That the 'preparation of our food-stuffs may in some small measure assist in the production of caries seems possible, but that it is 'the cause' is highly improbable. Much of Dr. Wallace's reasoning is unsound, and many of his statements are incorrect. He crosses arms with those investigators who maintain that the teeth are degenerating in some unknown way, and so are unable to resist the action of the acids set up by fermentation in the mouth. He prefers to hold the view that the cause is to be found in the food-stuffs being prepared in a manner which makes them more apt to lodge in the mouth, and he makes the statement, quite unsupported by any data, that 'the teeth of the present day are as perfectly formed from a chemical and microscopical point of view as are the teeth of those races which are practically free from caries.' That the structure of the tooth plays a most important part in the resistance to caries is within the knowledge of a dental practitioner with even a small experience. For example, in mouths where there is but a slight amount of caries, and that slow, the enamel of the teeth is generally hard and resistant to the instrument, while where caries is prevalent and rapid the reverse is the case. Indeed, it requires but little observation to show that there is something, so far not recognised or understood, which plays a most important part in the liability of teeth to be attacked by caries. Crowding of the teeth is a fruitful predisposing cause of caries, and this is acknowledged by Dr. Wallace, but he

attributes the crowding to want of development of the tongue from lack of fibrous material in the food-stuffs. The removal of this fibrous material from the food-stuffs robs the tongue of a certain amount of activity, and so interferes with its development. Here, again, as with nearly all his statements, no data are given in support of his contentions. The true cause of caries has yet to be discovered, and is not quite so simple as Dr. Wallace would lead us to believe."

By way of reply to this criticism, we may quote a letter which followed from Dr. Harry Campbell:

"Dr. J. Sim Wallace holds that the great prevalence of dental caries among civilised peoples is due to their eating soft and pappy foods requiring little mastication. Some years ago you were good enough to publish in the *Lancet* a letter from me, in which I urged the same view. My interest in the subject led me to read Dr. Wallace's work carefully directly it appeared, and I hope I may be permitted to say that I was greatly impressed by the closeness of his arguments and the scientific spirit pervading his book.

"My original contention was that soft foods predispose to caries by leading to imperfect mastication, and thus to defective nutrition and development of the teeth; and although I still venture to think that this may be a factor, Dr. Wallace has converted me to his view that soft foods lead to caries essentially by modifying the buccal environment of the teeth, the teeth being no longer properly cleansed by coarse fibrous foods, the buccal secretions being no longer adequately excited, and so forth.

"Regarding Dr. Wallace's remarks as to the tooth-brush not being altogether an unmixed blessing, it is significant that the very next day after reading them there consulted me a man, aged twenty-two years, who had never in his life used a tooth-brush, and he had thirty-two sound teeth in his head.

"I feel convinced that if Dr. Wallace's views are taken to heart by the medical profession, we shall do much to diminish caries and other defects of the teeth. I, indeed, believe with him that we have it in our power to rear a race having teeth every bit as good as those of our primitive ancestors."

After this the following letter from Mr. Berlyn then appeared:

"In the *Lancet* of July 14 (p. 134), to hand by this last mail, I notice a letter from Dr. Harry Campbell, in which he supports the theory of Dr. J. Sim Wallace that 'the great prevalence of dental caries among civilised people is due to their eating soft and pappy foods requiring little mastication.' Would either of these gentlemen kindly explain how they reconcile this theory with the following fact? The great majority of South African natives live on nothing but soft pappy food, which consists of a very soft porridge made from ground mealies or Indian corn. Their only method of cleansing their teeth is to fill the mouth with water and rub the teeth with the finger. And yet carious teeth among natives are the exception rather than the rule; on the contrary, they possess beautiful, sound, strong, milky-white teeth, of perfect shape and formation, absolutely free from any taint of tartar or

other discoloration, and seldom, if ever, malformed or irregular."

This elicited the following replies from Dr. Harry Campbell and myself:

"If Mr. A. Berlyn's assertion be correct that 'the great majority of South African natives live on nothing but soft pappy food,' and if it can be shown that they do not habitually chew hard things of any kind, then the view I hold, in common with Dr. J. Sim Wallace, falls to the ground. That, however, these natives do use their muscles of mastication far more than civilised peoples seems to me to be proved by the perfect development of their jaws and muscles of mastication. Nothing is more certain than that if these structures are not adequately used they will not develop properly.

"In the *Lancet* of August 25 I notice that Mr. Berlyn, of Cape Town, would like explained how the fact which he put forward could be reconciled with the theory I advanced, and which was so generously supported by Dr. Harry Campbell. Mr. Berlyn says: 'The great majority of South African natives live on nothing but soft pappy food, which consists of a very soft porridge made from ground mealies or Indian corn . . . and yet carious teeth among natives are the exception rather than the rule.' I should like to point out that this porridge is made of Indian corn which is bruised or crushed, and there is no attempt made to eliminate the coarse and fibrous part such as is done by the elaborate processes which wheat, for example, undergoes in the manufacture of flour. As far, therefore, as this, the staple article of

diet, is concerned, the Kaffir does not eliminate the fibrous part from natural food-stuff. According to my views, such a food is not liable to lodge in the crevices of, and between, the teeth, and the act of masticating it tends to keep the teeth free from fermentable matter. I bruised and crushed some Indian corn, first with a hammer and then with pestle and mortar, after having soaked it in water for twenty-four hours so as to try to make it soft. I then boiled it for an hour. On examining, I found the more or less powdered part mixed with a fine tough, transparent scale, which naturally surrounds the corn-grains. I then added a little salt, and ate the porridge thus prepared. It required a very considerable amount of mastication, much more than does coarse brown bread.

"I think, however, Mr. Berlyn is hardly correct in saying that the majority of the natives 'live on nothing but soft pappy food,' as the following extract from Ratzel's 'History of Mankind' (vol. ii., p. 433) would indicate: 'Thus the Kaffir gets his food about equally from his fields and from his herds. The basis of it is sour milk (*amasi*), and bruised maize (*amabele*), or millet (*umbla*). Meat is eaten alike boiled or roast, and is much relished by the natives. According to Gardiner's estimate, four or five can manage to eat up a whole ox—entrails, sinews, and all—in a day and a half.' The teeth are often much worn from the very considerable amount of mastication which they perform, and, as will be observed from their eating the sinews of an ox, they are not particularly addicted to eliminating the fibrous part from their food-stuffs. These people are very free from dental caries, and are an interesting con-

firmation of the theory that 'the cause of the prevalence of dental caries is that the natural food-stuffs (of the civilised) are, to a large extent, ridded of their accompanying fibrous parts, and prepared and consumed in a manner which renders them liable to lodge and undergo acid fermentation in the mouth,' etc."

Several other letters on this subject appeared in the *Lancet*, but I shall only allude to Dr. T. G. Read's views, which, in the form they now take, appear to support my contention that the prevalence of dental caries is due to the fact that food is "prepared . . . in a manner which renders it liable to . . . undergo acid fermentation in the mouth."

It may be well now to refer to certain observations which appear to have largely misdirected the attention of observers on this subject.

Dr. Miller says: "The structure of the teeth plays the most important part as a predisposing cause of dental caries. Poorly developed, soft, porous teeth, with many large interglobular spaces, are highly predisposed to caries. As a lump of table salt dissolves more rapidly in water on account of its porosity than an equally large piece of rock salt, porous dentine is more rapidly decalcified than well developed, firm dentine, because the acid may the more readily penetrate the tissue, and because less acid is required to decalcify a porous than a hard tooth."*

I disagree with Dr. Miller, more especially in his interpretation of the causes of the structural defects and

* Miller, "Micro-organisms of the Human Mouth," p. 216.

deterioration in teeth which he assumes to exist. He says:

"There can be no doubt that a deterioration of the teeth accompanies the progress of civilisation. The reasons for this are many. The mode of life of most uncivilised races not only conditions a sound, well developed body, but the osseous system, of course, including the teeth, shows the same vigorous development, and, above all, a compact structure. An individual whose youth is spent in the open air, unrestricted in his bodily freedom, is likely to possess a body better developed in all its parts than one who has been brought up in a modern schoolroom.

"The quality of the food also exerts an influence on the teeth not to be underrated. They form no exception to the rule that an unused member will be less perfectly developed than one constantly used.

"The pressure brought to bear upon the teeth by mastication causes a more lively circulation in the periosteum and in the pulp, thereby inducing an increased deposit of lime-salts or a more complete calcification. Practical experience also teaches that children brought up on soft food (broths, paps, etc.) generally have bad teeth. If a race of human beings or of animals were to make no use of their teeth for several generations, we should expect to find a gradual deterioration of the dental structure. It is, to say the least, highly probable that the soft quality of many of our foods as compared to those of uncivilised races, conditions a soft, porous, dental substance, as well as an imperfect development of the jawbone, and a concomitant crowded position of the teeth."

Let us consider the points above quoted seriatim. With regard to the general mode of life of savages conditioning a sound, well-developed body and the bones and teeth showing a compact structure, this may be wholly doubted, for the general mode of life of savages is usually less hygienic and less conducive to general good development of body, and, indeed, for physical endurance the savage is usually not equal to the civilised.

It is true that an individual whose youth is spent in the open air, unrestricted in his bodily freedom, is likely to possess a body better developed in all its parts than one who has been brought up in a modern schoolroom, but this is because functional activity is necessary to the complete development of the muscles and body generally. The development of the teeth is totally independent of this functional activity—indeed, the vulnerable part of the crown is invariably formed before the tooth has cut the gum, and before the child has reached the modern schoolroom. They thus do form an exception to the rule, that an unused member will be less perfectly developed than one constantly used. Moreover, assuming that the pressure and strain of mastication did cause a more lively circulation of the blood in the periosteum and pulp, and on that account induced an increased deposit of lime-salts, this could have absolutely no effect upon the enamel, which is an inorganic substance formed once for all in early childhood. Caries commences in the enamel, and if the enamel is once disintegrated, the ultimate destruction of the tooth is almost inevitable unless operative measures are taken to prevent it. That children who are brought

up on broths, paps, etc., generally have bad teeth, or rather, carious teeth, is true, but this arises from a different cause than Dr. Miller would have us believe. It arises from the fact that foods requiring much mastication have a detergent action, while soft, non-fibrous food not requiring much mastication is very liable to lodge in the crevices and between the teeth. This point is of importance, for, according to my theory, the eating of fine biscuits and hard sweets may help to induce caries, whereas, according to Dr. Miller's contentions, such hard foods ought to give rise to compact structure of the teeth, and ability to resist caries.

