

## Remarks

ON

THE INFLUENCE OF A CEREAL-FREE DIET  
RICH IN VITAMIN D AND CALCIUM ON  
DENTAL CARIES IN CHILDREN

BY

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Throughout a series of investigations upon dental disease our aim has been to correlate animal experiments and investigations on man, the former serving as a basis for the latter. It is obvious that these two means, taken in conjunction, hold out the best hope for the discovery of the aetiology of dental disease and for the evolution of suitable methods for its elimination.

It has been shown<sup>1, 2</sup> that normal, well-developed teeth are more resistant to caries than poorly developed (hypoplastic) teeth. Since the majority of human teeth in this country are defective in structure,<sup>3</sup> it would seem that one method of reducing the incidence of dental caries should be the production of teeth of good structure by suitable diets, both for mothers during pregnancy and lactation, and for their offspring during the period of tooth calcification.\* This is essentially the prophylactic method of attacking dental caries.

A problem of no less immediate importance is that of arresting the development of dental caries in teeth already erupted. When teeth are attacked by caries, or when they are injured by some other agent, a protective barrier of secondary dentine is frequently formed in the pulp chamber opposite the site of injury. The strength of the defence depends partly on the original structure of the tooth, for the better the structure the less the tendency to caries,<sup>1, 2</sup> and partly, as shown by animal experiments<sup>5</sup> on the dietetic conditions existing during the period of injury. For instance, if the diet contains abundant vitamin D, the power of resistance of the living tooth is augmented; the tooth responds to injury by producing a large amount of well-formed secondary dentine, and, in the case of attack by caries, the infective process may be either delayed or arrested.

## PREVIOUS INVESTIGATIONS

We have previously reported three successive investigations<sup>4, 6, 7</sup> upon the effect of diets rich in calcifying properties on the progress of caries. In the later investigations the energy value and the protein, carbohydrate, fat, calcium, and phosphorus content of the diets were similar, and only the fat-soluble vitamin content varied to an appreciable extent. These investigations showed that vitamin D had a dominant influence in delaying the spread and even in arresting the progress of active caries.

[It has only been possible by degrees to differentiate between the various vitamins, and, owing to this fact and to the method adopted of naming newly discovered vitamins, confusion has sometimes arisen. At first only one fat-soluble vitamin, known as vitamin A, was recognized. When the antirachitic vitamin was discovered (1918) and its properties and distribution were seen to be similar to those of vitamin A as then known, it still seemed necessary only to postulate one fat-soluble vitamin. Later, however, this

\* Experimental work on dogs and other animals has shown that for the normal development of the teeth the diet should include abundant vitamin D and calcium, and not be overweighted with cereals.

original vitamin A was found to be a complex of at least two fat-soluble vitamins, for one of which the name vitamin A was retained, while for the other, the antirachitic factor, the name vitamin D was adopted. In the first of this series of publications (1924) the term "vitamin A" refers to the complex—that is, vitamins A and D—and not to vitamin A (sometimes called the anti-infective vitamin) as now recognized. In the third of the series (1928) the same term refers only to one factor of the complex.]

As a consequence of these results, the Medical Research Council, on the advice of the Dental Disease Committee, decided that an investigation on a larger scale, and extending over a longer period, should be initiated. The investigation was made in Birmingham and the interim findings have recently been published.<sup>8</sup> They corroborate our observations, and particularly emphasize the help afforded by irradiated ergosterol (vitamin D) in combating dental caries. In our investigations the percentage increases of carious teeth in children having olive oil and irradiated ergosterol as additions to the basal diet were 10 and 1 respectively, and the corresponding figures obtained in the Medical Research Council's investigation were 7.6 and 2.

The chief problem with which we were concerned—namely, the possibility of retarding or arresting dental caries by dietetic measures—was now solved. We were, however, still faced with the problem why caries is not arrested in *all* children on a given diet. In the first place, the original structure of a tooth affects its resistance,<sup>1, 2</sup> and not only do the teeth in different individuals vary in structure, but the types of teeth in any one individual may also vary; for instance, the structure of the incisors is usually better than that of the molars, and they are also more resistant to caries. Again, during the period of the investigation, the blood supply to one deciduous tooth may differ from that to another owing to dissimilar stages of absorption. It appeared, however, that there might well be dietetic factors apart from vitamin D influencing the carious processes. We recognized that some local chemico-parasitic condition in the mouth might explain the continued activity of caries at some points, but we were not then concerned with that aspect of the problem; our purpose was to ascertain the metabolic influences of food constituents acting on the teeth via the dental pulp after digestion.

