ordinary alveolar abscess. The patient was sent for X-ray examination and a mouth wash was ordered.

The X-ray photograph showed unerupted teeth, four being plainly visible, but which teeth they were was uncertain (fig. 1).

The patient could not supply any definite history; he was a healthy man and had had no illness and no trouble or pain with his teeth. He had been without front teeth for at least twelve years. He remembers having had little black stumps level with the gum, but these fell out, they were not extracted.

His work necessitates his using a stock and bit, which he rests against his chin in working it. This has caused some thickening of the soft tissues.

The operation, which was carried out under chloroform and ether anæsthesia, consisted in making an incision to the full extent of the swelling and cutting away the outer wall. This did not give a very satisfactory field for operation, but the teeth could be felt quite easily. They were loosened by the straight

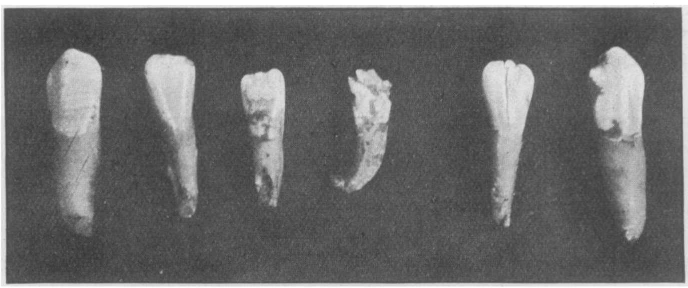

FIG. 2.

elevator and removed with Reed's forceps. Their removal did not present any great difficulty. They consisted of the two canines and lateral incisors. The patient did well and at the end of three weeks I examined him again and was surprised to find that a tooth could be felt in the cavity. Further X-ray examination showed two teeth, one almost horizontal, the other leaning over to the left side. The patient was again anæsthetized with chloroform and ether and the teeth were removed by the same method used for the others; but these caused a considerable amount of difficulty, due no doubt to their being implanted more deeply in the bone and to their position. On examination of the teeth it will be noticed that the left central incisor has a curved root and is undoubtedly the one which was horizontal, the right leaning towards the left side; each tooth shows some rarefaction at the root; the canines only show the thickened cement, which is usual in cases of delayed eruption (fig. 2).

The Effect of Diet on the Resistance of Teeth to Caries.

By MAY MELLANBY.

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IN the March number of the *Dental Cosmos* the following statement occurs in the editorial article:—

"Dr. Black's researches led him finally to the belief that caries of the teeth is a factor of the environment of the teeth, and not of the structural peculiarities of the teeth themselves; that structural features may influence dentine is an indication of increased resistance to caries even when the enamel and primary dentine are badly formed. Thus twenty out of the twenty-four exceptions to the general rule fall into line with the subsidiary hypothesis. A definite proof of this subsidiary hypothesis, in support of which I have supplied some evidence, would be of great importance, for it would suggest a means different from any previously suspected of altering the resistance of erupted teeth to harmful influences.

Further evidence which supports the hypothesis is seen in cases of teeth where caries has been arrested. This process is a reaction controlled by the activity of the pulp, and only takes place when this tissue is alive. The extensive translucent zone in the primary dentine and the large amount of secondary dentine often found in arrested caries, are evidences of the potent reaction of the tooth, and are strongly suggestive of the unity of the problem of arrested caries with that described above. It appears, in fact, that the mechanism of dental defence controlled from the pulp and the inside of the tooth is of great importance, and demands consideration in any study of the ætiology of dental caries.

I have attempted to show that the reaction on the part of the tooth, both to caries and attrition, may be strong or weak, as evidenced by the amount and condition of the secondary dentine produced during the reaction. Thus if the secondary dentine is well formed, the damage produced by caries is more likely to be slow or arrested than when it is poorly formed. I have provided statistical evidence which suggests that this holds in the case of the deciduous teeth of children. The few results so far obtained in regard to the relation of diet to the structure of secondary dentine in animals indicate that this relationship is similar to that already shown to exist between diet and the structure of enamel and primary dentine.

If this should ultimately prove to be the case it will be evident that not only is the structure of teeth controlled by the diet during their development, but also that their subsequent resistance to caries and other harmful influences is dependent on the food, and more especially on certain substances supplied to the body in some foods acting on the teeth by way of the blood-stream, through the pulp, and possibly also in other ways. In other words, those dietetic conditions which result in the formation of perfect teeth, regularly arranged in well-grown jaws, will also assist in the defence, even of badly formed teeth, against noxious agencies.

