CONTROL OF DENTAL CARIES AND SOME ASSOCIATED DEGENERATIVE PROCESSES THROUGH REINFORCEMENT OF THE DIET WITH SPECIAL ACTIVATORS

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CONTROL OF DENTAL CARIES AND SOME ASSOCIATED DEGENERATIVE PROCESSES THROUGH REINFORCEMENT OF THE DIET WITH SPECIAL ACTIVATORS*

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DENTAL caries is generally considered to be the most nearly universal disease to which man is subject. It is considered by many to be the most serious single disease in its direct and indirect effects. Careful, critical observation in many communities has indicated that it is on the increase and that this was true even before the present world-wide industrial depression. A century of intensive study has not revealed in full its etiology nor considerably reduced its severity. Like many other affections, dental caries has been looked on in the past almost entirely as a unit problem. Until very recently, it has not been seriously associated with nutrition. It has been associated primarily for the last three decades with the acid-producing bacteria, as suggested by W. D. Miller.

I shall include in the consideration of a dietary food products not only by title but also by their fundamental nutritional factors. The term "control" I shall understand to apply both to prevention and to the checking of the progress of caries when established.

The irregularity in the appearance and incidence of dental caries in various individuals brings to consideration many possible contributing forces. The fact that dental caries may be relatively infrequent or of mild degree in persons living in a given community and at the same time very severe in persons living in another community introduces for consideration not only the physical environments of the two groups, including climate, but also individual factors such as physical and mental stress, the care of the mouth and the quantity and type of food eaten.

Until we can have a common understanding of the many contributing conditions, confusion and conflict in interpretation will be inevitable.

An illustration of the fundamental need for a much broader concept and understanding of the conditions with which we are dealing is provided in the apparent interpretation of the data available with regard to increased susceptibility to dental caries under the physical stress of pregnancy.

A study of the history of peoples as revealed by the idioms of their language has disclosed that practically every race with a language has a phrase equivalent to a "tooth for every child," notwithstanding these languages may have had

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their origin in the dim and distant past.

This can be accounted for only on the basis of the recognition of a clinical fact. It is probable that clinicians from different countries of the world would give quite different reports of their observations with regard to the correctness of this statement as applied to the people of their communities. The majority doubtless would corroborate this observation. The difficulty in corroboration would depend on facts which were fundamentally correct, but only apparently comparable, for both might have a controlling influence in diet. In the light of the data which I shall present, foods of the same name but produced in different sections may have very different values from the standpoint of their adequacy to provide complete nutrition.

My researches of the past decade have been directed largely toward establishing data, both clinical and laboratory, that would throw light on both the possibility of accomplishing control of dental caries and pyorrhea and the practical means for so doing. My several research reports made during this period, and some in process of publication, present data apparently indicating that dental caries can be controlled under the specified conditions presented. That we have perhaps reached the time when it is possible to control and prevent dental caries is important for the following reasons: (1) it is the most nearly universal disease and in nearly all civilized countries is increasing in severity notwithstanding prophylactic procedures; (2) no other area of the body provides a comparable portal of entry for organisms that become pathogenic and produce serious degenerative processes by metastatic invasion of other organs and tissues, and (3) dental caries in the light of our newer knowledge is even more important because of its significance as one of many symptoms of nutritional imbalance and organ and tissue degeneration than the injury of the teeth, important and serious as that injury is.

As an approach to the discussion of this problem in the light of our newer knowledge, I shall first present clinical data and secondly discuss the nature of the nutritional factors involved and requirements of the body for mineral nutrition.

There are few clinical conditions associated with so rapid and persistent a type of dental caries as is found in xerostomia. In 1923, I published results of successful treatment of this disease with cod liver oil.[1] It is of interest that the patient referred to as having been under treatment then for a year has had a marked and progressive improvement in all her symptoms to date. This is particularly significant since a large majority of the cases reported up to that time had not responded to treatment, but had bad progressive involvement, the dryness of the mouth extending to the throat, air passages, eyes and other mucous membrances. In practically all cases, severe arthritic involvement developed. This patient, at the time she came in, could scarcely walk or use her hands owing to a severe arthritis. The treatment has been continuous during these years and she has been practically free from arthritis for several years. Mineral metabolism disturbance in arthritis, with and without dental caries, will be discussed later.

The product that was first given this patient was ordinary raw cod liver oil and a parathyroid gland tissue prepara-

1. Price, W. A.: Dental Infection and Degenerative Diseases, Vol. 1, Cleveland: Penton Publishing Co., 1923.

tion. The latter was early discontinued, for it was found that activation of the cod liver oil by exposure to the sunshine for a few minutes produced quite favorable results. This treatment was later improved, as will be related.

Among the patients under treatment during 1923 and 1924 was a boy who, at the age of 14, had seventeen cavities, some of which nearly entered the pulp chamber. He was put under treatment with the activated cod liver oil. The roentgenographic appearance of the teeth as they appeared in 1924 and 1925, a year intervening, is shown in Figure 1. During this year, no new cavities had formed and, in addition, as shown in the illustrations, there was a marked improvement in the density of the teeth. This was reported in detail in April, 1926.[2] It seemed apparent in this case that something was provided by the cod liver oil that reduced the dental caries.

In a series of eighty-seven patients carried through the two years 1928 and 1929, a critical study was made to compare the number of cavities in two groups, one receiving additional vitamins and the other not receiving them, with the result that forty-nine patients receiving no treatment and using their regular diet had an average of 4.85 cavities in 1928 and an average of 4.73 cavities in 1929. The most severe cases were placed in another group on special treatment with a mixture containing a concentrate of vitamins from a high vitamin butter, which I shall describe later, and a very high vitamin cod liver oil in small doses of from 0.5 to 2 gm. of the mixture. This group before treatment in 1928 had an average per person of 8.02 cavities. In 1929, after being on the treatment for a year, they had an average per person of 1.44 cavities.

A group of fifty-six who were examined between March 25 and April 7, 1930, a two-weeks' period, was divided into subgroups and studied. These subgroups consisted of those persons from 12 to 18 years, the boarding school group and the pregnancy group. These studies revealed that those in each group that were receiving treatment showed marked improvement. In practically all cases, they had been put on the treatment because they showed very severe dental caries. For example, in a general group of forty-four without treatment, the average number of cavities per person was 2.9; whereas, the twelve having treatment had an average of 0.25 cavities per person. In the teen-age group, the nine without treatment had an average of 5.5 cavities per person, and the six having treatment had no cavities. All of these cases were examined in or about September, 1929, the study including roentgenograms, which are used routinely in all these studies. In the boys and girls from boarding schools, the four without treatment had an average of 8.5 cavities per person which developed in practically a six-months' period. The four receiving treatment were all without dental caries. Of the two pregnancy cases examined, the one without treatment showed nine cavities, the one receiving treatment, one cavity.[3]

2. Price, W. A.: Calcium Metabolism Studies, Am. J. Dis. Child., 33:78-95 (Jan.) 1927.

3. Price, W. A.: Some Contributing Factors to Degenerative Diseases, with Special Consideration of Rôle of Dental Focal Infections and Seasonal Tides in Defensive Vitamins, D. Cosmos, 72:1049; 1119 (Oct.) (Nov.) 1930.

4. Price, W. A.: New Light on Control of Dental Caries and Degenerative Diseases, J.A.D.A., 18:1189-1219 (July) 1931.

In July, 1930,[4] I reported progress, presenting data on about 200 persons, approximately 100 in each group, one receiving and the other going without additional vitamins. The number of cavities per person in the group not receiving the capsules was for all ages ten times that which occurred in the group receiving the capsules. For the teen-age group, the difference was very much greater. For example, in the twenty persons not receiving additional vitamins in capsule form, the total number of cavities was 143, and in the group of twenty receiving the additional vitamins, there were three cavities in the entire group, which had developed in a period of less than one year. Practically all of these persons had been studied critically with roentgenograms of the teeth, bitewings or full dental films. The data developed in the group from 50 to 60 years old were particularly interesting in view of the fact that in the group from 20 to 50 years of age not receiving vitamins in capsule form, the curve for caries had been progressively downward, but, in the next decade, the number of cavities per person doubled, increasing from an average of one cavity per individual to two cavities per person; whereas, in the group receiving additional vitamins, there were no cavities in either the 40 to 50 age group or the 50 to 60 age group.