Two facts suggested that the cereal intake might tend to neutralize the effect of vitamin D in checking or inhibiting the spread of caries in children. (1) Experiments had shown<sup>9</sup> that cereals, especially oatmeal, tended to counteract vitamin D in producing perfect calcification of the teeth in dogs unless this vitamin were present in abundance. (2) In our first investigation on children we had observed that the diet containing most cereal, especially oatmeal, was associated with the greatest spread of caries. This observation seemed to receive support in some investigations of Boyd and Drain,<sup>10</sup> who found that in the teeth of forty-five diabetic children who were being fed on the standard diets used for the treatment of this disease, caries was arrested; later, in conjunction with Nelson,<sup>11</sup> they fed thirteen non-diabetic children on a similar diet, and again found that any active caries present at the beginning of the investigation was arrested. The diabetic diet given was devoid of cereals and rich in vitamin D. Although these authors did not themselves ascribe their results to any particular ingredients in the diets given, but attributed them to richness in minerals and vitamins and good balance, we assumed, on the basis of the previous animal experiments and clinical observations, that the lack of cereals and abundance of vitamin D and calcium was probably responsible for the results observed. We therefore decided to test our assumption in a fourth clinical investigation.

TABLE I.—Average Daily Consumption of Food (in Grams)

	Present Investigation (IV)	Investigation III (1928)	Investigation II (1926)			Investigation I (1924)		
	<i>Diet 8.</i> Cereal-free. Rich in Vitamin D	<i>Diet 7.</i> Rich in Vitamin D	<i>Diet 6.</i> Rich in Vitamins A and D	<i>Diet 5.</i> Some Extra Vitamins A and D	<i>Diet 4.</i> No Extra Vita- mins A and D. Increased Oatmeal	<i>Diet 3.</i> Rich in Vitamins A and D	<i>Diet 2.</i> Some Extra Vitamins A and D	<i>Diet 1.</i> No Extra Vita- mins A and D. Increased Oatmeal
Milk, whole ... ..	1,190.7	893.0	1,071.6	744.2	535.8	1,190.7 to 893.0	893.0	496.5 to 297.7
Milk, separated ... ..	—	—	—	—	164.3	—	—	—
Bread ... ..	—	283.5	251.1	283.5	226.8	56.7 to 14.2	ad lib.	141.8
Butter and cream ... ..	70.9	28.4	28.4	28.4	28.4	28.4	—	—
Cooking fat ... ..	14.2	7.1	7.1	7.1	7.1	—	28.4	28.4
Sugar, jam, syrup ... ..	56.7	56.7	56.7	56.7	56.7	42.5	85.0	85.0
Oatmeal... ..	—	—	—	—	51.0	—	Occasionally	56.7 to 113.4
Rice, tapioca, etc. ... ..	—	14.2	14.2	14.2	14.2	14.2	14.2	14.2
Meat ... ..	141.8	113.4	127.6	127.6	127.6	42.5	70.9	42.5
Fish ... ..	28.4	—	—	—	—	—	—	—
Bacon ... ..	14.2	28.4	28.4	28.4	28.4	—	—	—
Potatoes... ..	212.6	141.8	141.8	141.8	141.8	56.7	113.4	113.4
Vegetables other than potatoes ... ..	212.6	141.8	141.8	141.8	141.8	56.7	14.2	14.2
Cocoa ... ..	14.2	14.2	14.2	14.2	14.2	14.2	14.2	14.2
Eggs ... ..	56.7	28.4	45.0	14.0	6.0	56.7	Very little	Sometimes
Sodium bicarbonate	—	—	—	—	1.3	—	—	—
Cod-liver oil ... ..	8.6	—	21.0	10.5	—	10.5 to 21.0	7.0 to 10.5	—
Olive oil... ..	—	—	—	10.5	21.0	—	—	—
Radiostol ... ..	0.4	2.5	—	—	—	—	—	—
	2,022.1	1,753.5	1,953.0	1,566.5	1,623.0	1,580.3 to 1,229.6	?	?

Fruit additional to above in each case.

