organic enamel matrix would enable us to retain our present eating habits and our useless teeth, which would then become merely organs of sexual selection " a miss is as good as her smile " sort of thing. This would be in the tradition of medical science which has always been, it seems to me, less concerned with the achievement of positive health than of repairing or dodging the result of disease.

How we can change our eating habits while great commercial interests are at work, I do not know. We should remember that we are all first citizens and only secondly physicians and dentists. We are not always in our consulting rooms—or shouldn't be. Fluoridation, by making the structure of our teeth more resistant to the ill result of our misuse of them may become a licence to eat what, how, and when we like without merely being worse off dentally. At all events there is a basic contradiction in our accepted methods of dealing with dental disease. We endeavour with our expensive bag of tools and our technical skills to restore our teeth to the structure necessary to eat raw food—just as though we were going to eat it. In fact the structure of our dental apparatus needs only ability to deal with stewed fruit, mashed potatoes and minced meat—food that melts in your mouth! The gum pads of the toothless infant are sufficient for that kind of food. Why bother to repair our teeth to enable them to eat raw beef? The fact that we lose our teeth and survive means that we can do without them. Ultimately we have to make up our minds whether we want to keep teeth or not. If we want to keep them, if only for aesthetic reasons, the only way is to use them.

II

Fluorides in Diet

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In the subject of fluorides and nutrition, the main fact to be borne in mind is the wide distribution and ubiquity of the element over the earth's surface. It is constantly present as fluoride in soil and plants and water, but scattered and not uniform in amount. Now recognized as a minor trace element, the universal occurrence of fluorine in

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nature renders it an inevitable component of animal nutrition. A normal human diet must contain some proportion of fluoride daily, fortuitous only in amount. It has been suggested as an essential trace element, in view of its limited ability at optimum levels to prevent dental caries. However, an absolutely fluorine-free experimental diet has not yet been devised, and a true test for its indispensability for normal growth and reproduction has not been adequately established. The average daily intake of fluoride is determined, excluding over-exposure from industrial and other sources, by the amount and type of food eaten and by the level of consumption and fluoride content of the water drunk. While the fluoride content of the food locally produced in the United Kingdom does not show appreciable regional variation, it must be recognized that a great proportion of our own food—meat, cereals, and tea—is imported, and the natural geographical distribution of fluoride in these food-producing areas abroad is unknown.

Dietary patterns vary between races and between countries, and are influenced by social, occupational, and economic factors. There is a gradual change in the diet from infancy to old age and variables occur in weight and age groups. The seasonal variations of climate, temperature, and humidity all affect the consumption of water and other beverages. Furthermore, before ingestion, food is subjected to many forms of processing and preparation which may affect its contents before it undergoes the complex chemical changes of absorption and metabolism. No staple foodstuff in the average diet can compare with drinking water as a constant source of fluoride, but this widely occurring element is very unevenly distributed in natural water supplies. Thus water from volcanic rock formations contains fluoride in comparatively large amounts and in parts of the U.S.A., in Morocco, and in India concentrations of from 8 to 14 parts per million (ppm.) are found but these levels are exceptional. In Great Britain, with a predominantly surface supply of water of low fluoride content, and a small underground supply of higher fluoride concentration lying above impermeable strata, the average fluoride concentration in the natural water is from 0.1 to 6 ppm. Thus, in Anglesey and in London the fluoride content is 0.2 ppm. or less, while in districts in East Anglia it may range as high as from 5 to 6 ppm. The average figure of public water supplies appears to be less than 1 ppm.

Food-borne fluorides are as assimilable as water-borne, and in the United Kingdom, in contrast with conditions prevailing in many other countries such as the U.S.A., they constitute a major proportion of the daily fluoride intake. It can be accepted with some exceptions that the common foodstuffs—meat, vegetables, cereals, eggs, and fruit—contain an average fluoride concentration of less than 1 ppm. with a range of 0.03 to 0.7 ppm. On this basis of calculation, various North American estimates suggest that the average daily intake from dry food substances is from 0.2 to 0.3 ppm., which, with the intake of 1.2 to 1.5 ppm. from water of estimated fluoride content of 1 ppm., makes a total daily intake of 1.4 to 1.8 mg. by an adult from food and water. These figures, when applied to the United Kingdom, would appear to be conservative; Longwell, for example, shows that with fluoridated water at 1 ppm. the average daily fluoride intake of men may increase from 1.8 to 3.2 mg., of women from 1.3 to 2.2 mg., and of children from 0.6 to 1.2 mg. It is to be noted that in these latter estimations the fluoride content of water is reckoned at 1 ppm., whereas the average fluoride content of public water supplies in the United Kingdom ranges from 0.02 to 0.4 ppm. My own figures indicate that at the present day in Great Britain, excluding all sources of fluoride other than food and water, the total daily intake of fluoride ranges from 1.6 to 2.35 mg. in adults, and from 0.8 to 1.2 mg. in children up to the age of 12. The variation in values may be accounted for by the difference in dietary habits in Britain where, among other factors affecting intake, relatively more tea and beer are drunk, more fish but less meat is eaten, a higher proportion of cereal is consumed, and where the national flour is reconstituted with calcium having a fluoride content.