SUMMARY.

There is evidence that those dietetic conditions which, as I have shown in earlier publications [1], control the formation of good enamel and primary dentine, also confer upon teeth after eruption the power to resist bacterial invasion and other destructive influences for :—

(1) The experimental evidence at present existing, although small in amount, suggests that the pulp of erupted teeth reacts to destructive stimuli, so as to produce well formed secondary dentine when the diet is "good," and either does not react at all or only with the production of imperfectly formed dentine when the diet is "defective."

(2) Among the children's deciduous teeth examined, those which had resisted caries, in spite of defective structure, show in general well formed secondary dentine produced as the result of attrition (fig. 4), whereas those which are carious but of normal structure have usually badly formed secondary dentine (fig. 5).

(1) Thick and poorly calcified jaw bone and alveolar processes.

(2) Irregularity in the arrangement of the teeth, generally most noticeable in the lower incisors.

(3) Delay in, and retardation of, the eruption of the permanent teeth.

(4) Interference with the calcification of the enamel, which is often either deficient in amount or defectively formed.

(5) Interference with the calcification of the dentine, which may be either small in amount, or poorly calcified containing varying numbers of interglobular spaces.

(6) The tissues at the gingival margin and the periodontal membrane are often abnormally developed.

It may be added that defectively formed deciduous teeth can also be produced in puppies by feeding bitches during pregnancy and lactation on diets which are abundant from the point of view of energy and also protein, fat, carbohydrate and salt-content, but poor in quality, and especially in vitamin A.

Whereas it is comparatively easy to produce the above-mentioned abnormalities by defective diet it is also easy to produce in other puppies of the same litter perfectly formed teeth and jaws by feeding them on similar diets but containing abundant vitamin A [1]. Another dietetic factor which has been shown to influence the teeth at least of guinea-pigs, is the antiscorbutic vitamin. Zilva and Wells found that the deprivation of this substance was followed by profound changes in the pulp and dentine of guinea-pigs' teeth [2].

There is some hope that in the near future it will be possible to make direct observations not only on the relation of diet to the development of teeth but also to the production of dental caries. American workers have repeated and extended some of my early experiments and claim to have produced caries-like lesions in rats' teeth by feeding these animals on diets deficient in vitamin A, calcium, phosphorus, and other substances. If this hope is justified a great advance will have been made in the study of dental defects, for, although the experiments on the production of artificial caries *in vitro* are of interest, observations of this nature do not appear to touch the real problem. This type of work has resulted in almost universal concentration of dental authorities on carbohydrates, and while I am prepared to admit that these substances probably play a part in the development of dental caries, I have failed to produce this condition in dogs even after feeding them for over two years on a pappy diet containing on the average two ounces of glucose a day; nor has Howe [3] been successful in producing caries in guinea-pigs on diets containing different carbohydrates.

It seems probable that the influence of carbohydrates on caries is not only due to changes in the mouth but also to their action after digestion and absorption. I have found that, under some conditions, foodstuffs, rich in carbohydrates, such as cereals, antagonize the calcification of teeth. Their action on caries may be closely related to this.

In order to get at closer grips with the problem of dental caries I have extended my investigations to children. In a recent publication [1*c*] I pointed out that, contrary to the usual teaching, a large number of children's deciduous teeth are imperfect in structure. Out of 302 examined microscopically 84·5 per cent. were badly formed. This percentage is to be contrasted with the 3 per cent. described as hypoplastic by the dental surgeons who supplied the cases. Thus it appears that naked-eye examination is, according to standards used at present, of limited value in determining the structure of teeth. In the following table the result of the histological examination of these teeth as regards both structure and caries are set out:—

TABLE I.