Lastly, Dr. Miller's contention that the diminished use of the teeth and jaws should be expected to give rise to a gradual deterioration of the dental structure is not in accordance with present day biological teaching, and moreover the belief is a pernicious one, for if such were the case the hope of regaining this perfection in our teeth could only be but a remote one, instead of being within the immediate power of every intelligent parent.

There is no doubt that a persistent belief in the inheritance of acquired characters, and in the modification by disuse through successive generations is at the root of our long continued beliefs in the inherent degeneracy of teeth at the present day. This belief has absolutely prevented the correct interpretation of the causation of caries, for if caries is assumed to be hereditary an explanation must be made which elicits the cause acting through the individual, and through the reproductive cells. Until quite recently it was supposed to originate through the teeth—*i.e.*, through

some defective structure of the teeth, and perhaps this is still the prevalent belief. However, Dr. Black has shown that at least the relative amounts of lime salts in teeth supposed to be susceptible to caries, and in teeth which are not supposed to be susceptible to caries, can no longer be held to be the reason for "susceptibility" and "immunity" to dental caries. The dominant idea of hereditary transmission of the disease has led Dr. Black into the equally extraordinary idea that the transmissibility of the disease is *via* the oral secretions. I admit that had it not been for an unswerving belief in the non-transmissibility of acquired characters I should never have arrived at my own conclusions. The *apparent* hereditariness of the disease is almost overwhelming, and the *apparent* diminution in size of the jaws from relative disuse through successive generations has made it be selected as a good example to illustrate the tenets of those who believe in the hereditary transmission of acquired characters (*e.g.*, Herbert Spencer).

If the hereditary nature of the disease is believed in, of course the investigation of the qualities of food-stuffs is an almost profitless investigation; if, however, the Neo-Darwinian doctrines of heredity are believed, it becomes an almost self-evident corollary that it is in the food that we must seek for the cause of the prevalence of caries.

The next set of beliefs which seem to have misdirected attention are those originating from a recognition of the parasitical nature of dental caries. Immediately it was proved that dental caries was caused by bacteria the whole dental world rose in arms against the bacteria of the

mouth. Antiseptics of all kinds and strengths were used in the hope of exterminating the micro-organisms. It never dawned on anyone that the bacteria of the mouth might, under proper dietetic conditions be "valuable agents in the preservation of the teeth,"* or that under normal conditions the use of antiseptic mouth-washes is to be deprecated. When I advanced these views a few years ago, I knew I was going straight in face of what was considered established fact, but in a recent discussion in the *Lancet* Dr. Harry Campbell has ably championed my theory, and Dr. Miller in his recent experiments, while perhaps not going quite so far, has at least furnished us with material which tends very strongly to confirm the position which I originally took up.

This is indeed particularly strong evidence in favour of my views, for up till this year, Dr. Miller was the arch-champion of the antiseptic or bactericidal method of preventing caries.

I do not intend at this late hour to enter into a discussion of other beliefs which have tended to prevent the solution of this "vexed question," but I should like to refer to a criticism by our distinguished President.† After quoting my generalisation, he says: "That such a factor does occur is certain, but it hardly explains the fact that animals—dogs, cats, monkeys, rabbits, etc.—which exhibit no dental caries, are yet found to have food particles frequently lodged between their teeth after a meal, the fibrous matters themselves remaining impacted.

* "The Cause and Prevention of Decay in Teeth," pp. 99, 100.

† K. Goadby.

Interstitial caries is rare in animals, and yet commonly occurs in man." There is no doubt some validity in this criticism of the view I originally put forward, but recently I have supplemented my remarks by showing that when mastication is efficiently performed the starch is converted in the mouth and swallowed, so that, given efficient mastication, lodging food particles and shreds are of little consequence, because their starchy ingredients have been expressed and swallowed.

In conclusion, I would advise you to urge your patients to desist largely from consuming pap foods. Mothers especially should be reminded that the teeth are there to to be used. Tell them that their children should eat toasted bread from which the crust and outside have not been removed. Tell them to eat apples daily—English Ribston Pippins, or some such hard apple by preference. Advise them to eat meat, which should not be artificially minced or cut small, and let the fish which they consume be by preference of the coarse variety—*e.g.*, cod. Tell them to limit the amount of sweets they consume.

Try to make medical men realise that children may be allowed to cut their teeth on a crust, and that at no subsequent period should the teeth be allowed to go without cutting crusts or some such food-stuff. Remind them that doctors' children's teeth are worse than the average, and that the reason is that medical men are the greatest advocates of the pap feeding of children. Remind them that hospital nurses who are largely under their régime have particularly bad teeth.

Addendum.

Several other discussions on that part of my theory which relates to the relationship of fibrous food and the incidence of dental caries have from time to time appeared. They have been of a similar nature to the discussion referred to in the *Lancet*, and may be referred to by those interested in the subject. Those who were on the whole favourable are marked *pro*, those against *con*.

"Recorder": *Dental Record*, April, 1902.
Sim Wallace (*pro*): *Dental Record*, May, 1902.
W. C. Grayston (*pro*): *Dental Record*, January, 1903.
S. Colyer (*con*): *Dental Record*, July, 1904.
A. Berlyn (*con*): *British Journal of Dental Science*, April, 1904.
C. R. Howard (*con*): *British Medical Journal*, March 18, 1905.
H. Campbell (*pro*): *British Medical Journal*, March 25, 1905.
W. G. Creswell (*pro*): *British Medical Journal*, April 1, 1905.

One, at least, of those who at first were *con* is now *pro*, or, at least, has considerably modified his opposition.

CHAPTER II.

SOLUTION OF THE PROBLEM OF SUSCEPTIBILITY AND IMMUNITY TO DENTAL CARIES.*

I do not know the chronological sequence of the several theories which have been advanced to account for the prevalence of dental caries among civilised people, but two, to which I would refer, probably existed before we did; and although these two theories are supposed to have been completely exploded and practically expunged from dental literature, they yet contain some truth which all our scientific knowledge has scarcely improved upon.

I refer to the idea that sugar is harmful to the teeth, and to the less popular, but, possibly, equally old, idea that the refined foods of civilised man are responsible for the prevalence of the disease.

These popular notions were vague, and the question of how such causes acted was not, apparently, settled. There were not many important investigations undertaken to decide the point, but a few of first-rate merit which have had great influence must be referred to.

The first which I would mention was that undertaken by Mummery. This has been a standard monograph, and

* The three following chapters were published originally in the *Dental Record*, November and December, 1903, and January, 1904.

was "meant to establish the relation of caries to the healthy or unhealthy manner of life of a given race."

Much as I admire Mummery's investigation, I am bound to say that it tended to divert further search from a dietetic cause. The most that could be said as regards foods was that meat-eating races appeared to be rather less susceptible than others, and this even could only be seen on careful analysis of the tabulated results, and the fact was by no means a marked one.

Unfortunately, this investigation opened up the way for the idea that susceptibility to caries was not brought about as much by food as by general constitutional and hygienic conditions.

Although Mummery's investigation made it seem quite improbable that the nature of the food would give a clue to the complete solution of the problem, yet the idea that the teeth were perhaps insufficiently nourished either through hygienic conditions, constitutional states, or improper feeding, still held ground, and appeared to support the assumption that the teeth were deteriorating. Moreover, the unfortunate belief in the inheritance of acquired characters seemed to further enforce this idea, and the constitutional degeneration of the teeth was considered an unquestionable fact.

It naturally followed that when Dr. Black published his investigation on the "Physical Characters of the Teeth in Relation to their Diseases," especially when he revealed the fact that differences in the density or in the percentage of lime salts have no influence as to their liability to caries, he seemed to completely stagger the

dental world. Two courses seemed only possible—either to deny the truth of Black's observations, or to assume that the hereditary and constitutional influences which induced caries were outside the tooth structure itself. Many adopted the former course, and considered that there were differences in the molecular arrangement of the lime salts, or that Black's experiments "fail to differentiate clearly between water of composition—*i.e.*, the degree of chemical hydration of the calcoglobulin and water of structure, that taken up by simple imbibition." Dr. Black naturally respected his own experiments, and tried to explain the susceptibility to caries in constitutional states, which alter the secretions of the mouth. Black considered that the hereditary nature of the disease was so obvious that no one would venture to suggest the opposite. When, therefore, a few years later Black published his paper on "Susceptibility and Immunity to Dental Caries," it was quite natural that the dietetic factor should be completely ignored. He, like other writers, had completely expunged the idea that an investigation of the nature of the foods could by any possibility explain the known facts, or, rather, the facts which were assumed to be indisputable.

Meanwhile, the advance of bacteriology and the important investigations of Dr. Miller had established definitely the exact nature of caries. Miller's work seemed to lend some support to the popular idea that sugar was harmful to the teeth; but, unfortunately, he confined his considerations almost wholly to the chemical differences in food, and thus such well-known facts as, for example, that

native children who consume large quantities of sugar from sugar-cane seemed to remain a proof that this was not a cause of the prevalence of caries of any consequence.

Miller also records experiments indicating variable susceptibility of different teeth to the action of acid, just as ordinary table salt is more easily dissolved than rock salt, thus appearing to confirm the hypothesis that there is a molecular difference in the constitution of teeth, which would explain more or less varying susceptibility. Miller also indicates his adherence to the idea that acquired characters may be transmitted,* and in the hereditary predisposition† to the disease, although if I am not mistaken he places less importance on the hereditary and constitutional nature of the disease than do other authorities.

Next to the erroneous beliefs with regard to heredity, the idea which has been most potent in preventing the solution of the question of susceptibility and immunity was the discovery of the direct or exciting cause of caries—namely, acids and micro-organisms—for immediately this was demonstrated it was but natural to think that immunity would be secured by the more or less complete destruction of the micro-organisms. Under the sway of this theory antiseptic mouth-washes, tooth-soaps, and tooth-powders have been introduced, and elaborate investigations made of the antiseptics which are most powerful in destroying the micro-organisms of the mouth, while bactericidal properties have been searched for in every

* "Micro-organisms of the Mouth," p. 219.

† *Ibid.*, p. 218.

possible constituent of the saliva or of the secretions which are poured into the mouth. How thoroughly past research has diverted investigators from any guidance in the search for the cause of immunity may be gathered from Dr. Miller's recent communications* and negative results.

I do not mean to depreciate the excellent work of the authors to which I have referred, but only to point out that, together with the good, there was always, in my opinion, something which prevented thought and investigation from settling on the true solution of susceptibility and immunity.