Light is provided by the following case: A young girl came to Cleveland from Ontario at the age of 16, at which time she had a remarkable set of teeth, never having had a cavity develop in any teeth. She had been complimented by her dentist on having a practically perfect set of teeth. She attended a university in Ohio and during the first year was reported to have developed twenty-two cavities. These were filled by a skilful dentist. The following year, she was brought to me for study of the possible cause of the continued active progress of dental caries, at which time, namely, July, 1930, she had twelve cavities, which had apparently developed since the filling of the twenty-two cavities the year previous. These cavities were filled and she was placed on additional vitamins. She has been examined

Fig. 1.—Severe dental caries with seventeen open cavities in a boy of 14 years, completely checked by treatment. Reduction in the size of the pulp chambers in one year, especially in the bicuspids, is evident. Above, films taken Dec. 5, 1924; below, films taken Dec. 24, 1925.

frequently during the past eighteen months, and not a single new cavity has been found. It must be noted first that these teeth apparently were of good structure and, under her home environment and dietary program she was completely free from dental caries. In her new environment and under a new dietary program, she developed more than thirty cavities in two years, and in that same environment and largely under the same dietary program, except with additional vitamins, the dental caries was apparently completely controlled. It is, of course, important that advice was given in regard to the selection of foods, although much opportunity for improvement in a dietary schedule may not be offered in a boarding house where, of necessity, the rate of charge is moderate and the selection and variety of food somewhat limited.

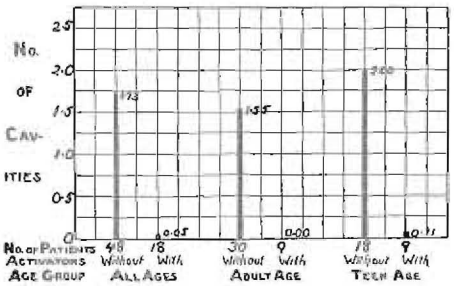

Fig. 2.—Control of dental caries. Of sixty-six patients examined during one month, a comparison of those receiving special activators with those not receiving them showed a ratio of cavity development of about 1:30.

The program of reexamination is continuous. The results after a typical month will be given. During the last Christmas and New Year holiday period, several of the boys and girls attending colleges and boarding schools returned to their homes and they, with local students, came in for examination. The period included in this particular study of caries was from Dec. 16, 1930, to Jan. 16, 1931, and included persons of all ages. These cases were carefully studied by direct examination, with the aid of roentgenograms, for the presence of dental caries (Fig. 2). This group included sixty-six persons, forty-eight of whom had not been receiving activators as provided by me in capsule form, and this group had eighty-three cavities, or an average of 1.73 cavities per person; eighteen had been receiving the special activators to prevent dental caries as provided by me in capsule form, and, in this group, only one cavity was found,

Fig. 3.—Reduction in size of pulp chambers under treatment. This patient when first seen had thirty-eight open cavities of active caries. The changes in tooth structure in three months are evident.

or an average of 0.055 cavities per person, a ratio of 31:1. In the entire group, twenty-seven were of teen age, and there were thirty-seven cavities in the teeth of these twenty-seven persons. Of these, eighteen had not been receiving special activators, and these eighteen had thirty-six cavities, or an average of two cavities per person. Nine of this group had been receiving special activators and, in the entire nine, only one cavity was

found, or an average of 0.11 cavity per person. There were thirty-nine adults, who had a total of forty-six cavities, or an average of 1.24 cavities per person. In this group, there were thirty who had not been receiving additional vitamins, and they had forty-six cavities, or 1.35 cavities each. Nine had been receiving the special activators in capsule form and not one cavity was found in any one of the nine.

It will be kept in mind that practically all of those receiving capsules had been examined in the early or late summer, mostly both, by the same careful procedure, and these persons were placed on the special vitamin capsules because of previous marked susceptibility. Several were patients who had been placed in my care at the request of their dentists because of the excessive amount of dental caries that was developing. The results here obtained are in spite of that previous marked evidence of susceptibility to dental caries. It will also be kept in mind that, of the adults examined, about two-thirds had had their mouths repaired within the last six or twelve months. It will be seen from these several special groups of studies that the same general results are being produced with an average ratio for the several groups of studies of about 30:1. This group contains some especially instructive cases which were referred because of the aggravated nature of the susceptibility to caries.

One young woman was transferred to me at the request of her dentist, who stated that he had had appointments with her monthly and could not keep up with the progress of the dental caries and did not wish to continue to have the responsibility. This patient presented thirty-two cavities, which were repaired, and she was then placed on the special vitamin capsules. During the next three years, she had two or three small cavities a year while taking the capsules. She stopped taking them when she went away to college, and, in the following six months, developed seven cavities.

A young man was sent from a distant city with the report that his dentist could not keep up with the progress of the caries with an appointment a month. He presented thirty-six cavities, which did not include one molar tooth that had so many cavities and so serious a pulp involvement that it had to be sacrificed. The first three months after he began to take the vitamin capsules, he had two small carious areas, which may or may not have been new. They were very slight and at the gingival margin of an old alloy filling and in a position where they were not disclosed by the roentgen rays. Probably, they had not been considered important because they were so slight in comparison with the many deep

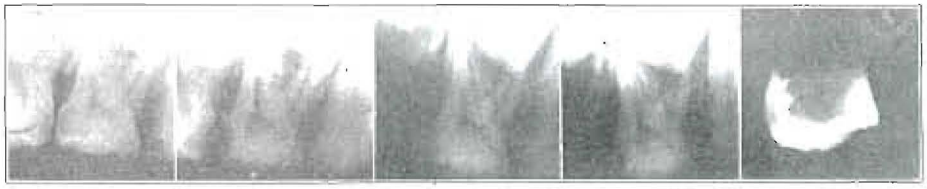

Fig. 4.—Caries inactive under treatment: Left to right: Nov. 16, 1929; Feb. 18, 1930; May 22, 1930; Sept. 13, 1930; September, 1931 (when shed).

cavities that the patient previously had. An important phase in this case is illustrated in Figure 3*A* which shows the change in the size of the pulp chamber in that short time. The lower left second molar had a carious cavity that apparently had reached the pulp chamber. As much of the caries was removed as was considered safe if exposure was to be avoided. The remaining caries was sterilized and a temporary filling placed with the hope that the pulp would build a defensive wall and thus protect itself. It will be seen that this has actually taken place and that the pulp chamber is actually smaller than it previously was. In the following year, only a few small areas developed under treatment. A similar rapid reduction in the size of the pulp chamber, which is associated with successful treatment for the control of dental caries in a girl 12 years of age, is shown in Figure 3*B*. This reduction in the size of the pulp chamber of a molar during treatment is also shown in Figure 1. In a number of persons whom I can watch carefully, I have purposely left cavities without filling to ascertain whether caries would cease to be active. I have several of these that have gone for an extended period with no recurrence of activity. A typical one is shown in Figure 4*a, b* and *c*.

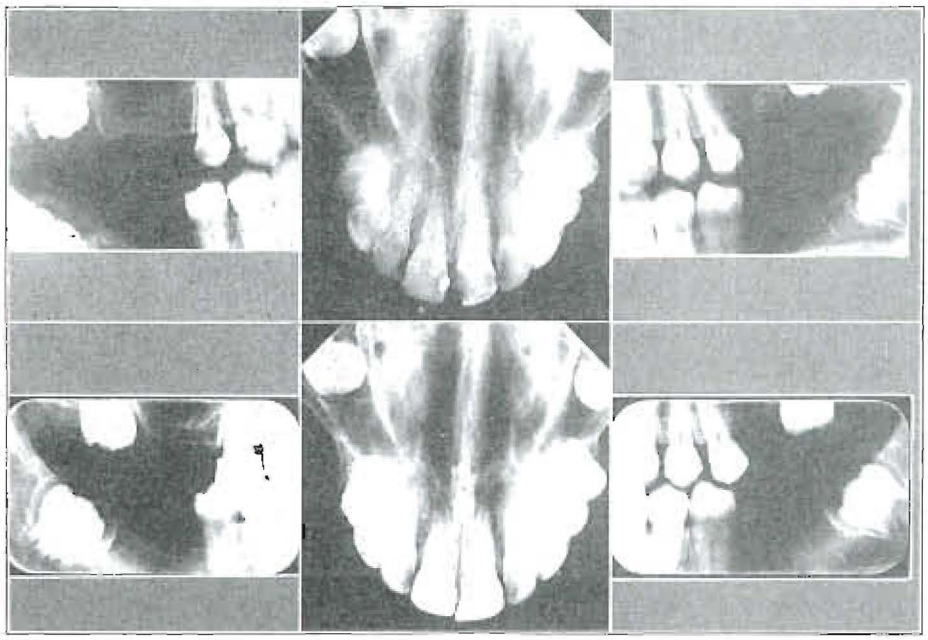

Fig. 5.—Rampant dental caries controlled by treatment. Above: Eight molars and bicuspid lost and many open cavities present at age of 14. Below: No new cavities or extension of unfilled decalcified; age 15. This patient, a girl, was broken in health from faulty nutrition, which was also the cause of the excessive tooth loss from dental caries. Dental and general health have been restored.