Type	No. examined	Normal Structure: No caries	Normal Structure: Caries	Hypoplastic Structure: No caries	Hypoplastic Structure: Caries
Incisors	47	34	5	—	8
Canines	29	1	—	12	16
First molars	88	1	5	1	81
Second molars	138	—	1	—	137
	302	36	11	13	242

There is obviously a close relationship between structure and caries, since 83·8 per cent. of the teeth referred to were carious and 84·5 were hypoplastic, but more detailed examination revealed that the correlation is not quite so close as these figures imply, for eleven teeth were well formed and yet carious, while thirteen were free from caries although defectively formed. That is to say, of the 302 teeth examined twenty-four (7·8 per cent.) were quite out of harmony with the hypothesis that well formed teeth are more resistant to caries than those badly formed, whereas 278 (92·2 per cent.) agreed with this hypothesis. Most of the exceptions were found in incisors and canines. Thus, out of twenty-nine canines twelve were defectively formed and yet free from caries, and five out of forty-seven incisors showed some caries, in spite of being normal in structure. In the case of the molars the correlation between structure and caries was almost perfect, for only two out of 226 molars were quite free from caries and of these two the first was well formed and the second had nearly normal enamel and dentine.

In trying to find a reason for the above-mentioned twenty-four exceptions I was impressed by the varying types of secondary or adventitious dentine found in many of the sections (see figs.). Throughout life the tooth has the power of reacting to external stimuli whether these be of a physical or of a chemical nature. For instance, even as the result of attrition of the enamel, the pulp can apparently be stimulated to bring about alterations in the primary dentine and also to form secondary dentine (see fig. 1). Caries may cause a similar reaction.

Since the structure of the primary dentine is regulated by the quality of the nutriment supplied during the actual growth and calcification of the tooth, it seemed most probable that the same control might also operate in the production of the secondary dentine. If this were the case, it would afford an opportunity of testing the truth of the suggestion I had previously put forward to explain the exceptions to the simple relationship between dental structure and caries. I have elsewhere [1*c*] suggested that:—

(1) If the nutrition of the child were "good" in early life but "defective" after the eruption of the teeth, then the teeth would be well formed and therefore, to some extent, resistant to caries, but less resistant than they would be if the diet remained "good" throughout the whole period, for the resisting power of the pulp, surrounding tissues, and saliva would be depressed.

(2) If the nutrition were "defective" in early life but "good" afterwards, then the imperfectly formed teeth would have their resistance to invasion increased by the improved diet after eruption, but would again be more liable to caries than when the diet was "good" throughout.

If the secondary dentine were badly formed under the first of the above conditions and well formed under the second, then substantial support would be given to the hypothesis that, apart from original structure, diet after absorption plays an important part in regulating the resistance of teeth to caries. I shall refer to this as the subsidiary hypothesis, the main hypothesis being that well formed teeth are more resistant to caries and vice versa.

I shall now deal briefly with some evidence obtained in experimental animals which tends to show that this subsidiary hypothesis is valid. Up to the present time I have examined histologically the deciduous teeth of about 100 puppies and found secondary dentine in only thirteen cases. The relatively few cases in which secondary dentine is present in these deciduous teeth can be easily understood, for the two main stimuli, attrition and caries, responsible for its production in the teeth of man, are usually lacking in the puppy experiments. The softness of the diet, no doubt, accounts for the small amount of attrition in the puppies' teeth. I have begun experiments to investigate this point further, and hope by artificial means to induce more frequently the development of secondary dentine.

Microscopic examination showed the structure in these cases to be as follows:—

TABLE II.—*Secondary Dentine in the Teeth of Experimental Animals.*

	Well formed	Badly formed
"Good" diet	7	2
"Defective" diet	1	3

On the whole it would appear that the structure of the secondary dentine is related to the type of diet eaten during the period of its formation (photomicrographs illustrative of these facts can be seen in figs. 2 and 3). The evidence on this point is meagre, and the problem demands further attention.

Table III gives a classification of the secondary dentine in the human deciduous teeth previously examined for general structure. As explained elsewhere, these teeth were first examined microscopically, and then ground sections were made by Weil's process.