On quite other lines knowledge was accumulating, which I believe points in other and more profitable directions. The Neo-Darwinians had shown that acquired characters were not transmitted, and thus to them the idea of the hereditary degeneracy of teeth collapsed. Those who adopted this Neo-Darwinian view saw at once that Black's investigation into the calcification of teeth only confirmed their deductions, and I at least saw no reason for the prevalent carping criticisms and the attempt at molecular disintegration of the facts which he brought to light. Further deductions from the belief that acquired characters are not transmitted led me to ignore the assumption that "hereditary predisposition to caries is the first importance."†

Notwithstanding the tide of opinion among dental surgeons and the weight of authority which supported

* *Dental Cosmos*, January and February, 1903.

† Black, *Dental Comm.*, September, 1899, p. 829.

it, I came to the conclusion that we had been drifting in the wrong direction, and that a dietetic solution of the problem was the only one possible. After more or less prolonged investigation, I ventured to make the generalisation that "the cause of the prevalence of dental caries is that the natural food-stuffs are to a large extent ridded of their accompanying fibrous parts, and prepared and consumed in a manner which renders them liable to lodge and undergo acid fermentation in the mouth; while from the same cause and the induced conditions, the micro-organisms of the mouth lodge, and multiply and augment the rapidity and intensity of the acid fermentation." I further even affirmed "that under proper dietetic conditions the bacteria of the mouth are valuable agents in the preservation of the teeth."

It could hardly be expected that views such as these would be readily accepted at the time they were first published, but they have now met with so much approval and criticism that further amplification and justification of the theory seems almost to be called for. Moreover, the generalisation gives the key not only to susceptibility and immunity in general, but also even to the relative susceptibility and immunity of individual teeth.

CHAPTER III.

SOLUTION OF THE PROBLEM OF SUSCEPTIBILITY AND IMMUNITY TO DENTAL CARIES (*continued*).

A SUBJECT of great importance in the investigation of this problem is the physiology of mastication. Here, again, I must insist on an abandonment of hitherto current beliefs. The process of mastication is not as described in books on physiology.* Take, for example, the description given in the text-book usually read by dental students. It runs: "When solid food is taken into the mouth it is cut and ground by the teeth, the fragments which ooze out upon the outer side of their crowns being pushed beneath them again by the muscular contractions of the cheeks and lips; while those that escape on the inner side are thrust back by the tongue, until the whole is thoroughly rubbed down. . . . When the food is sufficiently ground it is collected, enveloped in saliva into a mass or bolus which rests upon the back of the tongue, and is carried backwards to the aperture which leads into the pharynx."

It will be observed that this description would lead one to think that the food is comminuted, mixed with saliva, and made into bolus form and then swallowed.

* Since writing the above some descriptions of the process of mastication substantially similar to my own have appeared.

It seems difficult to believe that such an erroneous description should have been written by Huxley, and equally difficult to conceive that no one has had the courage to call its accuracy in question. For anyone can observe for himself at each and every meal that the description of the process is quite inaccurate. Before describing the process, however, when it is thoroughly performed, it should be noted that certain food-stuffs which are consumed at the present day are hardly subjected to the process of mastication at all. The food is simply taken into the mouth, receives a general squash between the teeth or between the dorsum of the tongue and the hard palate, and is then swallowed. This method of mastication—if mastication it can be called—is as a rule adopted for custards, fine meal porridge, soft puddings, and soft non-fibrous foods generally.

When there is a certain amount of coarse or fibrous matter in the food-stuff, then the process is essentially different, and mastication is performed in a more thorough manner. In this case the food is crushed and torn between and heaped on to the masticating surfaces of the teeth by the muscular contractions of the tongue, cheeks, lips, and motions of the lower jaw. During comminution between the teeth the juices of the food-stuffs, the saliva which becomes incorporated, and the suspended non-fibrous part, are pressed out from the fibres and gradually collect during the process on the dorsum of the tongue, which is gradually hollowed out for the reception of such food, and this part is then swallowed. The fibrous part of the food, however, is subjected again and again to the crushing and disin-

tegration between the teeth. If any of the fibrous part passes towards the back of the dorsum of the tongue it is arrested by the pressure of the anterior part of the tongue against the rugæ of the palate, and while the fluid and finely comminuted part gets sucked or pressed back into the hollow formed at the back of the dorsum of the tongue, the coarse and fibrous parts are thrown between the teeth and subjected again to the crushing, squeezing, and comminution. The rough surface of the tip and dorsum of the tongue and the smooth-ridged palate are especially well adapted for this separation of the food prepared for swallowing, and that which requires further mastication.

When a child is brought up on foods of a consistency demanding real *mastication*, it acquires the habit of masticating, whereas pap-fed children do not acquire the habit so thoroughly. Leaving aside other considerations which tend to make certain people masticate efficiently, it should be observed that the act of mastication is most important in the natural self-cleansing of the mouth. For when it is efficiently performed, the ptyalin gets thoroughly incorporated with the food, and converts the starch into a soluble form, which becomes expressed from the bolus and swallowed; or if a little lodges about the teeth, the constant rushing of the saliva between and about the teeth tends to dislodge or dissolve any starchy matter that might otherwise lodge and undergo acid fermentation. Thus with efficient mastication it is not only the exposed surfaces of the teeth which the saliva helps to clean, but even the most inaccessible crevices. It

should be remembered, too, that the mastication of food which demands considerable muscular activity calls forth a corresponding flow of saliva, and no doubt the continued use of food causing a healthy flow of saliva tends to develop the salivary glands. Thus, again, those who habitually consume food stimulating the flow of saliva are both directly and indirectly less susceptible to dental caries.

Another general effect of coarse food and efficient mastication is to wear the cusps of the teeth so that the crevices become small or obliterated, and consequently the susceptibility for food to lodge is lessened.

The modern refinement and preparation of food makes particles which lodge about the teeth peculiarly unirritating. If the food is highly refined, "short," and soft, it may be plastered into the crevices of and between the teeth after meals, without stimulating saliva, or exciting the tongue to dislodge it; but if, for example, nuts are consumed, there is something in their physical nature which makes one very conscious of their presence and stimulates, not only the flow of saliva but also the motions of the tongue and cheeks until they ultimately are dislodged.

So also the modern preparation of food tends to deprive it of the natural fresh vegetable acids which would otherwise almost invariably accompany vegetable foods. Thus it correspondingly happens that the saliva is not so fully stimulated as it should be. Now when acid is taken into the mouth, not only is the saliva stimulated directly, but the acid which reaches the stomach stimulates the flow of saliva also—at least, I appear to notice a much more

copious flow of saliva after having eaten, for example, stewed apples than after eating some bland, neutral, or alkaline pudding. The importance of what we may call the after-flow of saliva can hardly be doubted; for the frequent swallowing which it causes after meals is a most potent factor in the self-cleansing of the mouth.

Before proceeding further it may be advisable to draw attention to some facts with regard to the secretion of saliva. In general, it should be remembered that the work of the salivary glands is capable of adapting itself to certain conditions—that is to say, bears a definite relationship to the requirements which must be fulfilled by the saliva produced.* "It is of importance to bear this in mind, for as things are usually taught at present one is led to suppose that the work of the salivary glands is of no import, and that they respond in haphazard fashion to every form of stimulus."†

The general relation of the saliva to the nature of the food and to the self-cleansing of the mouth may firstly be indicated by the following observations: If some sand is thrown into a dog's mouth "the saliva flows in quantities, because sand cannot otherwise be got rid of than by a free stream of fluid. Upon all substances which the dog rejects—for example, acids, salts, bitter and caustic substances—saliva will likewise be poured, because these require to be neutralised, diluted, or washed out of the buccal cavity. This explanation is fully confirmed by the

* Pawlow and Thompson, "The Work of the Digestive Glands," p. 150.

† *Ibid.*, p. 151.

absolutely constant and striking fact that a thin watery saliva containing mere traces of mucin is poured out by the mucous salivary glands upon every substance without exception which requires to be removed, while upon eatable substances a slimy mucin-holding fluid is secreted which lubricates the food bolus and facilitates its descent through the œsophagus. Further, the quantity of saliva secreted is closely related to the dryness of the food. The drier this is the more saliva flows—a striking proof that the first of the digestive glands adapts itself to the physical conditions of the food."*

I shall now refer to an observation which can scarcely be doubted—namely, that on the whole people who eat but three meals daily are less susceptible to caries than those who eat a greater number daily. The explanation of this is, I believe, as follows: When only three meals are consumed the stomach generally is allowed to empty itself before another meal is taken, so that the process of digestion goes on normally. During the consumption of one of these meals there is a considerable flow of saliva, for the appetite tends to be keen and the secretion fairly abundant. After the meal is finished the after-flow of saliva continues for a time, but gradually decreases as the acid secreted by the stomach gradually increases. Suppose on the other hand that four or five meals are taken daily, then the stimulation of the flow of saliva is unduly divided, and the amount secreted during and immediately after a meal is less than when only three meals are consumed. But if the amount of saliva is less, both during and after

* Pawlow and Thompson, pp. 151, 152.

the meal, then the self-cleansing of the mouth by this means is correspondingly less. If, as is the case with cooks and confectioners, the place of vigorous stimulation of the salivary glands is taken by repeated little stimuli, then the results are even worse. Moreover, of course, if a little food tends to lodge after each meal, should six meals be taken instead of three, then there will, other things being equal, be twice the susceptibility to the results which follow the lodging of food.

Another habit which influences the susceptibility to dental caries is the time taken over a meal. Thus, if a meal is begun, continued, and ended without intervals or without unnecessary waste of time, the likelihood of harm resulting to the teeth is not as great as is usually the case. When we consider, too, the general question of the physiology of digestion, it is evident that spending a long time—say, more than half an hour—over a meal is in no way conducive to the digestion of the latter portions of the meal. Nor can we expect that the after-flow of saliva will be considerable after a long-drawn-out meal.

Let us now direct attention to the method of the self-cleansing process. If the food has been of such a nature that real or thorough mastication has been called forth, then, of necessity, any particles of food that do lodge will be well incorporated with saliva, and as the ptyaline does not exhaust itself appreciably, the process of the conversion of starch into a soluble form will continue so long as the starch remains. The after-flow of saliva from the parotid passes round the buccal sides of the teeth, and is sucked in between the teeth each time the act of degluti-

tion occurs; thus, any food particles tend to be dislodged and swallowed. With some people the mouth seems to become callous, and the particles of highly-refined food do not materially stimulate this self-cleansing process, but with others the case is different, and after meals they may be observed swallowing frequently, and may, unfortunately, sometimes be heard sucking the saliva between their teeth, evidently semi-consciously dislodging food particles. With each act of deglutition, too, the floor of the mouth is brought upwards and the tongue pressed forcibly on the teeth and palate, while part of the saliva from the sub-lingual and sub-maxillary glands is forced out between the teeth. Then, again, the tongue performs certain movements which tend to dislodge food particles. It may be pushed out over the molar teeth, and the point bent upwards or downwards between the cheek and the gum, and then carried forward, or it may otherwise be thrust between the teeth and the cheek or lips, and made to dislodge particles of food.