This is a deciduous tooth in the mouth of a boy, 11 years of age at the

time the first picture was taken, namely, Nov. 16, 1929. The succeeding views, taken Feb. 18, 1930, May 22, 1930, and Sept. 13, 1930, show no increase in the depth of the caries cavity. The adjoining bicuspid was shed and the frail margins of this cavity were broken down. This tooth was preserved by the patient when it was exfoliated, in accordance with my request. The resorptive organ had removed much of the dentin from the crown and sufficient of the enamel to make a perforation in the occlusal surface. The surface of the cavity is hard and almost glassy in smoothness. The decalcified carious dentin had been removed by attrition. The remaining dentin had greatly increased in density by precipitation of minerals into the tooth structure, probably chiefly from the saliva. Figure 4*c* is a roentgenogram of this exfoliated tooth.

In connection with these studies of dental caries and its control, a distressing feature is the finding of many young men and women who are seriously breaking in health simultaneously with the development of the dental caries. These are generally associated as symptoms or effects of a common cause rather than being regarded as having the relation of cause and effect.

Girls, who in their late teens are suffering from active dental caries, may enter the responsibilities of womanhood with physical handicaps which will often be the beginning of complications and low vital capacity. These girls frequently not only suffer from depressing disorders but also develop ovarian cysts which require operative procedure in later years. In their normal lives as mothers, they are handicapped because of physical deficiency during the growth period. This condition is probably directly related to the absence of certain vitamins or activators as is also their dental caries.

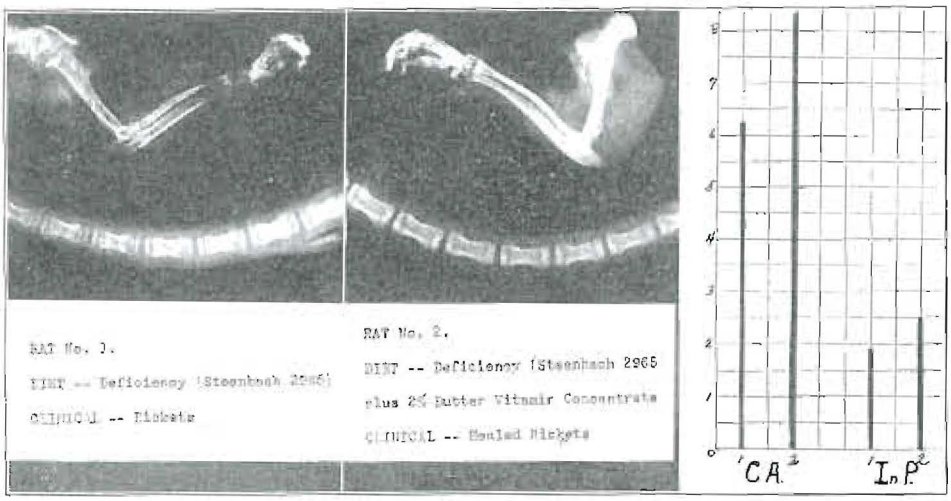

Fig. 6.—Treatment of rickets in rats by adding to deficient diet 2 per cent of butter vitamin concentrate. The addition of the concentrate has prevented rickets in rat 2 which is pronounced in rat 1. There is also a marked change in the level of calcium and inorganic phosphorus of the blood serum.

A young man was brought to me from

another state in June, 1931, with thirty-eight open cavities, several enlarged glands in his neck, acute rheumatism and a heart lesion. He was 16 years of age. His mouth was put in good order and he was placed on the special vitamin capsules. When he returned three months later, there had been no extension of dental caries, but instead a marked improvement in the structure of the teeth. He returned with a buoyant physical expression and reported that he was now more rested with six hours' sleep than formerly with ten hours'. He said he was able to carry on his work without tiring. The heart condition was greatly improved. The swelling of the glands had disappeared, as had also his rheumatism.

The dental caries was primarily a symptom of nutritional deficiency, in that he could not maintain a proper health level on the vitamin intake and dietary schedule to which he was accustomed.

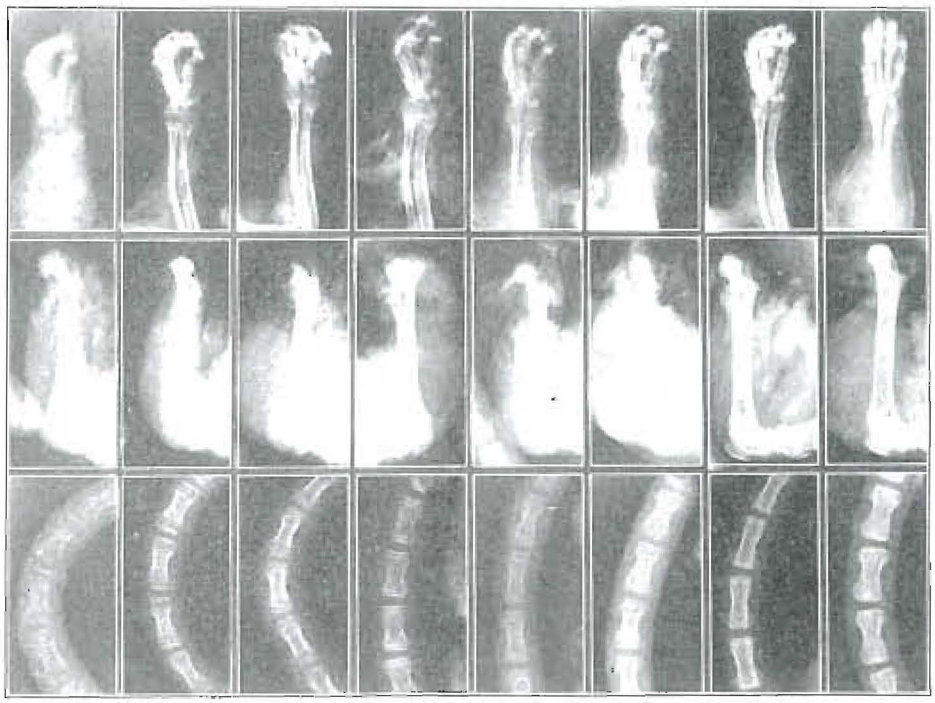

Fig. 7.—Progressive calcification with the amount of butter activators and a comparison with cod liver oil. Left to right: No activators; 0.5 per cent butter activators; 1 per cent butter activators; 2 per cent butter activators; 4 per cent butter activators; 8 per cent butter is a marked change in calcification with different percentages of butter activators and a strik- activators; 2 per cent cod liver oil; 2 per cent each cod liver oil and butter activators. There ing difference in the last two of cod liver oil alone and cod liver oil plus butter activators.

Among the striking associated data reported by patients has been the general experience of increase in efficiency in school work and freedom from colds. During the past year, as has frequently

occurred in previous years, reports have been sent in by parents to the effect that the grades of their children were distinctly higher during the time of treatment than they had been previously. Probably no single criterion is more significant than the promptness with which telephone calls or telegrams are received if there has been a failure in receipt of the capsules on scheduled time. This, of course, applies chiefly to adults and older people.

During the decade that I have been working on the preventive program,

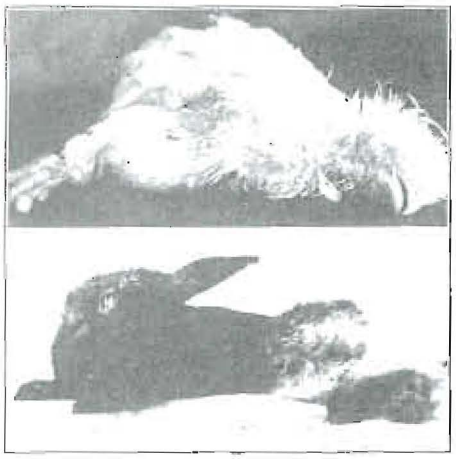

Fig. 8.—Progressive paralysis produced in a chicken and a rabbit, apparently by an overdose of cod liver oil. The daily quantity per body weight was approximately that often advocated for children.

there has been evidence of a progressive increase in the efficiency of the effort expended, in the light of the data just recorded, which are only a small part of the experience entering into the basis for judgment, which I interpret as indicating that dental caries can be very largely controlled at this time by the procedures I have used, which will be outlined.