It is convenient to consider the foodstuffs commonly eaten in our country and others and forming typical meals under their individual headings. We will take first of all meats. The mean fluoride content of the tissues of a normal healthy animal used for human consumption ranges from 0.02 to 0.07 ppm. in muscles, from 2 to 4 ppm. in the organs used as food, and from 200 to 250 ppm. in the bones. In those animals grazing in a high-fluoride area, the amount of fluoride deposited in the bones is greatly increased, and may range from 1,000 to 2,000 ppm. In the latter cases, the fluoride content of muscles and organs (with the exception of the kidney) does not attain a significantly higher level than in the normal animal. The kidney, however, may contain 3 to 5 times the normal. From preparations and products of bones, such as soups and stocks, the daily intake may be considerably increased. These preparations may contain as much as from 3 to 4 ppm. (this would represent about 1 ppm. in an average helping). Baby foods contain 11 to 12 ppm. and bone meal has about 12 ppm. of fluoride. No analytical figures appear to be available for meat extracts or sausages.

The average consumption of fish in the United Kingdom is almost twice that of the U.S.A. The protein values of meat and fish are similar, but fish, particularly such fish as sardines, whitebait, sprats, and canned salmon in which the bones are eaten, have a high fluoride content, but here again the absorption combined with calcium is likely to be at a lower figure than first indicated on analysis of those fish which contain some 7 to 12 ppm. of fluoride as served. The fluoride of the edible portions of fresh fish contain, according to many observers, around 1 ppm., but there are seasonal and type variations within wide limits. A child eats less fish as a rule, but an adult employing fish predominantly as a source of protein may acquire high levels of fluoride. It is a matter of interest and conjecture, too, to reconsider the relative value to the calcification of bones and teeth of vitamins A and D and fluoride in fish liver oils and extracts.

Eggs are generally considered as a not insignificant source of fluoride, and Phillips and others found 0.8 to 0.9 mg. in the yolk, together with some other trace elements. Average values ranging from 0.02 to 0.7 ppm. have been recorded, and again it is a matter of speculation whether eggs from hens on a high fluoride ration (fish meal, for example) contain an additional amount of fluoride.

Milk, rich in protein and calcium and the most complete of all foods at all ages, has an average fluoride content of 0.2 to 0.5 ppm., too little perhaps for the needs of calcification in childhood. Additional fluoride acquired by cattle feeding on rock phosphate or grazing in fluorosed areas or on pastures contaminated from industrial sources is not excreted in milk, and does not materially increase its fluoride content. In the milk products such as butter, cheese or dried, condensed, and evaporated milk, the fluoride content, mostly in the form of calcium fluoride, is concentrated and possibly increased by the removal of water, but no analytical figures are available at present.

The common cereals, such as wheat, oats, barley, rye and rice, contain some two per cent of minerals and vitamins, mostly distributed in the outer layers and germ of the grain, and partially lost in modern milling processes. It is assumed, though there is surprisingly little analytical work to support this, that the refining of cereals reduces their fluroide content, as it undoubtedly does their calcium content with its combined fluoride. The replacement of the calcium under the Bread Order of 1953 contributes an additional 0.1 mg. of fluoride to an average diet containing about 6 oz. of bread daily. Another source of fluoride in flour is the fluoride associated with the acid phosphate used in self raising flour and baking powder, and is reduced from 30 to 3 ppm., under the recommendation of the Food Standards Committee. In the refining of cereals, the composition and fluoride content, for example, of white flour as compared with brown flour, or of polished rice in comparison with unpolished, or of wheat-germ products, depends on many factors, some controllable and others inconstant and variable. The original mineral and fluoride content is influenced to an unknown extent by such ecological factors as the nature and composition of the soil and the physiological uptake of the species and type of grain. On milling and extraction, much of the mineral is lost, and is replaced somewhat empirically by synthetic supplements. Just how much the cariogenicity of certain refined cereals can be ascribed to the loss of fluorides alone, or to the loss of other elements (vitamins), or to the reduction of the carbohydrate to a substance which requires no chewing and mastication is unknown, but it is probably owing to a combination of all these circumstances. Values published by an Analytical Methods Committee of 1944 gave the fluoride concentration of white and National flour as 0.42 and 0.84 ppm. respectively. In 1957, Coppock and Knight found the average fluoride content of bread to be 0.9 ppm., but in rye bread it is higher, and in figures published in Switzerland in 1960 a fluoride content of 1.63 ppm. has been recorded. Although for years the consumption of bread in the United Kingdom has been falling, the relatively large proportion still included in the national diet suggests that it might form an important source of fluoride, were it not for the fact that the addition of fluoride-containing calcium carbonate to the flour would not tend to favour its absorption.