There are certain conditions which influence this self-cleansing process—for example, the arrangement of the teeth. I have shown elsewhere* that the arrangement of the teeth is chiefly influenced by dietetic considerations, but what I would here refer to is that the natural movements of the jaws during mastication are frequently prevented by the mal-occlusion of the teeth. It often happens that the occlusion is of such a nature that the lateral or grinding movements are prevented. Now, this grinding movement is of importance, especially for the

* "Essay on the Irregularities of the Teeth."

self-cleansing of the molar teeth, for the more the lateral movement, the more is the saliva pressed and sucked to and fro between the approximal surfaces of the molar teeth. We shall have occasion to refer again to the arrangement of the teeth in elucidating susceptibility and immunity of the different teeth.

Another condition of some little importance in the self-cleansing process is the mucous coating over the teeth. In every mouth there are parts of the teeth which are not naturally subjected to much mechanical cleansing, and these parts are consequently liable to lodge food particles. They are more or less protected by a thin, slippery film, which adheres to the teeth so firmly that if the tongue is swept over it, it is not removed. Now, if the particles of food lodge on the surface of this film, the self-cleansing motions of the lips, cheeks, and tongue tend to dislodge them. Similarly, the removal of particles of food by the tongue from the mucous membrane of other parts of the buccal cavity is no doubt facilitated by the slippery nature of the mucous membrane.

It is thus somewhat important to stimulate the mucous secretions of the mouth by the consumption of a fairly coarse and fibrous diet, and, as we shall see presently, the stimulation of the mucous membrane to epithelial proliferation helps to prevent acid formation.

Then, again, the relative amount of carbohydrate in the food is of importance. If it is concentrated and soft, it is much more liable to cause caries than when it is small in amount compared with the amount of fibrous matter which demands considerable mastication and insalivation. The

presence of much sugar in the food is of special importance, because the action of the saliva is hampered by the presence of sugar. It may, perhaps, be imagined that children always consumed nearly as much sugar as they do now; but note this fact: "In 1883 the import of sugar for home consumption per head of the population was 9·91 lbs. of refined sugar; in 1900 it was 52·23 lbs." But this does not represent the total increased consumption of sugar, for there has been an astonishing increase also of tinned fruits, which are generally preserved in syrup. I need hardly mention that some people consume more sugar than others, and here, again, we have a potent cause of variation in susceptibility and immunity.

The nature of the saliva differs under different circumstances. In a state of health it is alkaline, abundant, and active. When the subject suffers from dyspepsia, it may be acid, and more or less inactive. In cases of hyperchlorhydria, however, it is said that the saliva is markedly alkaline, a condition which shows certain important relations of the gastric and buccal secretions; in fact, I believe that the secretions of the mouth are almost as frequently vitiated by the consumption of unsuitable food as are the secretions of the stomach and intestines, and one of the commonest forms of indigestion is what we may call oral indigestion. This oral indigestion closely resembles indigestion in the stomach, and is associated with insufficient movement, vitiation of the secretion, tardy chemical digestions, prolonged lodgment of the food, fermentation, and frequently acute pain. The conditions above referred to are, directly and indirectly, almost solely the result of

improper food, and, consequently, the susceptibility and immunity brought about by oral indigestion are almost solely of dietetic origin.

In conjunction with the variable nature of the salivary secretion, due to the difference in chemical and physical properties of the food, we should note the difference in quantity of the mucous secretion. If the food is of a bland, soft nature, the mucous secretion is not stimulated much; but if it is coarse and fibrous the mucous secretion is considerably stimulated. The nature of the mucous should be considered. It clings tenaciously to the surfaces with which it comes in contact, and thus, besides facilitating deglutition, it coats the teeth where they are not subjected to friction, and being of an albuminous nature it does not induce the acid-forming bacteria to proliferate, while if the food is acid it becomes insoluble and forms a more or less impassable barrier for the acid. After the meal, however, the alkaline saliva—in which it is soluble—tends to clear it away, together with adherent food particles. Akin, no doubt, to this mucous coating are the gelatinous plaques under which caries starts. I am inclined to believe that caries occurs not on account of the plaques, but in spite of them.

We may now consider the nature of the micro-organisms of the mouth. Some are acid producers, some are liquefiers, and some produce acid or liquefy according to the medium in which they exist. It is obvious that those bacteria which liquefy gelatine and other albuminoid substances must be of great importance in rendering shreds of food-stuffs soluble and so helping to

clean the buccal cavity, and within limits the acid producers may have a similar function; in fact, it would seem impossible to do without the mouth bacteria, as there is no ferment in the mouth capable of digesting the albuminous shreds and particles which otherwise would be bound to accumulate between and about the teeth.* It may be said that at least we would be well to be without a considerable proportion of the acid-producing bacteria, for without acid it is impossible to have dental caries. No doubt this is so; but this result is best obtained by efficient mastication, for food which requires considerable mastication calls forth a corresponding flow of saliva, which gets thoroughly incorporated with the food. The ptyalin converts the starch into a soluble form, while the mastication expresses it from the rest of the bolus. Thus, therefore, the starchy matter is more or less thoroughly swallowed, while the remaining part is being more completely masticated. By this means the smallest possible residue tends to lodge about the teeth, and what little does remain, being almost devoid of starch, allows the bacteria which liquefy to predominate while preventing the multiplication of the acid-producing bacteria. If, however, food, especially starchy food, is taken in a soft form the flow of saliva is, relatively to the amount of starch, but inefficiently stimulated. The starch is not fully converted and swallowed, but remains plastered, as it were, into all the crevices in and about the teeth. Furthermore, the chronic lack of efficient stimulation of the salivary glands engendered by relatively soft foods

* Compare the septic tank system for the purification of sewage.

leads, no doubt, to a corresponding lack of development and output of ptyalin. Now, if there is a relatively great amount of starch left about the teeth, can we wonder that the acid-producing bacteria largely preponderate and play havoc with the teeth.

There are some clinical observations which tend further to corroborate these observations—for example, the fact that millers who are constantly breathing flour-dust are particularly susceptible to caries, while, on the other hand, those who suffer from chronic gingivitis, due to tartar, tend to show signs of immunity to the disease. In the first case we have a constant supply of carbohydrates without the physiological processes which clear them from the mouth, and a consequent increase in the number and intensity of the acid-producing bacteria; while, on the other hand, the chronic inflammation of the gums at the necks of the teeth give rise to an undue proliferation of the albuminous epithelial and other cells, and a consequent increase in number of the liquefying bacteria. Presumably, also, the inflammation produces an increased flow of the *alkaline* secretion which is normally produced at the necks of the teeth.* This at least may be assumed to take place in the early stages of the disease before there has been much destruction of the structures round the necks of the teeth.

Another observation which tends to lead me to similar conclusions is the fact that the excavation of carious cavities is more or less painless when the decay is slow, while it is, as a rule, rather painful when the decay is rapid.

* "The Causes and Prevention of Decay in Teeth," pp. 65, 67.

When the decay is slow, carbohydrates being limited in amount, the proliferation of the liquefying bacteria is as a rule predominant, and consequently the dentinal fibrils are disintegrated in advance of the decalcification, while when the decay is rapid the acid-producing bacteria are particularly predominant, and therefore the dentine is decalcified in advance of the living and sensitive dental fibrils. So, too, if a very sensitive cavity is but partly cleaned and covered over with cement so as to exclude carbohydrates more or less completely, it will gradually become less sensitive, as presumably the liquefying bacteria destroy the albuminous fibre.

"Of special interest is the peculiar relationship between the parotid secretion and acids, for then a saliva is always secreted which is particularly rich in proteids. This peculiarity is still without an explanation. Perhaps it concerns some antitoxic precautionary measures."*

"Submaxillary saliva . . . contains, often in abundance, salivary corpuscles, and amorphous masses of proteid material."†

What is the meaning of these facts? I can do nothing more than offer a suggestion. Since teeth came into existence it was necessary to have them protected from the action of acid, and to do so effectually, not only does

* Pawlow and Thompson, "The Work of the Digestive Glands," p. 152. This quotation refers to the saliva of the dog, and is introduced on account of its suggestiveness and to indicate that in the case of animals, especially when the ptyalin is very weak or absent, immunity to caries may come about in a manner essentially different from that which obtains in man.

† M. Foster, "Text-book of Physiology," 3rd edition, p. 219.

acid produce a free flow of saliva, but a provision is made whereby it shall also be possible to track out the source of the acid, supposing it has its focus at any particular place in the mouth. Let us suppose that a group of acid-producing bacteria have a particular position in the mouth, and that the salivary corpuscles are possessed of positive chemiotactile properties, then they will move in the direction of greatest concentration, and thus centre round the group of acid-producing bacteria. The future of these bacteria would no doubt be disintegration by the leucocytes. We see in this a special provision for the destruction of acid-producing bacteria. It should be remembered, however, that this beneficent action could not take place if the carbohydrate in which the acid bacteria were proliferating was too concentrated and closely packed to allow of the ingress of these amœboid cells.

The meaning of the masses of proteid material is equally problematical. Beyond supplying the liquefying bacteria with pabulum, and so letting them predominate over the acid-forming bacteria, their use as concerns immunity appears to be quite meaningless.

CHAPTER IV.

SOLUTION OF THE PROBLEM OF SUSCEPTIBILITY AND IMMUNITY TO DENTAL CARIES (*continued*).

"The question of the different susceptibilities of different teeth to caries still remains an unsolved problem."* If, therefore, we can show that the known susceptibilities of the various teeth conform to and are the result of the conditions which we have explained with relation to susceptibility to caries in general, then not only will the solution of an unsolved problem be an interesting addition to our knowledge, but it will be an argument of considerable importance in establishing the truth of the general contention which we have already advanced. We now enter upon a problem which obviously does not necessitate us making further reference to the nature of the food. We have now to deal solely with the conditions which permit of the lodgment of fermentable food where susceptibility is known to exist, while we have to show that these teeth or parts of teeth which show immunity are subject to those self-cleansing processes already described.