It has been a common experience that clinicians have been observing persons of all ages who for an extended period have had no dental caries. It was found that this was not due to oral hygiene as a prophylactic procedure. It has been abundantly demonstrated that there was absence of dental caries in some persons making no effort at oral hygiene nor receiving a special dietary program.

Several workers of late have presented data indicating the important rôle of dietary factors in dental caries, among them Mellanby and Pattison[5] in England; Bunting and his associates[6]; Boyd, Drain and Nelson,[7] Hanke[8] and Howe.[9]

Mellanby has stressed the importance of vitamin D; Hanke and Howe have stressed the importance of vitamin C; Boyd, Drain and Nelson have stressed cod liver oil, milk, eggs and butter, and Bunting and his associates, the reduction of carbohydrates and a balanced diet. The last group has made an important contribution based on the clinical results obtained in several orphanges in Michigan. In their summary, they say:

1. In the study of the cause and control of dental caries, there is need for a fuller understauding of the basic facts concerning the diseases which have already been established. Many theories have been advanced which are not in accord with known faets.

2. Evidence is given in support of the view that dental caries is a specific infective process, the activity of which is dependent upon certain metabolic states.

3. As the result of dietary and therapeutic experiments, active dental caries was re-

5. Mellanby, May, and Pattison, C. L.: Brit. M. J., 2:1079 (Dec. 15) 1928.

6. Bunting, R. W., et al.: Am. J. Dis. Child. 40:536 (Sept.) 1930.

7. Boyd, J. D.; Drain, C. L., and Nelson, Martha V.: Am. J. Dis. Child., 38:721 (Oct.) 1929.

8. Hanke, M. T.: Relation of Diet to Caries and Other Dental Disorders, J.A.D.A., 16:2263 (Dec.) 1929.

9. Howe, P. R.: D. Cosmos, 62:921 (Aug.) 1920.

duced to a negligible quantity in 433 children. Of the methods employed, dietary measures appeared to be the most important.

4. The diets prescribed for the control of dental caries were well balanced, well fortified, adequate rations in which sugar was reduced to the minimum.

My studies have indicated that dental caries is a seasonal malady in large part, having its most rapid development from January to June, and having its lowest level of severity in the summer months and early autumn, which, as I have previously shown, is in accordance with the incidence of other diseases as I have discussed them in various phases of my recent reports.[10]

Among the important considerations, one which is being greatly emphasized at this time (I believe unduly so) deals with the structure of the teeth as influenced by environmental dietary conditions during the period of tooth development. The phase that I wish to discuss at this point is not the influence of the deficiency of the nutrition at the time the teeth were formed as a factor in the susceptibility to dental caries, but rather the fact that in persons with apparently well organized teeth in their embryonic and formative periods, and a history during a period of several years showing a complete freedom from dental caries, these same teeth, notwithstanding their good structure, may be attacked by rapid and serious dental caries in a relatively short time on a new dietary régime.

Many dentists have an opportunity to make observations of persons who have moved from southern European countries to our American environment. A large number of these persons arrive in this country at a susceptible age, namely, that of rapid growth. They have little or no dental caries on arrival, and a history of very little attention to oral hygiene. Often, within a year, these apparently unusually good teeth have been extensively attacked by dental caries. Ou inquiry, these people may say that they are eating the same food that they ate in southern Europe. This introduces several important prohlems, such as climate, sunshine, altitude and the actual difference in the intrinsic value of the same article of food when produced in a different district.

The work of Bunting and his associates emphasizes, and I think wisely so, the importance of limiting the carbohydrates, particularly sugars, partly for the purpose of preventing the satisfying of hunger with carbohydrates. It is of importance that, when possible, all children obtain a liberal supply of dairy products, including an abundance of fresh sweet milk.

One of the questions that we must consider critically is the relative value of the same food products when produced in different places at different times of the year. The suggestion that diet plays a very important part is illustrated in the following case.

10. Price, W. A.: Calcium Metabolism Studies on Nature and Rôle of Activators: Researches on Fundamentals for Prevention of Dental Disease, J.A.D.A., 16:265 (Feb.) 1929. New Fundamentals for Treatment and Prevention of Dental Caries Based on Calcium Utilization and Disturbance, with Special Consideration of Factors Determining When an Infected Tooth Becomes a Liability, J.A.D.A., 16:456 (March) 1929. Calcium and Phosphorus Utilization in Health and Disease; Certified Milk, J. Am. Ass'n M. Milk Commissious, October and November, 1929. Seasonal Variations in Butter-Fat Vitamins and Relation to Seasonal Morbidity, Including Dental Caries and Disturbed Calcification, J.A.D.A., 17:850-873 (May) 1930. New Standards for Dental Diagnosis, Am. D. Surgeon, 50:74 (Feb.) 1930. Why Annual Pilgrimages to Hospitals? Your Health (March) 1930. Footnote 3.

A girl, 14 years of age, was brought for consideration of a program which involved the extraction of all her remaining teeth and the insertion of full dentures because of very rapid dental caries from which she had suffered. An examination of her mouth in November, 1929, revealed that already eight molar teeth and one bicuspid had been extracted because of extensive dental caries. Nearly all of the remaining teeth had one or more cavities, some of them very extensive. The girl's health was not good and she had great difficulty in keeping up with her school work. A study of the dietary showed that this girl did not like milk and had been fed largely white flour products, syrup and sugars. Her favorite daily dish was pancakes swimming in syrup. Chemical and microscopic analyses were made of the blood, the saliva and the urine. We were amazed to find a very high level of albumin in the urine, i.e., 596 mg. per hundred cubic centimeters, or about 0.6 per cent of the total volume of the urine. After changing the diet to an increase in dairy products and a decrease in carbohydrates, particularly sugars and starches, and with an addition of minerals and vitamins, the urinary albumin in one week's time, dropped to 67 mg., and, in a few weeks, the albumin had entirely disappeared from the urine and at the same time there was a marked improvement in the appetite and physical well-being. Under the changed dietary program, in which additional vitamins were provided in capsule form obtained from a high vitamin butter together with a few drops of a high vitamin cod liver oil, this patient, during the next year, did not develop a single cavity and her physical well-being reached and remained at a high level. The roentgenograms of her teeth, taken in November, 1929, and October, 1930, are shown in Figure 5. In this case, evidence is strong that there was a deficiency in both the minerals and activators or vitamins in the food. Note that

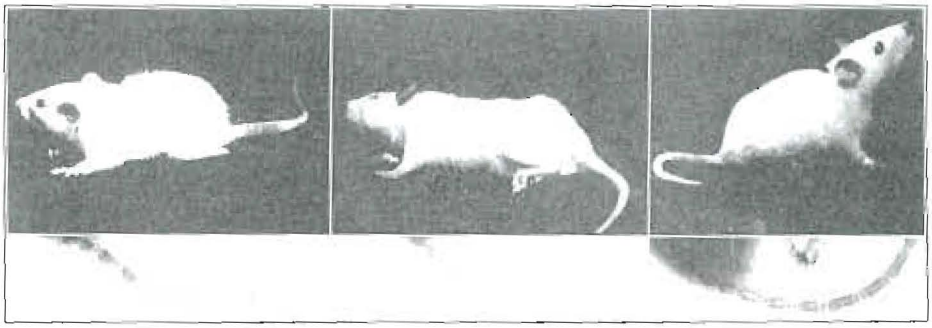

Fig. 9.—Influence of butter vitamins. Left to right: Rat on diet deficient in phosphorus (Steenbock 2965), calcification deficient, with marked rickets (condition clinically inactive); rat on diet deficient in phosphorus (Steenbock 2965) plus 2.5 per cent cod liver oil, calcification improved, with healing two plus (progressive paralysis); rat on diet deficient in phosphorus (Steenbock 2965) plus 2.5 per cent cod liver oil and 2.5 per cent butter concentrate, calcification excellent, healing four plus (clinically normally active). There is marked improvement in the calcification in the tail of rat 3, receiving both cod liver oil and butter concentrate, over that of rat 2, on cod liver oil alone

some decalcified surfaces which were purposely left unfilled, did not have an extension of the caries. Also note that I had a root filling placed in a straight rooted tooth. The pulp was exposed but vital.

nutritional conditions which evidence a need in the body for activators as well as minerals for the control of dental caries. Since the activators furnished in separate form were of the fat-soluble group as obtained from a high vitamin