TABLE II.—Analysis of Daily Diets

	Present Investigation (IV)	Investigation III (1928)	Investigation II (1926)		
	<i>Diet 8.</i> Cereal-free. Rich in Vitamin D	<i>Diet 7.</i> Rich in Vitamin D (Irradiated Ergosterol)	<i>Diet 6.</i> Rich in Fat-soluble Vitamins A and D (Cod-liver Oil)	<i>Diet 5.</i> Contained some Extra Fat-soluble Vitamins A and D (Cod-liver Oil)	<i>Diet 4.</i> Contained no Extra Fat-soluble Vitamins A and D. Increased Oatmeal
Energy value ... ..	2,427 calories	2,477 calories	2,680 calories	2,490 calories	2,450 calories
Protein ... ..	87 grams	89 grams	96 grams	85 grams	85 grams
Carbohydrate ... ..	154 "	287 "	284 "	281 "	283 "
Fat ... ..	159 "	116 "	133 "	117 "	111 "
*Calcium... ..	1.7 "	1.3 "	1.5 "	1.1 "	1.0 "
Phosphorus ... ..	1.9 "	1.6 "	1.8 "	1.4 "	1.5 "
Ca : P ratio ... ..	0.89	0.81	0.84	0.69	0.76

The majority of the above data were obtained from Sherman's *Chemistry of Food and Nutrition*.

\* The average amount of calcium required by growing children between 6 and 13 years of age is stated by Sherman to be about 1 gram daily and by English workers the minimum is said to be 0.67 gram daily.

## METHOD OF PRESENT INVESTIGATION

The purpose of this investigation was to test the effect of a cereal-free diet on the incidence and extension of dental caries in children, and to compare the results with those obtained in the third investigation; the diet in each case was rich in vitamin D and calcium, but whereas in the present investigation it was devoid of cereals, in the third it contained a fair amount of these substances. A few children, receiving only the hospital diet, were used as controls, but the results are not given here; they corroborate those obtained with the ordinary hospital diet in the earlier investigations.<sup>4 6</sup> As in the previous investigations, the children were under our direct supervision in an institution, where diets could be

closely controlled and varied at will consistent with their health. They had not been dentally treated except in relation to the investigation.

Contrary to expectations, surprisingly little difficulty was experienced in providing substitutes for cereals, especially for bread, which forms the bulk of the day's food in the homes of the poorer classes, and to which these children were accustomed. The following are two sample diets given on consecutive days:

1. *Breakfast*—Omelette, cocoa, with milk.*Lunch*—Milk.*Dinner*—Potatoes, steamed minced meat, carrots, stewed fruit, milk.*Tea*—Fresh fruit salad, cocoa made with milk.*Supper*—Fish and potatoes fried in dripping, milk.

2. *Breakfast*—Scrambled egg, milk, fresh salad.  
*Dinner*—Irish stew, potatoes, cabbage, stewed fruit, milk.  
*Tea*—Minced meat warmed with bovril, green salad, milk.  
*Supper*—Thick potato soup made with milk.

Some alternative dishes used:

*Breakfast*—Egg—boiled, fried, poached.  
 Omelette containing 2 oz. minced meat.  
 Fish, fried or steamed, or fish cake with potatoes dipped in egg and fried.  
 Bacon, fried or finely chopped with parsley, and scrambled egg.

*Dinner*—Meat, boiled or steamed.  
 Cold meat cut into small pieces with cold dried carrot, onion, and potato, and served on a lettuce leaf.  
 Fresh fruit salad with egg custard or cream.  
 Tinned pineapple with jelly, or mixed tinned fruit with jelly.  
 Baked apple, centre filled with golden syrup before cooking.  
 Junket and milk jelly, or honeycomb mould which contains eggs.

*Tea*—Potato cakes or fish cakes.  
 Eggs, cooked in various ways.

*Supper*—Lentil or celery soup made with milk, minced meat, etc.

An approximate analysis of the diet in this (Diet 8) and in the earlier investigations is given in Tables I and II. The energy value and the protein content of the

diet are seen to be similar to those of the diet given in the previous investigation (Diet 7); the amount of fat, however, is greater, and the carbohydrate content is less. Examination of Table I shows that instead of cereals—for example, bread, oatmeal, rice, and tapioca—an increased allowance of potatoes and other vegetables, milk, fat, meat, and eggs was given. The total sugar, jam, and syrup intake was the same as before. Vitamin D was present in abundance in either cod-liver oil or irradiated ergosterol, and in egg yolk, butter, milk, etc. The diet of these children was thus rich in those factors, especially vitamin D and calcium, which experimental evidence has shown to assist calcification, and was devoid of those factors—namely, cereals—which interfere with the process.