TABLE III.—*Type of Secondary Dentine in the 302 Human Deciduous Teeth.*

	GOOD PRIMARY DENTINE AND ENAMEL		BADLY-FORMED PRIMARY DENTINE AND ENAMEL	
Secondary dentine	Caries (11)	No caries (36)	Caries (242)	No caries (13)
Badly formed	9	8	130	2
Well formed	0	23	15	9
None	2	5	97	2

The exceptions to the general rule that structure and caries are closely related consist of eleven teeth which are carious and yet are well formed (first column), and thirteen teeth without caries although badly formed (fourth column). In the first group, however, eight out of the eleven have badly formed secondary dentine (fig. 5), in one case the pulp is replaced by cement, while the remaining two show no evidence of reaction. In the other group of exceptions, nine out of the thirteen have well formed secondary dentine (fig. 4). The majority of the 302 teeth examined were carious, and had defectively formed primary and secondary dentine (fig. 7). Thus it would appear that badly formed secondary dentine is an indication of lowered resistance to caries even when the enamel and primary dentine are good, and well formed secondary dentine is an indication of increased resistance to caries even when the enamel and primary dentine are badly formed. Thus twenty out of the twenty-four exceptions to the general rule fall into line with the subsidiary hypothesis. A definite proof of this subsidiary hypothesis, in support of which I have supplied some evidence, would be of great importance, for it would suggest a means different from any previously suspected of altering the resistance of erupted teeth to harmful influences.

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(3) Diets which bring about the development of normal teeth in puppies are just those which enable the animal to resist bacterial infection. This point has been mentioned in earlier publications.

Of course I would be the first to admit that what I have said to-night is only part of the story, and that much more information is needed before dental caries can be really understood. On the other hand, the point of view as illustrated by the experimental results described is, I think, important, and will certainly lead to much further information concerning the physiology and pathology of teeth and the related tissues.

The expenses of this investigation were defrayed by a grant from the Medical Research Council, to whom my thanks are due.

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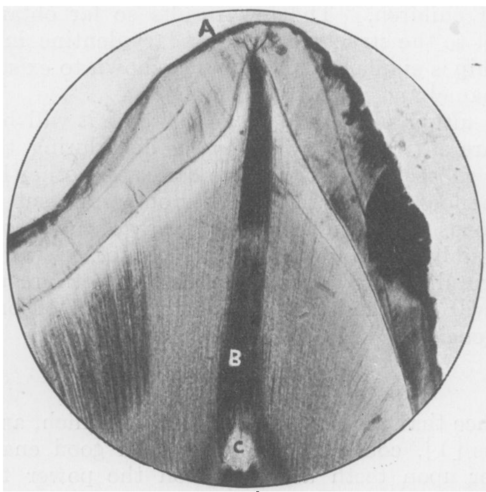

FIG. 1.

FIG. 1.—Human deciduous molar. Slight attrition of enamel at A, resulting in changes in primary dentine B, and the production of secondary dentine at C.

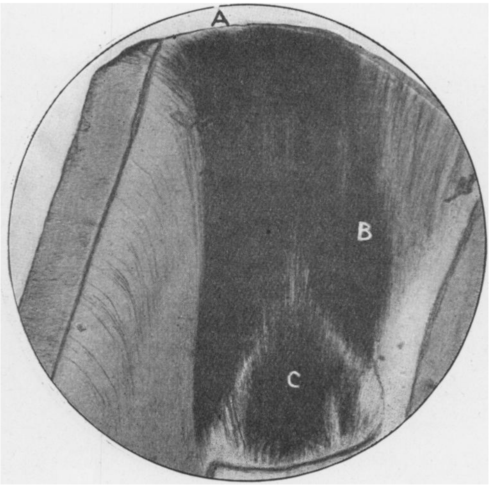

FIG. 2.

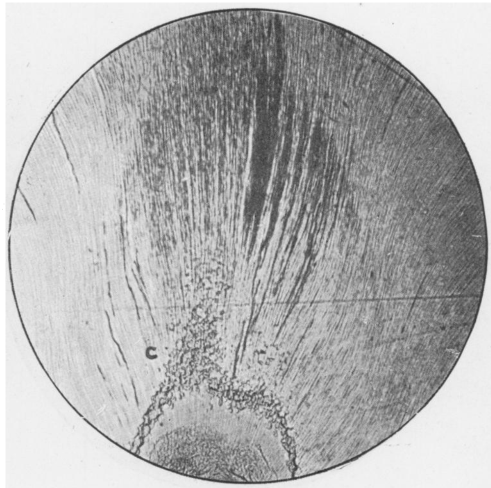

FIG. 3.

FIG. 2.—Deciduous tooth of puppy showing a large amount of attrition of enamel and dentine A, resulting in changes in the primary dentine B, and production of secondary dentine C. Secondary dentine well formed as result of a "good" diet after eruption and during time of attrition (cod-liver oil in diet).