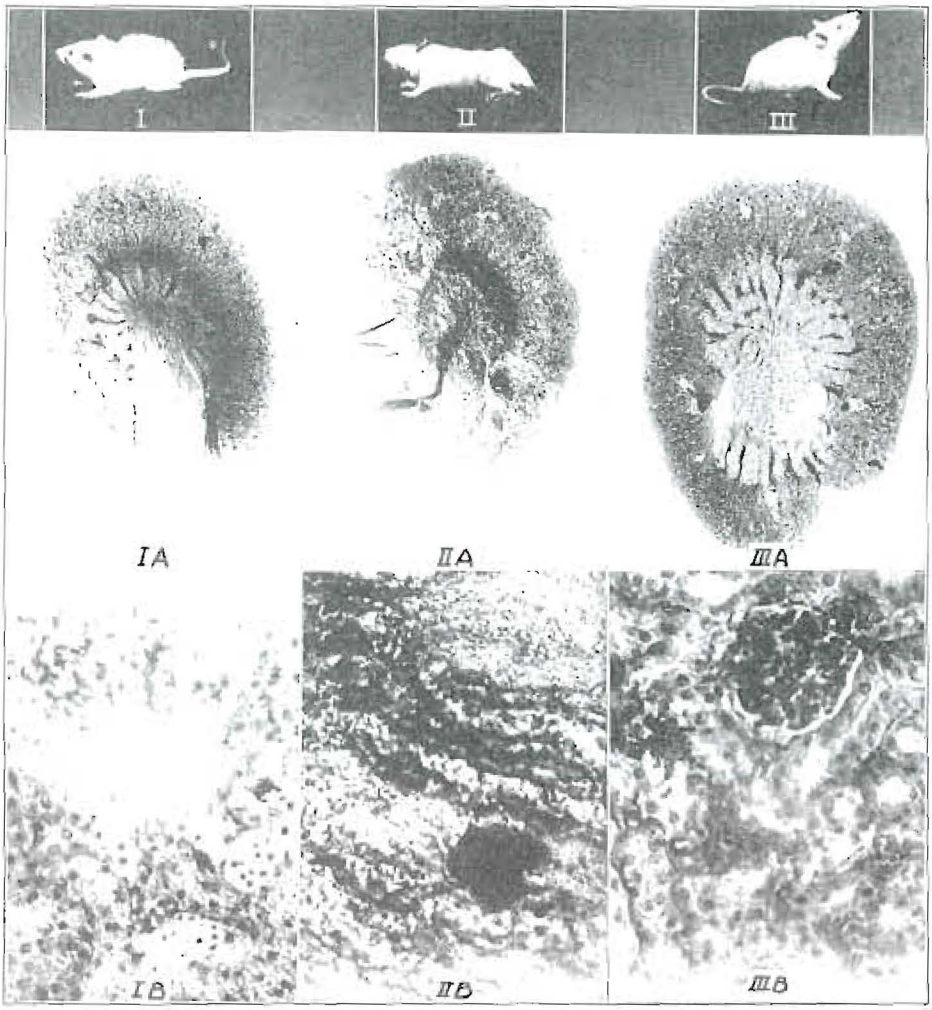

Fig. 10.—Influence of butter vitamins. Histologic appearance of kidneys of rats shown in Figure 9. The calcification produced by cod liver oil without butter activators and the better structure of the epithelial cells lining the uriniferous tubules and the glomeruli are evident.

From the cases and conditions cited, the evidence is that we are dealing with

butter together with a high vitamin cod liver oil, we have immediate need for

consideration as to whether any or all butters or any or all cod liver oils will satisfactorily accomplish this result. The fat-soluble vitamins as known are A, D and E, and evidence is strong that, associated with these factors, are many other activating substances not yet identified.

In my studies, I have placed much significance in the fact that all mam-

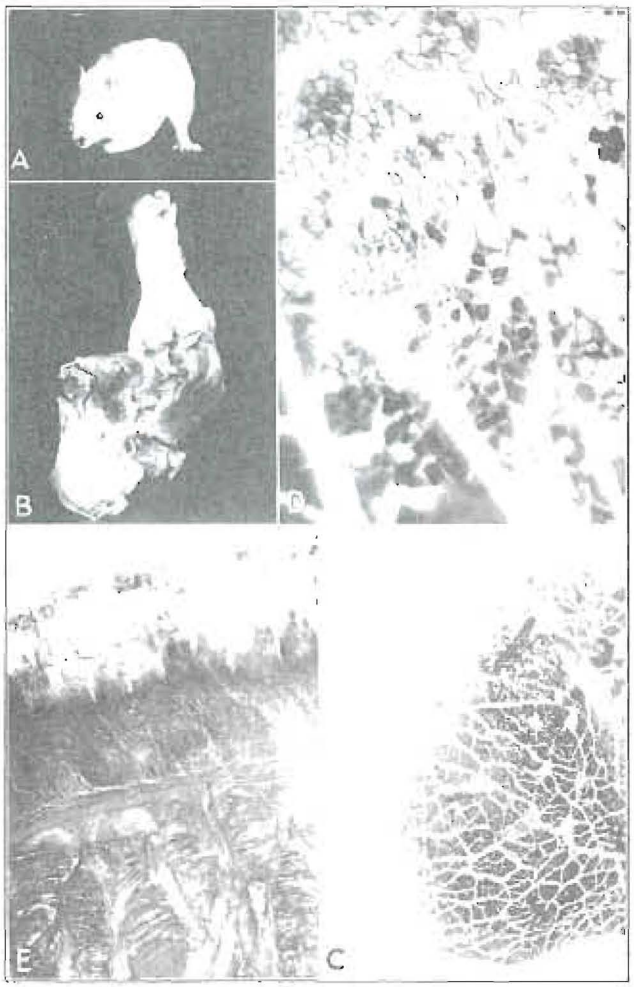

Fig. 11.—Tissue destruction produced by a toxic factor in cod liver oil. *A*, animal showing paralysis of foreleg; *B*, gross appearance of tissues; *C*, low magnification, showing boundary muscle degeneration; *D*, higher maguification, showing degeneration of muscle fibers; *E*, edema of tongue ten minutes after application of one drop. One of the toxic substances that have been found in cod liver oil is iso-amylamin, effects of which are shown above. Another is cholin.

mals start life on milk as the one and only complete food. Milk, therefore, must contain an adequate supply, under ideal conditions, of all the requirements both for dentition and for skeleton formation and for normal growth and function of the body, at least during the period of infancy. It is therefore very important that we study critically some of the effects of the activating substances in milk and its products.

I am now in the fifth year of analyzing in continually enlarging numbers and greater detail, milk and its products, chiefly butter, for their activator content with particular consideration of the fat-soluble vitamins. Samples of these products are now coming in every few weeks, mostly every two weeks, from several hundred places throughout the world, both north and south of the equator. These studies are showing a marked constancy in the repetition of the curves revealing a rise and fall in succeeding months of the year for various countries in both the northern and southern hemispheres. These studies are also relating the rise and fall of the butter vitamin level to the morbidity and mortality records of the various countries from which the samples are coming. These have been presented in progressive development of detail in various communications.[11] My data have revealed that dental caries follows a reverse phase from these vitamin curves, as do many of the morbidity curves.

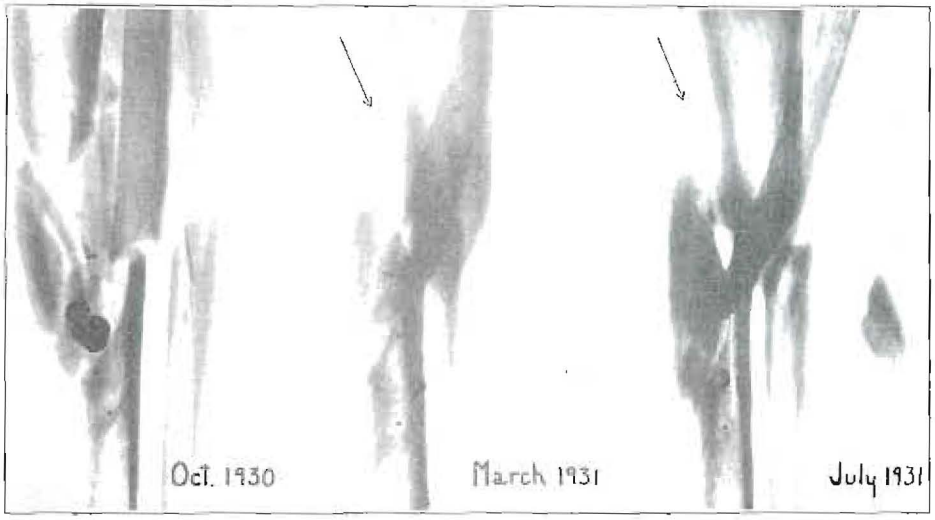

Fig. 12.—Healing of ununited fracture. Left to right: October, 1930; March, 1931; July, 1931. Healing delayed for five months was followed by rapid healing when the patient was given special vitamins. Arrow indicates the bridge of bone.