According to our present knowledge, therefore, the diet was optimal for the suppression and cure of active dental caries. On the other hand, it must be pointed out that the teeth of these children were fully erupted, for the most part badly formed, and often carious before the investigation was begun, and that the effects of the diet were tested at a time of life (that is, 5½ years) when dental caries tends to develop rapidly. This cereal-free diet, rich in vitamin D, was given to twenty-two children for an average period of twenty-six weeks. The methods of appraising the results were identical with those used in the previous investigations, details of which were given in the earlier publications.<sup>4 6 7</sup> The mouth of each child was charted before the diet was introduced, the number

TABLE III

	Present Investigation (IV)	Investigation III (1928)	Investigation II (1926)			Investigation I (1924)		
	Diet 8. Cereal-free. Rich in Vitamin D	Diet 7. Rich in Vitamin D (Irradiated Ergosterol)	Diet 6. Rich in Fat-soluble Vitamins A and D (Cod-liver Oil)	Diet 5. Contained some Extra Fat-soluble Vitamins A and D (Cod-liver Oil)	Diet 4. Contained no Extra Fat-soluble Vitamins A and D. Increased Oatmeal	Diet 3. Rich in Fat-soluble Vitamins A and D (Cod-liver Oil)	Diet 2. Contained some Extra Fat-soluble Vitamins A and D (Cod-liver Oil)	Diet 1. Contained no Extra Fat-soluble Vitamins A and D. Increased Oatmeal
Number of children in group ...	22	21	23	24	24	9	13	10
Number of weeks on diet ...	26	28	28	28	25	31	33	31
Average age (years) of children at beginning	5.4	5.4	8.7	8.8	9.0	7.5	7.1	7.5
Average number of carious teeth per child at beginning	9.4	9.1	9.3	8.8	5.5	6.5	7.0	6.1
Average number of new carious teeth per child at end	0.05	0.2	0.5	0.6	2.4	0.65	1.54	2.8
Average number of teeth per child showing increase of old caries	0.32	0.8	1.3	2.4	3.4	0.75	1.4	2.3
Average No. of teeth per child showing initiation or spread of caries	<b>0.37</b>	<b>1.0</b>	<b>1.8</b>	<b>3.0</b>	<b>5.8</b>	<b>1.4</b>	<b>2.94</b>	<b>5.1</b>
Average "degree" of increase of caries per child	0.32	1.1	2.0	4.0	5.7	—	—	—
The percentage increase of "degree" of caries	1.50	6.57	10.28	23.42	62.13	—	—	—
Average number of teeth per child in which caries showed hardening	<b>4.7</b>	<b>3.9</b>	<b>2.0</b>	<b>1.2</b>	Less than <b>0.1</b>	<b>1.6</b>	<b>1.0</b>	<b>0.7</b>
Average number of teeth per child in which caries showed softening	0.0	0.0	0.3	0.1	0.5	0.0	0.1	0.4

TABLE IV (average age of children under 6 years)

	Present Investigation (IV)	Investigation III (1928)	Investigations II and I (1926 and 1924)		
	Diet 8. Cereal-free. Rich in Vitamin D	Diet 7. Rich in Vitamin D (Irradiated Ergosterol)	Diets 6 and 3. Rich in Fat-soluble Vitamins A and D (Cod-liver Oil)	Diets 5 and 2. Contained some Extra Fat-soluble Vitamins A and D (Cod-liver Oil)	Diets 4 and 1. Contained no Extra Fat-soluble Vitamins A and D. Increased Oatmeal
Number of children in group ...	22	21	18	20	19
Average number of teeth per child showing initiation or spread of caries	0.37	1.0	1.4	3.3	5.0
Average "degree" or extent of increase of caries per child	0.32	1.1	1.7	4.5	6.0
Average number of teeth per child in which caries showed hardening	4.7	3.9	3.7	1.2	0.2

of carious teeth, the amount and extent of each carious area, and the "degree" of hardness or softness noted.