We should remember the direct effect of mastication; the indirect effects of mastication—*i.e.*, the muscular contractions of the tongue, cheeks, and lips, and the influence

* Miller, *Transactions of the Odontological Society,* March, 1903.

of these on the fluids of the mouth; and the effect of ptyalin in dissolving the carbohydrates, and thus facilitating the removal by swallowing of the converted starch.

Let us first direct out attention to the lower incisors and canines. These teeth are peculiarly immune to caries. Their shape is such as to render the lodging of food practically impossible except on their approximal surfaces, for not only are there no crevices in which food might lodge, but the motions of the lower lip and tongue are greater over the labial and lingual surfaces than over any other teeth. Leaving other things out of account at present, the fact that the mandible and the tongue are relatively fixed posteriorly, the greater susceptibility for food to lodge must be towards the back of the mouth. So, too, the saliva is for similar reasons caused to pass between these teeth more fully than it does towards the back of the mouth.

Then, again, when a piece of food is cut by the incisors the lingual surface of the superior incisors acts as a buttress upon which the food is held while the lower teeth cut through it. While the lower incisors are passing through the food the food is gliding down over the labial and lingual surfaces of the teeth, thus keeping them clean, so that, even though the lower incisors are irregular through crowding, the rubbing past of the food while it is being incised prevents, as a rule, a great tendency for the food to lodge and undergo fermentation. In this we see a remarkable difference from the upper incisors, for as the lingual surfaces of the upper incisors act as a buttress to the food a certain amount is squeezed between them, and

therefore the approximal surfaces of the *upper incisors* are liable to lodge food which may undergo acid fermentation. The incisors are unlike other teeth, in that, when they are slightly spaced, they are not so susceptible to caries as molars and bicuspids. This follows as a natural corollary from the fact that they do not bite the food down to the gum and leave it to lodge there. Each act of mastication tends to force it out from between the upper incisors, while the motions of the lips and tongue render it well-nigh impossible for food to lodge between the lower incisors when they are spaced.

When there is crowding of the upper incisors the tendency of food to be jammed between the teeth is great, and consequently the tendency to caries is very considerably increased.

There are frequently pits and crevices on the lingual surfaces of the upper incisor teeth, and these, of course, tend to have food jammed into them, and, consequently, to become carious.

The canine teeth are particularly insusceptible to caries, and if their shape is considered, it can hardly be wondered at. We may here illustrate an interesting detail. Though the shape of the tooth may in itself be of such a nature that food does not tend to lodge about it, yet the approximal teeth may have considerable effect in modifying this. Now, it very frequently happens that the first upper bicuspid decays on its mesial surface from the lodging of food, but, of course, this same food lodges against the distal side of the canine. We consequently expect, and almost invariably find, that there is approximal

decay on both teeth. However, it should be noted that the tooth presenting the broadest and flattest approximal surface (the bicuspid) is the most liable to be most affected, and, moreover, that the decay is most diffused. This naturally follows, as the fluids passing between the teeth get, as it were, focussed in passing over the more rounded tooth, and exert their beneficent influence while the food tends to lie on the flattened part of the bicuspids. The usual channel for the saliva, therefore, is closest to the most rounded tooth, and thus it may escape the destructive action of the acid fermentation altogether.

Passing now to the bicuspids, it need only be remarked that they are intermediate in size, shape, and position to the rest of the teeth, and are therefore intermediate in their susceptibility. Interstitial caries is fairly common, and the crevices between the cusps give rise to a susceptibility such as would be expected from the principles already brought forward.

The first molar is particularly susceptible to caries for the first few years after it cuts the gum, and its susceptibility to be attacked rapidly declines after about the eleventh year; in fact, if it has not been attacked before the child enter its teens, its shows but little special susceptibility to caries at all. This may seem a curious and almost inexplicable problem, but I think it resolves itself quite easily. Firstly, it should be remembered that the natural crevices are well marked, and the breadth of the tooth keeps the tongue and cheeks well away from the crevices and approximal parts midway between the lingual and buccal surfaces. This, of course, does not help much

to explain the special susceptibility of the tooth to decay in the early years of its existence, but yet it allows of a mal-environment being easily produced. Secondly, it should be remembered that during the first six years it is the hindmost tooth in the mouth, and the motions of the cheeks and tongue are relatively not very pronounced in its neighbourhood. Thirdly, in the earliest years of its existence the habit of mastication upon it has not been acquired. Nor is there any special demand for more masticating surface than the temporary molars afford. At least, there is no special demand for it if relatively soft food is consumed. Fourthly, the circumstance which hinders the child acquiring the habit of masticating efficiently, and consequently of acquiring the beneficial results of efficient mastication, is the fact that the temporary teeth begin to be shed just after the eruption of the first molar, and their looseness or tenderness tends to prevent the child masticating as efficiently as it otherwise would. Fifthly, the fact that by this time the temporary teeth are frequently carious and tender quite frequently leads the child into habits which only remotely resemble efficient mastication. Lastly, during this age sweets are frequently consumed much too freely.

I need not now go into much detail with regard to the second and third molars; the only special fact which we need refer to is the rapid and frequent destruction of the wisdom teeth. Here we need only remember the circumstances already referred to—namely, the position towards the back of the mouth and the very lengthy period which usually elapses between the cutting of the cusps of the

tooth and its rising to its position of full functional activity. When teeth in front of it have not been lost, the wisdom tooth may generally be regarded as more or less impacted, and not only is it uncommonly slow in erupting, but it has an unfortunate method of cutting the gum. When a molar cuts the gum as it ought, the cusps cut it first, and the tooth rises a considerable distance before the gum which stretches over the crevices disappears, so that these crevices are specially protected during that dangerous period when the tooth cannot be used for efficient mastication ; but in the eruption of a lower wisdom tooth the two anterior cusps cut the gum which overhangs behind and tend to lodge food during the whole time of eruption of the tooth.

How little the nature of the tooth itself has to do with the question of susceptibility may be gathered from the fact that if the teeth in front of it have been removed so that it erupts normally and easily the wisdom tooth seems even in "susceptible" mouths to be fairly "immune,"* provided it occludes properly with its fellow above or below.

I have not gone into this question so fully as the importance of the subject demands, but my object has been merely to supplement and further corroborate the contentions originally brought forward in my book on "The Cause and Prevention of Decay in Teeth." Moreover, the

* I have used the words "susceptibility" and "immunity" in these essays, though I do not believe that the use of these words in relation to dental caries is strictly accurate. There is little or nothing corresponding or analogous to the conditions which produce susceptibility and immunity to specific diseases.

problem is so very simple, provided we realise the real nature of the process of mastication, the function of the saliva and ptyaline, and the nature of the food.

In conclusion, I would urge upon the reader the following generalisation: *The cause of the present-day susceptibility to dental caries is that the natural food-stuffs are to a large extent deprived of their accompanying fibrous parts, and prepared and consumed in a manner which renders them—especially the carbohydrates—liable to lodge and undergo acid fermentation in the mouth, while from the same cause and the induced conditions the acid-producing micro-organisms of the mouth lodge and multiply and augment the rapidity and intensity of the acid fermentation.*

CHAPTER V.

THE CAUSE AND PREVENTION OF DENTAL CARIES.*

Several years ago I ventured to publish some observations on the means of preventing dental caries. These observations were based upon a theory of causation which appears now to be fairly well recognised, and even the various deductions from it have, I believe, a certain number of adherents. Although at first they were regarded as highly "iconoclastic," and though the converts to the new ideas were not numerous, I hope now to show that recent investigation, so far as it goes, tends to establish even the iconoclastic deductions.

To illustrate the position, however, which is taken up by some with regard to recent investigations on the subject, I shall quote a few statements which have recently appeared from authoritative sources:

"If we wish to deal with dental disease, we must first of all possess a correct knowledge of its cause. Do we possess that knowledge? It is now more than fifteen years since Dr. W. Miller's excellent work on the 'Micro-organisms of the Mouth' appeared, in which he clearly

* The four following chapters were published originally in the *British Dental Journal*, January 1 and 15, and February 1 and 15, 1906.

demonstrated that caries of the teeth was due to the abstraction of the lime salts by acid, followed by the peptonizing action of bacteria, the acids being formed from the fermentation of carbohydrate food. There seemed to be a general belief, at any rate amongst those practising dentistry, that the cause of caries had been found, and the fact seemed to be lost sight of that all that Dr. Miller had done was to demonstrate the phenomena of caries, and although his researches had shown the channels in which further investigation should be pursued, the actual cause of caries was still unknown, and is to the present day unknown."*

The same sentiment was echoed in the *British Journal of Dental Science*:† "In spite of Tomes' classic definition of dental caries, and in spite of the researches of Underwood, Miller, Black, Leon Williams, and others, we can no more tell why one mouth is immune and another riddled with caries than we could before these investigations were made."

Similarly, Mr. Stanley Colyer, in a suggestive article on "The Problem of Dental Caries," says: "It must not be lost sight of that the result of Miller's work was to establish the pathological, and not the etiological, side of dental caries; and that we still have to discover, as Goadby says, 'the ultimate liberating cause too often overlooked in the multiplication of predisposing ones'; in other words, we still have to discover what change or changes have taken place in the environment of man or in

* *Lancet*, Editorial, October 21, 1905.

† November 1, 1905.

his constitution that have rendered it possible for the micro-organisms in his mouth to form acids capable of dissolving the enamel of his teeth."*

It is evident that, although recent investigations have been elaborate and painstaking, they seem, nevertheless, to have produced disappointment amongst those who expected to find something of positive value in relation to the all-important question of the causation and prevention of dental caries. It would appear, indeed, that the "negative results" at which Dr. Miller has arrived after so much work have given rise to the depressing belief that we in our day will probably never know the secret of "susceptibility" and "immunity."

Now, although it may be true in general that Dr. Miller's investigations have ended in negative results, and although it may be that this is the necessary outcome of any search for what is essentially little more than an erroneous assumption, yet I believe there is something of positive value in Dr. Miller's recent investigations. I shall refer to four points which show a great advance, or at least an approximation to the views which I elaborated some time ago.†

Firstly, there is the admission that the mouth bacteria probably play an important rôle in protecting the mouth and organism in general against the invasion of pathogenic micro-organisms.‡ So far Dr. Miller assigns a somewhat different rôle to the mouth bacteria from that

* *Dental Record*, July, 1904.

† "The Cause and Prevention of Decay in Teeth," 1900.