The indications from the available

11. Footnote 10, third, fourth and sixth references. Price, W. A.: Some Means for Improving Human Life by Increasing Vitamin Content of Milk and Products; J. Int. Ass'n Milk Dealers, January, 1931. New View of Dental Caries and Other Degenerative Diseases Based on Tides in Available Activators and Relation to Body Demands (unpublished data). New Light on Cause and Prevention of Dental Caries and Other Degenerative Diseases, Proc. VIIIth Internat. D. Cong., D. Survey, August, 1932.

data, some of which have just been outlined, would include the following: that dental caries can, under certain conditions, be controlled; that it is more rampant in that season of the year in which the general morbidity is highest; namely, the winter months. Dental caries seems apparently associated, therefore, with the same conditions as general morbidity. It is not necessarily dependent on a deficient structure of the teeth due to a disturbance at the time of tooth development. It is somewhat regional. A group of fat-soluble activators found in certain foods under certain conditions but not always present in sufficient amount in these foods must be considered. It is not to the extent generally supposed, dependent on the cleanliness of the tooth or teeth in question, and therefore is not controlled by oral hygiene. It tends to occur at periods of stress for the minerals utilized in building hard structures. It, therefore, may have even more significance as a symptom than as a disease, notwithstanding the intrinsic value of the teeth. It becomes important, therefore, to study critically some of the principles involved in the normal utilization of minerals for building of hard structures, as an approach to the specific problem of dental caries.

As an approach to this, we will study a typical lesion; namely, rickets in rats. In Figure 6 will be seen the foreleg and the tail as disclosed roentgenographically of two rats on the same deficiency diet, namely Steenbock 2965. It will immediately be seen that all of the bones of number 1 are very transparent and the carpal bones of the wrist have not formed. The junction of the epiphyses and the diaphyses of the bones, especially of the tail, is shown to be characterized by a zone of separation. In rat number 2, there is a marked density of the bones, seen as an opacity to the roentgen rays, and the carpal bones are well formed. The head of the humerus and the epiphyseal zones of provisional growth of the tail, are well calcified, with only a line of separation between them and the diaphyses. This rat received in addition to the deficiency diet,

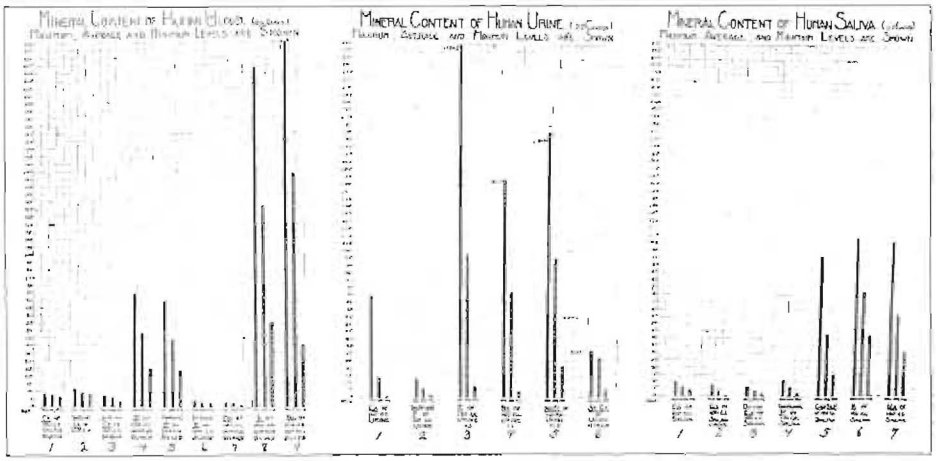

Fig. 13.—Comparison of mineral content of blood, urine and saliva. This graph visualizes the relative and actual amounts of these various minerals in the body fluids and the daily depletion by way of the kidneys.

Steenbock 2965, 2 per cent of the diet as butter vitamin concentrate obtained from a high vitamin butter. Clinically, this condition constitutes healed rickets. This quantity of this butter would only constitute one-half ounce for a child eating 2 pounds of food per day. This is a very small quantity for a growing child. To the right in this illustration will be seen the mineral changes in the blood serum of these two rats. The calcium for rat number 1 is at 6.26 mg. per hundred cubic centimeters, and, in rat number 2, it is 8.4. The inorganic phos-

Fig. 14.—Normal and arthritic hand at age of 17. In the deformed hand, the radius and ulna are small and there is a dislocation.

phorus in rat number 1 is at 1.93 mg. per hundred cubic centimeters, and, in rat number 2, it is 2.5 mg. We see at once that this clinical condition in these two rats is attended by certain characteristics in the blood chemical levels.

The product that was administered to rat number 2 is a normal constituent of a normal milk, Nature's only complete diet for mammalian infants and by far the most important single item of food for growing human beings in all periods of stress.

Having indicated that the addition of a certain group of fat-soluble activators, some of which are the known vitamins, to the dietary of the individuals suffering from dental caries is at least one

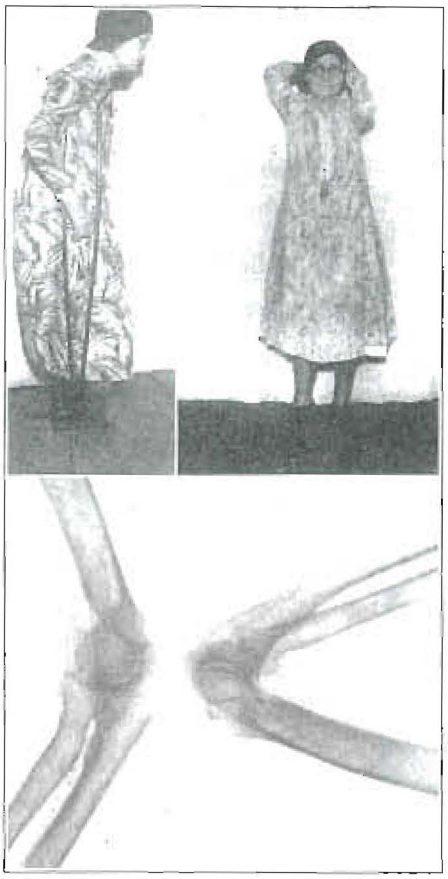

Fig. 15.—Marked improvement in deforming arthritis of long standing in a few months' time on special vitamins.

method which has been competent to reduce or overcome susceptibility to dental caries, there is immediate need for us to study the nature of the substances with which we are dealing. Since the

fat-soluble activators, some of which are the known vitamins, are recognized as existing in butter fat of milk and in certain fish oils, particularly cod liver oil, though in varying quantities in both, it is of particular importance to study some of the qualities which are characteristic of products obtained from these two sources.

Among the several specific investigations that I have made in order to study the relationship or characteristics of the administration of these two products to animals and to analyze them critically

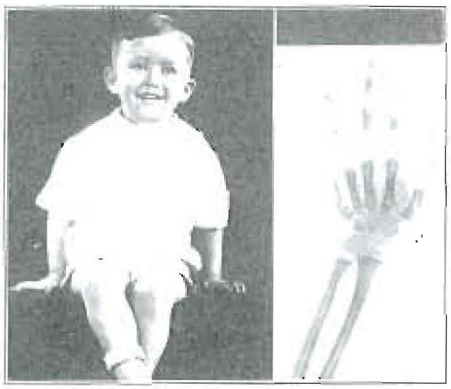

Fig. 16.—Butter vitamin fed boy who won a prize in a group of forty-one at 10 days of age. Neither this child nor his mother received cod liver oil or viosterol. Their fat-soluble activators have been provided from high vitamin milk, cream and butter which were specially selected by analysis.