The main results are summarized in Table III, and are compared with those obtained in the previous investigations. They indicate that a diet rich in vitamin D and calcium and devoid of cereals has greater inhibitory and curative effects on dental caries than any previously tested. Thus the new carious points observed to develop during the feeding period were only 0.05 per child as compared with the previous best result of 0.2 per child. The figure 0.05 is so small that it probably falls within the margin of error of this type of observation, and new caries may be considered, therefore, to have been suppressed. Only 0.32 teeth per child, as compared with the previous best figure of 0.8, showed an extension of the areas which were carious at the beginning of the investigation; this figure also probably comes within the margin of error. The average age of the children in the third and fourth investigations was under 6, while the average in the first and second was approximately 8 years. In order to make the figures more comparable, therefore, the results for the children of about 6 years in the first and second investigations have been grouped together in Table IV, with the results of the later investigations. The hardening of carious areas, which indicates the diminution in activity of the carious process and ultimate arrest, was one of the characteristic changes brought about by the diets used. It will be observed that the removal of cereals from the diet also increased the amount of arrest of caries as compared with that produced by the diets containing this food. The average number of teeth per child in which some hardening of active carious areas was found was 4.7, as compared with 3.9 teeth per child, the best result previously obtained. It is doubtful whether better results are attainable in hypoplastic teeth on the basis of our present knowledge.

The practicability of giving a cereal-free diet to children has, of course, to be considered. In the present investigation no difficulty was encountered in the elimination of cereals from the food, although the children did not like giving up bread. These children were in an institution, and were confined to bed, but it would obviously be more difficult to give the diet to active children, especially if living at home. The tests do not indicate that in order to prevent dental caries children must live on a cereal-free diet, but in association with the results of the other investigations on animals and children they do indicate that the amount of cereal eaten should be reduced, particularly during infancy and in the earlier years of life, and should be replaced by an increased consumption of milk, eggs, butter, potatoes, and other vegetables. They also indicate that a sufficiency of vitamin D and calcium should be given from birth, and before birth, by supplying a suitable diet to the pregnant mother. The teeth of the children would be well formed and more resistant to dental caries instead of being hypoplastic and badly calcified, as were those in this investigation.

#### SUMMARY

1. A group of children averaging  $5\frac{1}{2}$  years of age were given a cereal-free diet rich in vitamin D and calcium for a period of six months. The teeth of the children were defective in structure (hypoplastic), and much active dental caries was present at the beginning of the investigation.

2. Initiation and spread of caries were almost eliminated by these diets, and the results were better than those of the previous investigation in which the vitamin D alone was increased in a diet containing bread and other cereals.

3. Active caries was arrested on this cereal-free diet to a greater extent than in the previous investigations, when cereals were extensively used.

We wish to express our gratitude to the Medical Research Council for making this investigation possible.

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## MALIGNANT DISEASE OF THE HYPOPHARYNX AND ITS TREATMENT BY EXCISION\*

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Cancer of the pharynx presents to the surgeon a problem as urgent as it is difficult. The disease is far from uncommon, and its natural course is painful, repulsive, and always fatal, so that it may well be regarded as one of the very worst affections of middle age. For the surgeon the pharynx combines three of the most formidable obstacles to the exercise of his art: it is inaccessible in a high degree, it is the seat of delicate and concentrated function, and it contains septic material to which the surrounding tissues are in no way immune.

In spite of these difficulties it can fairly be said that in the last twenty years a certain degree of progress in the attack on the problem has been made, so that a not wholly inconsiderable number of persons have enjoyed a substantial number of years of good health or are still living, all of whom without treatment would have died within a few months. Two lines of treatment have contributed to this modicum of success: first, surgical excision of the disease, and secondly, radiotherapy, usually combined with some form of surgical intervention. In this paper I shall deal solely with the method of plain excision with the knife. This will be because a single theme lends itself to easy exposition, and because my experience of this method is by far the longer and the more extensive, and not at all because I have any doubt that radiotherapy is a most valuable addition to our resources in treating cancer of the pharynx.

#### DEFINITIONS

The term "hypopharynx" is not always used in the same sense. I have been accustomed to denote by it the tubular or post-cricoid part of the pharynx, a segment which from the physiological and the clinical points of view deserves a distinct name. For the purposes of this discussion, however, it may be more convenient to accept the extension of the word to all the pharynx that lies below the epiglottis—that is, to the so-called laryngeal part of the pharynx. The region thus denoted has from the surgical point of view, moreover, a unitary character, in that access to the whole of it is to be got by a single operative method—the lateral transthyroid pharyngotomy.

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