FIG. 3.—Deciduous tooth of puppy showing secondary dentine C, associated with attrition (not indicated in photomicrograph). Secondary dentine badly formed and containing many interglobular spaces as result of "defective" diet after eruption (olive oil in diet).

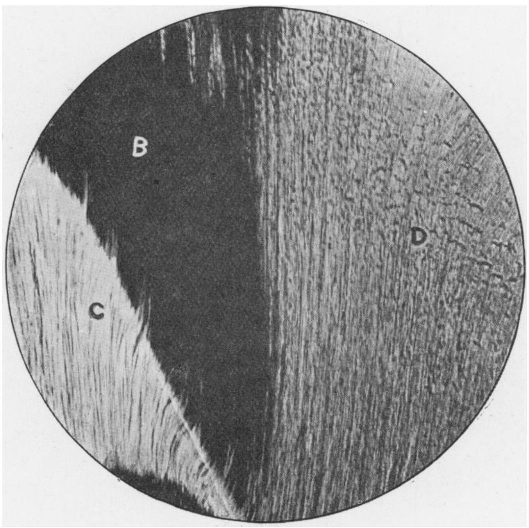

FIG. 4.

FIG. 4.—Human deciduous canine containing well formed secondary dentine C. There is no caries although the enamel and primary dentine D are imperfect.

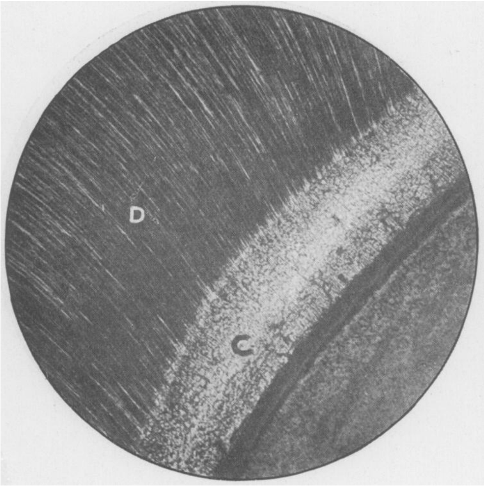

FIG. 5.

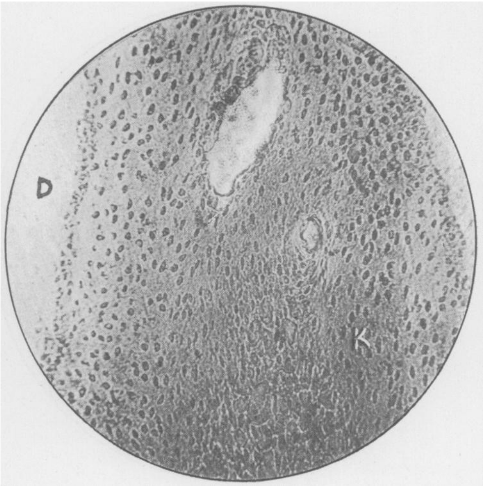

FIG. 6.

FIG. 5.—Human deciduous incisor showing badly formed secondary dentine C, with many interglobular spaces. The tooth is carious although the enamel and primary dentine D are well formed.

FIG. 6.—Human deciduous incisor (Mr. Law's case) showing pulp filled with cement K. The tooth is carious although the enamel and primary dentine are well formed.

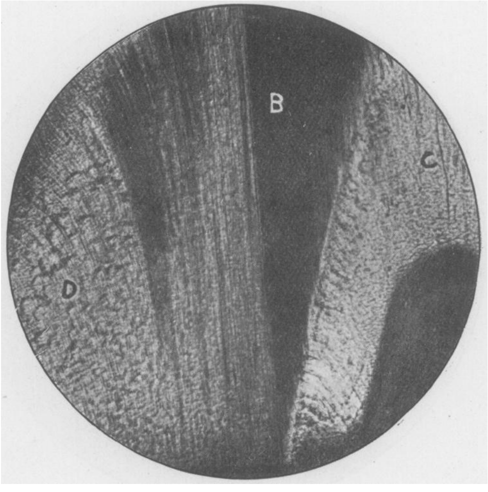

FIG. 7.

FIG. 7.—Human deciduous molar showing badly formed primary dentine D, and badly formed secondary dentine C. Tooth carious.