The fluoride content of vegetables and fruit depends to some extent on the type of soil and the plant uptake, subject to variation according to species. Supplementary amounts may be acquired from such extraneous sources as fertilizers, whether natural or artificial, and from sprays. No complete agreement exists between observers as to whether the fluoride content of vegetables and fruit is invariably raised to an appreciable extent from these sources. It is demonstrated that a greater proportion of fluoride lies in the outer layers of skin or rind, and a proportion is lost when the parings are discarded during the course of preparation of food. Root vegetables may lose a great part of their mineral salts in this manner. The average fluoride content of vegetables and fruit is from 0.02 to 0.7 ppm., but values for edible mushrooms on the other hand have been quoted as 0.05 mg. per 100 G., those of spinach and apples as approximately 1 ppm. Similar values are given for other vegetables, but it is evident that the fluoride content is affected by so many factors during growth and culinary preparation that further special investigations are necessary before figures would prove acceptable.

The United Kingdom with an annual per capita consumption of over 10 lb. of tea can with some justification be described as a tea-drinking nation, and all teas, irrespective of origin, have a relatively high fluoride concentration. A wealth of statistics from Government and other sources shows that tea contains 75 to 100 ppm. of fluoride, that concentration of 1 ppm. in a cup of tea is not unusual, and that an average tea-drinking person can obtain approximately 1 mg. of fluoride per day from tea alone. This amount of fluoride appears to be sufficient for the physiological requirements of an adult as known, but children do not drink as much tea and then only in appropriate dilutions. Coffee and cocoa, the less common household beverages, do not appear to have levels of fluoride higher than those usually found in seeds and fruit, and the amount is not significant.

It can be assumed that all beers have a fluoride content of 0.25 to 1 ppm., or a total of the original content in the water plus that of the barley and hops. It would appear that the fluoride is linked with calcium as calcium fluoride, the least soluble form of fluoride, and that for light and mild ales, for example, a hard water is a necessity. Insufficient data are available for the fluoride content of natural mineral water, which usually contains an excess of mineral constituents. Fluoride is constantly present in spa water, in amounts determined by the type of geological formation from which the water is taken and the source of the spring. There are also trace amounts of fluoride in soft drinks, aerated water, fruit juices, and various herbal beverages.

It is obvious that no staple foodstuff in an average diet can compare with drinking water as a constant source of fluoride. Individual intakes of fluoride from drinking water are influenced by many minor factors, and British evaluations have in the past been largely a matter of deduction rather than precise figures. It is estimated that the average daily fluoride intake from drinking water of 0.2 ppm. fluoride content ranges from 0.2 to 0.35 mg. for an adult and from 0.1 to 0.2 mg. for a child. To these amounts must be added those of the fluoride intake in food, estimated as from 1.4 to 2 mg. in adults and from 0.7 to 1 mg. in children. Thus, at the present day in Great Britain, excluding all sources of fluoride other than food and water, the total daily intake of fluoride is estimated to range from 1.6 to 2.35 mg. in adults and from 0.8 to 1.2 in children up to the age of 12. It seems apparent that these figures are high when compared with those from previous sources, but they appear to be more truly representative of conditions in this country, and agree more closely with corresponding figures from Western Europe. It seems likely, also, that these amounts of intake could be reached only under optimal conditions in the simple processing and preparation of food. The fluoride content of food varies in inverse ratio to the amount of refining, processing, preparation, and cooking it undergoes before final readiness for the table. A whole natural diet prepared from fresh substances will provide sufficient fluoride for all physiological requirements, as far as they are known; this includes optimal calcification of the teeth with increased resistance to dental caries. Such conditions, however, do not prevail in the civilized diet of modern times, and may be described as highly desirable but unrealistic and impracticable.

That is all we have to say about fluorides in the diet; as you all know, the Ministry of Health has just published the results of a five-year study on fluoridating the water in three districts of England, and has claimed up to 50 to 60 per cent reduction in dental caries. However, it is possible to have too much fluoride in the diet and in the drinking water, and when this happens it can produce not only a decreased resistance to dental caries but also actual damage to the teeth with mottling.

DISCUSSION

Question: It is not apparent at what stage fluoride affects the teeth. Nutrition can only affect teeth before they are fully developed and in breast-fed babies one notices that the teeth are longer in the gum before they erupt, and therefore longer under the influence of maternal nutrition. Presumably, if the mother is getting sufficient fluoride, it is getting to the immature infant in that way. Is that in fact established?

Mr Cannell: I believe so. If an adult receives fluoride in drinking water or from another source, it does not appear to make an appreciable difference to the caries resistance of his teeth other than is achieved through the actual process of drinking a glass of water and therefore subjecting the teeth to a wash of fluoride, but that is only for a few seconds. It is definitely established that the amount of fluoride the mother takes in bears a relation to the hardness of the infant's teeth, in that fluoride forms a sort of fluorapatite in the enamel, and this is of increased density and of increased resistance to caries. However, I would also point out that fluoride appears to inhibit or delay eruption slightly, and the more fluoride one gets the more eruption is delayed; therefore, the more fluoride these teeth are getting before they ever see the light of day, the more likely it is to achieve endemic fluorosis or tooth mottling.

Dr Toller: I do not feel that fluoride content of the diet, including the water, is of great importance after the eruption of the teeth.