‡ *Dental Cosmos*, September, 1903.

which I assigned to them, and he has not yet, so far as I know, condemned the general use of antiseptic mouth-washes, etc., in the prevention of dental caries. At the same time his investigations certainly do not run counter to my observations or inferences, and Dr. Harry Campbell has cited Dr. Miller's experiments in support of my contentions with regard to the rôle of the mouth bacteria, and the value of antiseptic mouth-washes.*

Secondly, there is a reference to the fact that teeth covered with a film of fat are less readily affected by caries than when they are uncoated.†

Thirdly, there is the important reference to the fact of the relative lodgability of different food-stuffs,‡ and fourthly, to the detergent effect of the mechanical action of mastication when the diet is not restricted to soft food.§ I have referred to these four important points for reasons which will be more apparent later; but it is not on account of these points alone that we must value Dr. Miller's recent investigations, for he has done good service in showing that several hypotheses are quite untenable—*e.g.*, the supposed antiseptic properties of the saliva, the presence of glycogen in the saliva, etc. Moreover, investigations are often helpful in another way. Thus, even though they are on the wrong track they may be helpful because they lead to negative results, for negative results on certain lines leave the positive results on other lines more conspicuous.

* *Lancet*, September 12, 1903.
† *Dental Cosmos*, December, 1904.
‡ *Ibid.*, December, 1904.
§ *Ibid.*, February, 1903.

CHAPTER VI.

THE CAUSE AND PREVENTION OF DENTAL CARIES
(continued).

Now I should like to refer to some theories which were dominant up till the very end of last century, but which seem to be disappearing, in England at least, from dental literature. Foremost amongst these was the belief in the degeneracy of the teeth and the hereditary transmission of the acquired constitutional taint. Thus in Messrs. Smale and Colyer's "Diseases and Injuries of the Teeth," first edition, 1893, we read: "On endeavouring to elucidate the causes of the degeneracy of the teeth, perhaps the most important factor is heredity, and yet it is not at all uncommon to find parents with strong healthy teeth whose children are afflicted beyond the average in the matter of decayed dental organs. This points to some cause other than that of heredity strictly interpreted, and the *fons et origo mali* must be sought for either in some constitutional taint, or in some faulty development during gestation, or in some errors in diet and hygiene during the early periods of life." It is hardly necessary to mention that this and much more in the same strain was discreetly omitted by the distinguished author of the second edition in 1902.

Similarly, Dr. Miller at one time maintained that "if a race of human beings or of animals were to make no use of their teeth for several generations, we should expect to find a gradual deterioration of the dental structure. It is, to say the least, highly probable that the soft quality of many of our foods, as compared to those of uncivilised races, conditions a soft, porous dental substance, as well as an imperfect development of the jawbone, and a concomitant crowded position of the teeth."* I am glad to say I have been unable to find any evidence of this assumption in Dr. Miller's recent writings.

The idea that the current methods of preparing wheat and concomitant elimination of the phosphates, which exists chiefly in the outer coating, is responsible for deficient calcification of the teeth, has received a rude shock by the discovery that more phosphates are absorbed or assimilated from white than from wholemeal bread.

Similarly, the assumption that drinking water, which is deficient in lime salts, predisposes the teeth to caries, has, I think, received its quietus from Rose, whose investigations, although apparently intended to support this theory, only seem to show that, if there is anything in the idea at all, it is practically a negligible quantity. Thus, in his recent investigation into "The Teeth of the Inhabitants of Delarne and Gothland," he admits and concludes that "it is the exceptionally hard bread eaten exclusively by the peasants in North Sweden that preserves the teeth of the Delarne people, and keeps them in such sound condition, whilst the Gothlanders ruin theirs by eating black

* "Micro-organisms of the Mouth" (1890), p. 219.

bread, which is soft and sour, and which, furthermore, contains sugar."*

In like manner, Dr. Miller, believing in a qualitative difference in the teeth, expected to be able to elucidate experimentally the cause of the varying "susceptibilities" of different teeth;† but, as far as I can gather from his recent work, his investigations have given little or no satisfaction to his expectations, although possibly they show how some teeth may decay more rapidly than others when once caries is commenced.

It is a noticeable and praiseworthy fact that the researches of those who set out to substantiate certain theories have, by the completeness of their own investigations, done great service in showing how unimportant these theories are in the explanation of "susceptibility" and "immunity" to dental caries.

The extinction of erroneous beliefs has the satisfactory result of concentrating attention on those that may contain the truth, and I believe it is impossible to arrive at a clear appreciation of the etiology of dental caries till we get rid of two other prevalent and erroneous assumptions.

The first that we must banish from our minds is nothing less than the gratuitous assumption of "susceptibility" and "immunity." When we see caries advancing rapidly in any mouth we are not justified in assuming the existence of "susceptibility." Before doing so we should

* *British Dental Journal*, February 1, 1905; abstracted from *Deutsche Monatschrift*.

† *Transactions of the Odontological Society*, March, 1903.

be able to prove that the rapid advance of caries is not the result of some dietetic error, or some other perhaps unknown external factor. To say that the teeth are susceptible or immune in any particular case is to assume that we know every possible external condition which may have brought about the caries.

Although I have taken a constant interest in this subject for a considerable number of years, I have never seen one case in which I could say that the individual was "susceptible" to dental caries beyond the susceptibility that some people have through irregularities in position, malformations of the teeth, habits in mastication, preferences and habits in feeding, and one or two minor considerations of like nature. If by susceptibility, those who talk of susceptibility mean these factors, then, of course, we know what susceptibility is, and the problem is solved; but those who are in search of the nature of susceptibility think that there is some other occult something which we do not know, and which it is their great wish to discover. It seems never to have occurred to those who attempt to find this occult something that it closely simulates the attempt to catch the *fata morgana*. Surely the persistent failures of those who have so laboriously searched should make us pause and ask first if there really is such a thing as this occult "susceptibility" and "immunity" to caries. The futility of this wild-goose chase has only been excelled by the search for the cause of the prevalence of caries in an assumed "hereditary predisposition."

Then, again, there is the assumption that the diet of

the several persons in any one family is essentially the same. They assume without investigation that children in the same family have similar dietetic habits, that they are brought up in the same way on the same diet, and that this is undisturbed either by natural or unnatural preferences in food, or by abnormalities in the visible structure and arrangement of the teeth. Do those who assume identity of diet take the trouble to investigate the habits, tastes, preferences, and dietetic vagaries of those in the same family who are "immune" and those who are "susceptible"? Suppose they are able to do so, suppose they are able to discover some of these little vagaries which seem to afflict more especially the modern child, do they calculate the relative fermentability of that portion of the food which does lodge when, for example, there is a variation in the time taken over a meal or in the thoroughness of mastication? Do they think it makes no difference if, for example, bread is eaten with, before, or after a glass of milk? Do they consider the time and arrangement of the meals? Do they know the effect of a relatively dry meal on the flow of saliva for the five minutes following the completion of the meal? Do they calculate whether acid food-stuffs increase the flow of saliva after the meal is finished, and, if they do, are they sure that their knowledge of the patient's diet and dietetic habits, and the self-cleansing processes which they set up in the mouth is sufficiently exact to tell whether the mouth will be physiologically clean three minutes or three hours after the taking of the food?

A clinical investigation of a complex subject such as

this is difficult and requires constant abstraction, analysis, verification, and cross-examination. To get simple statements of fact even often presents difficulties. This may be illustrated by one or two cases from recent experience. A mother came with two children, aged eight and four years respectively. The child of eight had all her teeth free from caries, the younger child had four teeth with caries more or less advanced. I asked if they had both been brought up in exactly the same way. The answer was yes. I went into detail, and found that the child of eight had never been allowed to eat sugar or sweets, as it had given rise, according to her doctor, to a skin eruption; while the younger child was fond of, and ate liberally of, sugar and sweets. I asked the mother if she considered that the two children were fed in exactly the same way when one had sugar and the other had saccharine. Her reply was that she thought this was of no consequence, as she understood the theory that sugar was harmful to the teeth had been exploded long ago. It is not the tendency to lie, of course, which makes people say that the children in any particular family are brought up exactly alike when they are not; it is simply ignorance of what the differences are which, in the course of years, give rise to materially different results. In the case of sugar, some of us have at least suspicions about it, and we can direct our questions to some purpose. It is not so easy, however, to arrive at the effect of some dietetic variation if we do not know what it is, or at least have no suspicion in our own minds as to its possible effect upon the teeth.

Another difficulty, and, curiously enough, a rather

common one, is illustrated by the following: A patient came with a friend, and the friend entered into a discussion with regard to the cause of caries. She said she had perfect teeth, and so had her mother. I asked her with regard to her dietetic habits, and from what she told me came to the conclusion that in all human probability some of her teeth must have decayed. I told her that my theory could not account for her case. The conversation became more jocular, and, in course of time, she broke out into rather hilarious laughter. Just at that time I observed a gold clasp encircling her upper second bicuspid on the left side.

Before passing on to another aspect of this subject, we should particularly note that there is no known susceptibility and immunity to dental caries in any way analogous to the true susceptibility and immunity which is exemplified with regard to the specific fevers. But there is a close analogy between the undue lodgment and fermentation of food in the mouth and in the stomach; in fact, we may truly say that the condition *par excellence* which leads to dental caries is simply chronic oral indigestion of carbohydrate food. Let us consider what advantage we would derive from reading a disquisition on (gastric) indigestion, in which we were persuaded to believe that there must be some unfathomable susceptibility to, and immunity from, the disease—something which, if only it could be discovered, would save the human race from all the penalties of persistent dietetic errors. Then, again, what benefit would we derive if this enlightened disquisition were to persuade us that indigestion was really the result of a pre-

disposition to inherit a degenerate rather than a good digestion from our forefathers? Lastly, what would we think, if, as a result of elaborate irrelevance and multitudinous experiment, we learned from this disquisition that in order to prevent indigestion we should, as a routine procedure, rinse out the stomach morning and evening with antiseptic washes, and clean it mechanically after the method adopted by chimney-sweeps, rather than give way to the dictates of physiology.

CHAPTER VII.

THE CAUSE AND PREVENTION OF DENTAL CARIES (*continued*).