to see the relative and actual effects is one shown in Figure 7. In this figure, there are eight groups of rats which have been fed a deficiency diet augmented by different amounts of various foods. One rat from each of the eight groups is shown in this study. These are marked 1 to 8. The roentgenograms shown for each rat are of the forepaw, disclosing the wrist, the femur and the tail. The only difference in the dietary intake consisted in a different quantity of the butter vitamin concentrate expressed as percentage of the diet in the first six rats. In the seventh, the activator used was cod liver oil alone; and, in the eighth, a mixture of the butter vitamins and the cod liver oil. Number 1 received no activators with its deficiency diet, and there will be seen at once not only that there is a lack of radiopacity of the various bony parts, but also that several of the bones are not completely formed or are absent. It will particularly be noted that the carpal bones are largely missing. The rat in group 2 received one part in 200 of its food as butter vitamin concentrate, or 0.5 per cent. This small amount produced a marked difference in the skeletal development, particularly as noted in the carpal bones. The relation of the epiphyses to the diaphyses of various bones is very easily seen in the bones of the tail. Group number 3 received 1 per cent of butter activators; group 4, 2 per cent; group 5, 4 per cent, and group 6, 8 per cent. It will be noted immediately that the density of calcification is progressive throughout the series. Group 7 received 2 per cent of cod liver oil, and it will be seen that there are certain structural characteristics of these rats that are different from those of the other rats. The shaft of the bones is longer than that of any of the rats in the butter vitamin group. The density of the calcification is not so great as in the rat on 8 per cent butter activator. The difference in these two activators will be seen in the following regards: The calcification is more diffuse in general in the butter group than in the cod liver oil group, and the epiphyses at their junctions with the diaphyses are shown to be more advanced in the closure of the interspace in the cod liver oil group than in the butter vitamin group. In group 8, which

received 2 per cent of cod liver oil and butter vitamin activators, it will be seen that all of these conditions are enhanced, all the bones being much larger and the development of the carpal bones more complete, and, in general, we have a result that is better than in either of the two when given separately. This series clearly demonstrates, as many of the others have done, the importance of butter and cod liver oil together as activators.

A need has been evident for additional data on the various characteristics of these two products as sources of activators in various nutritional phases of health and disease.

During the several years that I have been studying this phase of the problem, I have used several thousand chickens, rats and rabbits and other animals in my experiments, and I have made a study of a large group of human beings from both clinical and biochemical data. I have seen much evidence of toxic disturbance resulting from the administration of cod liver oil and other oils. Two illustrations will be seen in Figure 8, in each of which a chicken and a rabbit are shown to be partially paralyzed from the use of a quantity of cod liver oil which in proportion to body weight was approximately that frequently advocated. Agduhr[12] has reported extensive studies on mice, cats, calves and dogs. Rats, being scavengers, are less susceptible to injury from toxic substances than some other animals. They are sometimes affected though not so readily as mice, which Agduhr has used so extensively. He states that they die as early, but with fewer lesions.

12. Agduhr, Erik: Acta Paediat. 8:489, 1929. Agduhr, Erik, and Stenstrom, N: Acta Paediat., 9:229, 280, 307, 345; 10:167, 203, 271, 1930.

In Figure 9 will be seen an apparent influence of the activators from butter in neutralizing toxic effects produced by cod liver oil. The clinical result from using these two products in the combination in which I now use them has afforded an abundance of important data, which will be discussed presently. Rat 1 in this series received deficiency diet Steenbock 2965, low in phosphorus, and the roentgenograms of the tail show a marked deficiency in calcification which is characterized as severe rickets. Clinically, the animal had reached the stage in which it was inactive, which is characteristic of many animals on deficiency diets. Another characteristic of this diet is that it is low in mineral utilization activators. Rat 2 received the same diet as rat 1, but, in addition to the deficiency diet, received 2.5 per cent cod liver oil. Calcification is seen to be much better than in rat 1. The clinical condition of the rat was one of progressive paralysis. Rat 3 received the same diet and the same quantity of the same lot of cod liver oil, but in addition also received 2.5 per cent of butter concentrate. Calcification will be seen to be much better than that obtained with the cod liver oil alone and the rat was normally very active.

Histologic studies were made of various structures of these rats for use as comparative data. These are shown in vertical columns in Figure 10 for the kidneys. In *IA,* we see a low-power cross-section of the kidney of rat 1. *IIA* shows a low-power of a cross-section of the kidney of rat 2, and *IIIA,* a low-power of a cross-section of the kidney of rat 3. High-power views of these three structures are seen below the low-power views, as *IB, IIB* and *IIIB.* A marked difference will be seen at a glance. The kidney of rat 2 had so many islands of calcification that it was

difficult to cut it without tearing. These appeared as little stones all through the kidney cortex. This condition is evidenced by the torn state of the low-power section. One of the islands is seen in the high-power section *IIB*. There is a marked difference in the way the tissues took the stain. All were mounted on the same slide. Under the high magnification, as seen in the lower views, it will be noticed that the epithelial lining of the renal tubules is characterized by the flattening of the cells, with a marked change in the structural characteristics of the glomerulus. Those of rat 3 seem to be the only ones with approximately normal histologic structures, notwithstanding the fact that it had the same opportunity for injury as rat 2. Limited studies seem to have been made on the nature of toxic substances which may be present in cod liver oils. These are known chiefly from their clinical effects, which may be severe and striking. Only a small percentage of rats developed as marked injury as rat 2.

I have frequently had mothers bring this question to me as a serious nutritional problem with their children. They had desired to do all they possibly could for their children and, in their efforts, had tried to follow the directions on the bottle or as otherwise provided, which often meant large doses of cod liver oil. They have reported to me the difficulty they had in combating the rebellion of their children against the use of cod liver oil, which may have been in part a reaction of self-preservation. Many of the children were reported to regurgitate the oil when it was forced down. Since it has been demonstrated that only the oil that is utilized contributes to the well-being of the human being or animal, it can readily be anticipated that compulsion to take such a toxic product could be very injurious.

In studies to ascertain the nature of the toxic substances to be found in cod liver oil, Gautier and Mourgues[13] have found two particular substances which are very toxic; namely, isoamylamin and cholin. The former is found to be fatal in three minutes to a greenfinch in doses as small as 4 mg. Figure 11 shows the effect of injecting a small quantity of this material beneath the skin of a rat, shown in *A* to be carrying its foreleg. One small drop was placed subcutaneously in the center of its back and, on a later day, a small drop was injected under the skin of the abdomen. While these injections were not near the foreleg, the toxic substances extended their influence far beyond the local area of their insertion. The characteristic changes in the muscle color of the foreleg is shown in *B*. *C* shows a low-power section of the muscle of the foreleg. The boundary of the protoplasmic poison is clearly disclosed. *D* shows a high-power view of the degenerated muscle fibers, the dark cells showing clearly the effect of the progressive protoplasmic change. In order to study this product found in cod liver oil, I placed a small drop of it on the tongue of a rat. In five minutes, the tongue had changed color and was greatly swollen, and, in ten minutes, it was protruding from the rat's mouth. The animal was immediately chloroformed and the tongue removed for sectioning. The edema is shown in *E*, with the protoplasmic poison extending through the epithelial structure into the connective tissue. This shows the extreme toxicity of this substance. Little seems to have been reported on the toxic

13. Gautier and Mourgues: Compt. rend. Acad., 107:110, 1880.

substances in cod liver oil. Recently, Norris and Church[14] have called attention to the importance of considering the toxic substances in cod liver oils as possible explanation for differences in results obtained by different workers in vitamin studies.

Investigations made by Holmes and associates[15] have been directed toward a study of the influence on chickens of free fatty acids contained in four cod liver oils. Two were of low free fatty acid content; two, of high. The chickens on low fatty acid content oil developed into fowls of good quality. The death rate per hundred in these two groups was ten and fourteen, respectively; whereas, in the two groups receiving the high free fatty acid cod liver oil, the death rate was forty and twenty-eight, and of the birds that did not die, few showed normal pigmentation. All were listless and all were undesirable subjects for future experimentation.

The most important data that I have obtained directly or indirectly on the availability of cod liver oils that can provide what is required by the human body have come as a result of cod liver oil administrations to adults. These data indicate that this is not a satisfactory source of fat-soluble activators in ordinary diets. Experimental animals have the advantage of their availability for dissection and for reproducing the observations under controlled conditions. Neither children nor experimental animals can satisfactorily disclose their sensations, though much can be observed from their dispositions and evidence of well-being. It is clear from the many clinical data which I have accumulated that cod liver oil alone, as available on the markets, cannot provide all of the fat-soluble activators that we need, nor can it be taken for extended periods in large doses without the danger of undesirable results.

I have combined with the clinical experience of the patients evidence afforded by clinical and microscopic studies of the blood, saliva and urine and, by these means, have obtained information dealing directly with this problem of the availability of various substances as activators. The available data strongly indicate that there are marked limitations in the administration of available cod liver oils.

I have taken for granted in the discussion of this problem that it will be understood that the dietaries of patients are so arranged as to be what I deem adequate in vitamins B_1 (F), B_2 (G) and C.