With regard to rational ideas in the prevention of dental caries by artificial means, we can record remarkable progress. In an important series of articles in the *Lancet*,* Dr. Harry Campbell concluded by referring to and supporting my views with regard to the value, or otherwise, of the tooth-brush, tooth-powders, and antiseptic mouth-washes. He said: "The modern tooth-brush requires to be used with great caution, as it is capable of doing much harm, not only by removing the mucoid film—which, according to Dr. Wallace, protects the teeth from corroding agencies—but probably also by injuring the edge of the gum and the neck of the teeth, and thus setting up the condition known as 'erosion.'" Dr. Campbell referred also to the harmful effects of antiseptics, and was even more emphatic in condemning their use than I had been. Mr. Hopewell-Smith referred to these "iconoclastic" statements, and said: "Ask 100 per cent. of the members of the dental profession to name the two great remedies against the initial commencement of caries of the teeth,

* "Observations on Mastication," July 11, 18, 25, and August 8, 1903.

and all with one voice will exclaim: (1) The use of the tooth-brush; and (2) the use of antiseptic mouth-washes." Yet, Dr. Campbell's statements—at least, with regard to the protective coating—seemed to have impressed Mr. Hopewell-Smith favourably; and, further, he observed that he was "quite dissatisfied with the usual text-book explanations of the etiology of dental caries."*

Commenting on a discussion which ensued on Dr. Campbell's observations in the *Lancet*, the *Dental Annual* for the following year said: "Interest has been aroused by iconoclastic opinions ventilated in medical periodicals as to the efficacy of tooth-powders and the artificial operation of brushing the teeth and gums. There has been a remarkable concensus of opinion as to the superiority of early mastication, the use of hard and resisting food, and the general exercise of the jaw muscles . . . as compared with soft feeding and artificial cleansing." It would appear that we shall soon have to regard the procedure of brushing the teeth rather in the light of a cosmetic than as of any particular value in preventing caries. This view, indeed, has been expressed in the *British Medical Journal*,† and more recently in a leading article in the *British Journal of Dental Science*,‡ which says: "We have all observed mouths free from caries where no efforts at 'oral hygiene' have ever been made, and we are all familiar with mouths requiring constant dental attention, the owners of which are zealous in the use of the tooth-brush

* *British Dental Journal*, November, 1903.

† Dr. Carter, *British Medical Journal*, November 19, 1904.

‡ November 1, 1905.

and dentifrices. In fact, with respect to the tooth-brush, we are of opinion that its use is more of a cosmetic than of a prophylactic nature, though we by no means condemn its use as a means to prevent caries."

Lest misapprehension should arise, it may perhaps be advisable to say that it is not my intention to condemn the tooth-brush *in toto*, but only to relegate its use to a quite subsidiary position. I think its use may perhaps be advocated under most dietetic conditions which at present prevail during childhood; and those who are willing to take the trouble may be encouraged to do so, with special restrictions when there is recession of the gums or erosion cavities. Its use, unlike rational methods of feeding, however, cannot be depended upon solely to prevent caries, irregularities of the teeth, deposits of tartar, or recession of the gums and loosening of the teeth in later life. Nor can its use be depended upon to remove calcific deposits when the normal coating of the teeth is so fully impregnated with lime salts as to form tartar; in fact, when the teeth have a pathological coating, there is practically only one wise course open to the patient, and that is to go to the dentist and have it thoroughly, and, if necessary, repeatedly removed, and the accompanying pathological states properly treated.

The evidence which tells against any special reliance on the tooth-brush and antiseptics is now greater than when my contention was first made, for at that time no one had confirmed my contention with regard to the beneficent rôle of the mouth bacteria. Nor had experimental evidence been brought forward to show that a film of fat or

other material (*e.g.*, plaques) was in any way protective to the teeth. How these facts enforce my original contention I need not explain. My principal intention at present is to indicate the change of opinion which has taken place rather than to present arguments. It would, indeed, appear possible that the aphorism "clean teeth do not decay" will be changed to "cleaned teeth are most susceptible to decay"—*i.e.*, if we mean brush-cleaned teeth, and not physiologically clean mouths. Certainly we very frequently require to fill cervical cavities in the canine, bicuspid, and incisor teeth of those who are most scrupulously attentive to the use of the tooth-brush, while among those adults who do not use the tooth-brush at all, cavities of decay in these situations are rarely to be met with.

When Dr. Miller published his important work on "The Micro-organisms of the Human Mouth," he had not, of course, adopted my views with regard to the relative lodgability and the detergent action of hard food, so it was natural that any observations based upon his work did not lead to the solution of the problem which I have given. It would be absurd, if not impossible, to limit the diet of man to purely albuminous substances. This fact is so obvious that few have taken the trouble to give the subject more than a moment's consideration. Dr. G. C. Hunt, of Indianapolis, however, makes definite reference to the question of food selection, and gives a long list of the important foods which would require to be left out of the dietary. He says that "a casual reading of these lists will convince anyone of the impracticability of

inhibiting dental caries by food selection,"* and that "it would result in the elimination from our bills of fare of many cherished luxuries, and not a few substances viewed as necessaries."

Dr. Hunt, of course, bases his observations on Dr. Miller's investigations on the fermentability of food, and makes the assumption which has been practically universally made that "every meal leaves in the oral cavity carbohydrates and proteids, the two groups of substances most necessary for the nourishment of the oral bacteria, packed down in fissures, crowded into interapproximal spaces, and clinging to the tooth-crowns whenever slight immunity from the movements of the tongue, cheeks, and lips obtains." So long, indeed, as it was assumed that particles of all kinds of food lodged about the teeth after meals, irrespective of the relative lodgability of the foods and of the self-cleansing effects which different kinds of foods give rise to, it was, of course, impossible by a consideration of the foods to explain the relative freedom from caries in one mouth and the relative frequency of the disease in another, except in those rare cases where the diet was strictly limited to albuminous substances. Hence the search for "susceptibility" and "immunity" had to proceed along other than dietetic lines. So thoroughly, indeed, was the dietetic factor negatived by Dr. Miller's exposition of the nature of caries that Dr. G. V. Black and others who wrote between 1890 and 1900 apparently did not consider it necessary to refer to the food at all. No one can be blamed, of course, for not pursuing the

* *Dental Cosmos*, October, 1904.

search for "susceptibility" and "immunity" by an investigation of the physical nature of the foods when Dr. Miller himself proposed and investigated fourteen* different questions which he thought might throw light upon the subject, but as these questions were not concerned with food, dietetic habits, and the effects of mastication, they, of course, led into a similar number of blind roads.

It is, however, satisfactory to note that recently recognition has been taken of the more important consideration of the influence of the physical nature of the food in the causation and prevention of dental caries. Thus, the Royal Dental Hospital has recently issued a pamphlet on "Instructions on the Care of the Teeth," which says: "The kind of food eaten has a great influence on the teeth. Soft foods are more liable to cling about the teeth, whereas harder food, which is often more easily digested, requires more 'biting,' and in this way the teeth are kept cleaner and the growth of the jaws assisted." Similarly, another important pamphlet issued by the School Dentists' Society, "On the Care of Children's Teeth," says "that after the eruption of the molar teeth the food should be *of a firm and fibrous*† *consistency.*"

* *Dental Cosmos*, January, 1903.

† When first I presented my views on the etiology of dental caries, I frequently used the word "fibrous" to indicate the physical nature of those foods which most effectually stimulate vigorous mastication. And although the word does on the whole describe the consistency of the food which stimulates mastication most effectually, I cannot say that I like the word altogether, for two reasons: Firstly, there are some foods which are very efficient in stimulating mastication, but which, nevertheless, are not conspicuously fibrous. Thus, for example, an apple, although perhaps fibrous when compared with cheese or the white of egg, is not in ordinary parlance

Other quotations of like nature might be given, but I think enough has now been said to indicate the change of opinion which has come over the dental profession with regard to the importance of recognising the effect of the physical constitution of the food, to the wisdom of a reform in dietetics, and to the value or otherwise of the tooth-brush, antiseptic mouth-washes, *et hoc genus omne*.

Unfortunately, I must admit that this change in ideas is almost wholly confined to our own country. Although I have followed dental literature in America fairly constantly for the last few years, I have quite failed to observe

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called typically fibrous. Secondly, there is a psychological reason, for when the word "fibrous" is used with regard to food it seems to excite in some minds the idea of something disagreeably tough. Although I may yet on occasion use the word "fibrous" for brevity, it should be understood that I chiefly mean that consistency of the food which *stimulates the pleasurable activity of efficient mastication*. I have to draw attention to this because of what I have heard from too ardent believers in my views. Recently I heard of a medical man who gave his three-year-old child not only the liths of oranges, but also the pips and the rind to exercise its teeth upon. If he had taken the trouble to read a little more carefully he might have seen that I recognised certain limits. But, leaving aside such a stupid case, I shall quote a criticism from an intelligent critic. "Dr. Sim Wallace is of opinion that our food is at fault, and that we should thoroughly masticate food of a hard and fibrous nature rather than that of a soft and easily fermentable kind. He is possibly correct, but as it has never been put to the test, so far as we know, it can be only an opinion. And even were it proved to be correct, would the public relinquish the soft food, to which it has become accustomed, to chew coarser fare which it would probably dislike? We doubt it." I do not intend to make much comment on this, but only to refer to the fact that if by coarse and fibrous we only mean that consistency of the food which stimulates the pleasurable activity of efficient mastication, quite a different feeling is engendered as to the desirability of the proposed change.

any progress in ideas with regard to the cause of caries, to the relative lodgability, or to the detergent effects of the food. Indeed, one seldom sees any reference whatever to the physical nature of the food, except perhaps to maintain the old delusion that it is on account of the soft food of the present day that the teeth are not so perfectly calcified and resistant to the carious process as was the case in the time of our more primitive ancestors. We, of course, as odontologists, know that the crown of the tooth is formed under the gum and quite independently of functional activity, that the enamel is not strengthened by wear, and that the temporary teeth, which at the present day are so extremely "susceptible" to decay, always have, since the advent of man, been formed long before the child has left off sucking liquid milk at its mother's breast.

So, again, I must regretfully admit that in America the great dictum that the "tooth-brush is mightier than the dentist" still reigns supreme. If the dictum be correct, God help the dentist.

CHAPTER VIII.

THE CAUSE AND PREVENTION OF DENTAL CARIES
(concluded).

If in the prevention of caries we have relegated the use of the tooth-brush, of tooth-powders, of antiseptic and of alkaline mouth-washes to a quite subsidiary place, can we report progress in ideas with regard to any other method of combating the ravages of the disease? I venture to think we can. At the same time, we must recognise that those who admit at least a considerable amount of truth in the evidence upon which the proposed method is based doubt its practicability. Thus some of our most distinguished confrères have pronounced it as "impossible." Mr. Goadby, for example, writes thus: "We have seen from a rapid survey of the pathology of the mouth that the food-stuff question is an all-important one. It is, moreover, well known that our methods of food preparation have undergone very considerable changes during the last half-century, and a very large number of fine carbohydrate preparations are on the market, and have a wide sale. While the preparations are of such a nature, the mechanical effects of mastication in cleaning the teeth and gums is nil; the carbohydrate itself is not bad, but the fact that it remains around the teeth is the evil. It has

been suggested, and I think with not a little truth, that could we return to a diet containing a larger quantity of fibrous matter, we should largely reduce the incidence of dental disease. It is, however, an impossible task to change the food of a nation."*

I admit that at one time I, too, doubted whether it would be possible to effect the necessary reform. At that time I had the idea that there was a science of dietetics, and that the methods advocated for the feeding of children were physiologically correct; but this was an error. Recent investigation has conclusively proved that the restricted diet which children are *compelled* to subsist upon takes little heed of the physiological, anatomical, and instinctive requirements of the child, and results not only in the ruin of the teeth, but also in physical deterioration in general. I cannot enter into this subject here; I have recently done so elsewhere.† Suffice it to say that, if children are fed according to physiological principles, while hygienic requirements are not neglected, the teeth will not decay, nor will the other diseases which result from the infringing of physiological laws be at all likely to be prevalent.

Ask yourself. If you were a parent, would you feed your child unphysiologically if you knew what the physiological requirements of the child were? Your answer is, no doubt, that you would feed it physiologically. It is a miserable parent who will not exercise a moderate amount of care in the bringing-up of his

* K. Goadby, *British Medical Journal*, August 27, 1904.

† "The Rôle of Modern Dietetics."

children; and as regards the teeth this is, I believe, all that is required. It may be said that the children grow up and have preferences, and cease more or less to be under control, and that they will not take the trouble to live physiologically. But this supposition would not be justified in the vast majority of cases, for the instincts and preferences are *normally* as nearly correct as we could wish for, and we know from experience that if at the age of, say, eighteen a youth has a perfect set of regular teeth, the chances are that he will have little need of the dentist till pretty late in life, and this notwithstanding the fact that he is surrounded by the temptations of the toothless and the superstitions and prejudices bred from ignorance and antiquated physiology.

It is my conviction that if the dental armamentarium is not more or less destroyed, and if morbid tastes are not initiated before a youth gets "on his own," we need not fear that he will by preference take to pap-feeding and vagaries of diet which lead to the destruction of the teeth. We shall see later that the physiologically correct food is greatly to be preferred by the epicure, provided he has got his teeth, and is accustomed to use them.

I do not intend to go at all fully into the question of diet here. It is rather my intention to show how anything may be given to children without harm resulting. Certain apparently trivial considerations, however, in the routine dietary may be referred to. The first is that much the greater part of the diet should be of such a firm consistency that it will *necessitate* efficient mastication. It is sheer folly to attempt to teach a child the

habit of masticating thoroughly if at the same time a soft or milk-soaked diet forms much the greater part of the meals. Yet this is what is actually advocated in books on children's diet provided by our distinguished colleagues in the medical profession for the guidance of mothers. A child thrives just as well if it eats its rusk or what not and then drinks its milk and water as if it swallows rusks soaked in milk; indeed, it thrives much better, for however much it may have been neglected in the past, we now recognise the advantages of mastication, insalivation, and preparation of the food *in the mouth*, while we also recognise the harm of cheating the teeth of their share in digesting it. Then, again, it is ridiculous to advocate a liberal supply of fat in a child's dietary if by encouraging swallowing without mastication we induce a morbid craving for sugar and actual revulsion to fat. Yet this is systematically done. It should be realised that the palate is an important monitor in the natural selection of foods. If, for example, a child masticates a slice of toast thoroughly, a considerable part of the starch becomes converted into sugar in the mouth, and the palate appreciates the amount of carbohydrate consumed, so that after a time it gets satiated with this particular variety of food, and is willing to take fat. If, however, the carbohydrate is soaked in milk, it is rapidly slipped past the taste organs, and consequently the palate craves for more of the carbohydrate, as it is not cognisant of the amount already consumed. Whether this idea be considered correct or not, as a matter of fact, the only child that I know of, who of his own free will eats lumps of fat of all

kinds is the only child I know of who was deliberately brought up on food which necessitated thorough mastication. His parents, I may say, at the same age both revolted at the idea of eating the least shred of fat; indeed, his father only learned to eat butter at the age of eighteen.

The next point that I would draw attention to is the arrangement of the menu. Cookery is an art by which man has been able to bring to his use multitudes of foodstuffs, which without its aid he was debarred from enjoying, but although it has been one of the most important triumphs that man has made, it does not necessarily follow that it is an unmitigated blessing. Cooking not only softens food, but it makes the carbohydrates more fermentable and more likely to lodge in the mouth. Now, it is not my intention to advocate a return to primitive foods and an abandonment of cooking. It is my intention only to show how the disadvantages which are associated with our modern methods of preparing and cooking foods may be overcome in the simplest, most efficacious, most pleasant, and most physiological manner. It simply amounts to this: the last item in the menu should be dessert, not sweets. This is physiologically correct, whether we are concerned with oral or stomachic digestion. Uncooked fruit in the routine dietary should be looked on as a *sine quâ non*—at least, in the last meal of the day. The amount of fruit indulged in should be regulated by the amount necessary to keep the whole alimentary canal in physiological activity without the aid of medicine. It is an interesting fact that mothers who have a conscientious

objection to giving medicine, and whose chief concern seems to be the lower end of the alimentary canal, have children who, as far as my experience goes, have teeth which are remarkably free from caries. I need hardly say that some fruits are better than others for keeping the mouth clean. The best is, I believe, the apple. I have been struck with the freedom from caries of those who generally eat an apple after dinner, and a few days ago I heard that a patient's relative of ninety had thirty-two sound teeth, who claims to have always eaten apples, and, moreover, attributes his good teeth to this practice.

There appears to be an idea that foods which are acid in themselves are harmful to the teeth; but clinical evidence does not support this assumption. When foods which are acid are taken into the mouth they stimulate a flow of alkaline saliva, not only while they are in the mouth, but probably even after they are swallowed. This is analogous to the fact that chronic hyperchlorhydria is associated with marked alkalinity of the saliva. Moreover, acids are inimical to the acid-forming micro-organisms, and it is just possible that the acid of acid foods tends to precipitate the mucus on those parts of the teeth which are not subjected to friction, and thus tends to protect those parts of the teeth.* Here I might also observe that the amount of

* Professor Pawlow says: "It is apparent that acidity enjoys a special preference in the human taste" ("The Work of the Digestive Glands," p. 141). This beneficent preference is beneficent for the teeth also—in fact, there is no doubt in my mind that one of the chief causes of the extreme prevalence of caries in children may be attributed to the bland, alkaline, milk-soaked diet which they are compelled against their will to subsist upon.

acid fermentation which different foods are subject to is not necessarily a criterion of the amount that such foods are liable to produce caries. Thus, though bread and potatoes are much more fermentable than sugars,* clinical evidence shows that the latter are more injurious to the teeth. It should further be remembered that boiled starch, though more readily fermentable by bacteria, is likewise more easily and rapidly converted by the pytalin, and thus brought into a state which renders it likely to be quickly swallowed.

I have mentioned these few recommendations to indicate the extreme simplicity of making the principal alterations which are necessary to insure "immunity" from dental caries, to show that it is not restriction in the kind of diet that is required, and to show that but little alteration is required even in the diet of children.

If in recent years medical men have been able to inflict a restricted, soft, alkaline, insipid, unphysiological, and even repulsive diet on the vast majority of children, is it not possible that they will in the future be able (with the aid and advice of the dentist) to impose a less restricted, less pappy, less insipid, and in general a less disagreeable diet on future generations?

It may be remembered that the lancet was at one time the panacea for all diseases. Now, for children at least, milk, or anything which approaches its insipidity, seems to have taken its place. The infant's toothless mouth and immature stomach appear to be idolised, and the teeth and alimentary canal of children and adults deprived of

* Miller, "Micro-organisms of the Human Mouth," p. 208.

their normal requirements. Possibly the pap craze will go the way of the lancet.

It should be distinctly realised that "most of the delusions under which the public labour to-day its ancestors were taught by the medical men of their time. The history of medicine is largely a history of error; this, not because physicians are exceptionally stupid, but because medicine is always at the mercy of the more fundamental sciences, and these are but a growth of yesterday. Thus it is that what was universally taught and believed only a generation ago we now repudiate."*

It is not my desire to enter into argument with regard to the inflictions and restrictions which have brought about the frightful state of the teeth which we know of to-day. I want only to indicate that the natural and beneficent desires and instincts will rather help than hinder the prevention of decay in the teeth—*i.e.*, of course, if the desires, instincts, and anatomy of the child are not perverted or ruined in childhood. This is my reply to those who admit that I may be correct, but doubt if people would relish and adopt the proposed reform. It is suggested that the experiment should be tried on the *corpus ville* before the theory can be proved. This I have done, and the teeth are, at the age of five, absolutely free from all suspicion of caries,† and this in spite of the fact that, hereditarily, the child under consideration would have

* C. W. Saleeby, M.D., F.R.S.

† In a recent careful investigation into the state of school-children's teeth at that age, not one was found to have a perfect dentition; in the 95 children examined, 896 carious teeth were found (*British Dental Journal*, November 15, 1905).

been expected to have had remarkably bad teeth, and, further, in spite of the fact that he was a bottle-fed baby. Moreover, the tooth-brush and antiseptic mouth-washes were not used, except occasionally after partaking of food at the houses of friends. Yet, though considerably worn, his teeth are, and always have been, as white and clean as could possibly be desired; the darkest, the upper incisors, being B 1 of Ash's shades.

Further proof is surely forthcoming, for the theory is now believed by many to be in accord with common-sense and clinical experience, and it is impossible to prevent intelligent dentists as parents from adopting the same simple precautions for the benefit of those who are nearest and dearest to them.

It is hardly necessary to add, in conclusion, that what I have said in this communication does not constitute the whole of the reform in current methods of feeding children which I advocate. It is, however, perhaps enough to show that a fair knowledge of the true principles of dietetics is as necessary for the dentist as for the medical practitioner; and although I have only mentioned two important points here, it is not to be assumed that I overlook obvious corollaries, such as the injurious effects of little between-meals, or of the still more disastrous habit of taking "a little milk and a plain biscuit, or a piece of bread and butter" at "bed-time."* I might, indeed, add that this latter custom, on a moderate computation, accounts for the

* Chavasse, "Advice to a Mother," 15th edition, revised and brought up to date by George Carpenter, M.D., Editor of the *British Journal of Children's Diseases.*

destruction of millions of teeth, for the consequent general and correlated diseases of hundreds of thousands, and the premature death of tens of thousands *annually*. Yet this is encouraged by the most distinguished authorities in the medical profession, which exists for the alleviation of disease and the suffering of humanity.

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