In approaching a study of the etiology of dental caries, it is important that we learn as rapidly as possible the chemical processes involved in the utilization of the minerals of the foods and the significance of the variations in the chemical levels of the body fluids.

During the years that I have been studying these problems, I have placed increasing emphasis on the blood, saliva and urine chemical and microscopic pictures. These frequently reveal data strongly suggesting the nature of chemical imbalances, which, in many instances, can be improved through modification of the nutritional program. Study of the data obtained by these means will aid in visualizing some phases of this problem.

Among the many complicated mechanisms of the body which have to do with the maintenance of proper levels

14. Norris, E. R., and Church, A. E.: J. Biol. Chem., 89:421, 437 (Nov.) 1930.

15. Holmes, A. D., et al.: Does Cod Liver Oil of High Acid Content Have Toxic Properties? Poultry Science, 9 (March 1) 1930.

of various chemicals, some of which are the minerals which are in the various body fluids, is one with which we are greatly concerned and which has to do with the laying down and taking up of the hard tissues of the body. A physical condition which lends itself readily to a study of these phenomena has to do with mineral absorption and deposition, normal and abnormal, associated with progressive decalcification of the skeleton when the demands of the body for minerals exceeds the available minerals as obtained from the food. This condition is found in the changes of the bone which precede fractures that are spontaneously produced and in the progress Nature makes in the healing of such fractures. It is necessary to consider in detail progressive stages of calcification about the region of a fracture with a failure of union in which there is associated the roentgenographic evidence and the blood chemical data. These have shown, in several cases, progressive decalcification without union until the patients were placed under treatment providing important additions to the activators which seem to be requisite for the utilization of the minerals of the foods and for their deposition in the regions requiring them. These clinical data have also shown marked improvement in the calcification following an increase of activator intake. These data are of significance and interest when studied in connection with the blood chemical findings. Such a case is seen in Figure 12.

This man, aged 45, was shot in the leg in October, 1930. The bullet shattered both bones as is shown in the first view. The following March, owing to failure of union of the fracture, my assistance was sought. Blood was drawn and prepared according to my directions and sent to me by air mail for analysis. These studies revealed that the calcium, phosphorus and magnesium were each much below normal, being at levels 7.9, 3.3 and 1.7, respectively. The product of serum calcium and serum phosphorus, which is normal at about 40 for adults, was 26.1. Fractures do not heal readily when this product is below 35 and with great difficulty when it is below 30. In addition to suggestions relative to the foods to be selected and emphasized in the dietary program, capsules were sent containing the mixture of high vitamin cod liver oil and high vitamin butter concentrate. A rubbing oil (high vitamin cod liver oil activated in the sun for ten minutes) and a butter vitamin concentrate were also sent. Within ten days, the patient was conscious of a great reduction in pain and a sense of increasing strength, which progressed so rapidly that the cast was removed in a few weeks. In thirty-five days, as a result of this treatment, all of the chemical factors above mentioned increased considerably. The serum calcium went from 7.9 to 13.8; the serum phosphorus, from 3.3 to 4.3, the magnesium of the serum, from 1.7 to 1.9. The sum of the calcium and magnesium increased from 9.6 to 15.7, and the product of serum calcium and serum phosphorus advanced from 26.1 to 60.1. The patient was conscious of a great physical betterment. The roentgenographic picture of the bone, taken in March, at the time the treatment was started, is shown in comparison with the picture taken in July. It will be noted that, in the space between the large splinter and shaft of the tibia, a bony buttress has been built, by which time the leg was being used with comfort and efficiency. This is indicated by the arrow.

I have reported a number of cases of

ununited fracture in other communications.[16]

In order to better visualize the levels of the minerals in the body fluids in health and disease, particularly as variations of normality, I am presenting in Figure 13 a graph illustrating the levels for several chemicals in the blood, saliva and urine in twenty-five successive cases. This graph shows the highest, the lowest and average figures. It happened that no extreme cases appeared in this group. Several important facts will be observable at a glance, among them the following. The serum calcium varied from 10.7 to 8.1. The total phosphorus of 100 c.c. of whole blood, which will include the organic and inorganic phosphorus, is about five times that of the total calcium of 100 c.c. of whole blood, and of this phosphorus, by far the largest part is in organic combination. The inorganic phosphorus of 100 c.c. of whole blood is from a third to a half that of the calcium of 100 c.c. of whole blood. The magnesium of whole blood is about one-fourth that of the calcium. The two minerals that are present in largest quantities are potassium and sodium. It is seen at a glance that there is quite a marked difference between the maximum and minimum levels of all minerals, the maximum being from onefold to twofold greater in general for calcium, phosphorus and magnesium, and there is a much greater difference than this for potassium and sodium. The mineral content of human urine is seen to represent a large wastage, constituting that which has gone past the mill. It is not necessarily all wastage, though some of it is, as in the calcium of the urine in cases of infection, which may be distinctly an expression of undue wastage, the result in part of utilization of the available calcium of the blood stream for neutralizing toxic products due to infection. The minerals of the saliva tend to have a level that is related to the levels of the blood stream.

In a recent discussion of this problem,[4] I presented data indicating the mineral requirements of the body of animals, including human beings, each day. These have shown, for example, that a 1,000-pound cow requires 42 gm. of phosphorus, 63 gm. of calcium and 114 gm. of potassium, estimated as their oxids. Such a cow can eat approximately 56 pounds of fresh grass, which is 70 per cent water. An analysis of the grass produced in different locations immediately reveals that it is a physical impossibility for a cow to maintain life on the quantity of that grass which it is possible for her to eat. One of the grasses presented in that study, for example, furnished a total of 19 gm. of phosphorus a day; whereas, the cow required 42 for metabolism alone. The requirement for calcium was 63 gm., which was amply taken care of, the grass in question providing 199 gm. The cow would not fare so well for potassium, for her requirement for this mineral was 114 gm. a day, and this grass furnished only 11 gm. a day. The result was that even without the overload of pregnancy or lactation, the body became depleted, and these animals became ravenously hungry for minerals that they could not obtain from the diet. Throughout the world, animals express such hunger craving in abnormal chewing of various articles such as old bones, dirt and clothing. If this cow had the additional load of providing 5 gallons of milk a day, she would have to make large overdrafts on her stored minerals, since 5 gallons of milk requires 40 gm. of phosphorus in addition to that required for metabolism. The milk

16. Footnote 11, fourth reference.

would also require 34 gm. of calcium and 58 gm. of potassium. The total overload or shortage on this grass, which was obtained from a pasture on which the cattle were breaking in health, would constitute an overdraft of 63 gm. of phosphorus and 151 gm. of potassium. This pasture furnished an adequate quantity of calcium. Even the feeding of bone meal would not adequately furnish these minerals. It must be kept in mind that animals are dependent on plants to build the minerals into organic structures in order to provide the building blocks of the body. It has not been appreciated that there is a great difference in the content of various chemicals constituting the structure of plants with which we are familiar and which are being used for food for both human beings and domestic animals. In a chart which I have presented in the above-mentioned research reports,[17] I have shown the variations in the content of several minerals in each of eight different grasses which I have analyzed. The range of each is very great, potassium having a range of 1 to 50, phosphorus, 1 to 60, and calcium, 1 to 10. A discussion of this phase of the problem should be included here, if space permited.

We find ourselves confronted with a problem whose complexities have baffled science throughout all history. Why is it that some individuals suffer from dental caries and others do not, and why does one individual suffer at a particular period of life and not at another? One after another, theories have been presented which have been proved inadequate. Mistaken concepts have been costly to humanity in general. It would be exceedingly difficult to estimate the harm that has been and is being done through the mistaken guarantees of oral hygiene; not that oral hygiene is undesirable, but it must not be taught or be understood by the public that cleanliness alone can prevent dental caries. If "cleanliness is next to godliness," nutrition must be a part of godliness.

I am continually receiving communications from various districts inquiring as to why it is that the members of a given family or the inhabitants of a given district are so subject to dental caries. A dentist writing from a city in a large central state recently asked why is it that I find more dental caries in the mouths of the present generation of growing boys and girls than in any generation I have taken care of in the past thirty years, and why the condition is so progressive. It is also significant that about that same time I received from the agricultural department of that state a reply to my inquiry regarding soil depletion, stating that the carrying capacity of the pasturage lands and the crop capacity of the tilled lands of that state have decreased conspicuously in the last two or three decades, the reduction amounting in some sections of the state to 50 per cent in carrying capacity on pasturage areas. The experience of this state is not more striking than that I could cite for many other states. There is probably more evidence of an association of nutritional deficiency in animals and human beings in the same districts than has been suspected. I have presented data on this point in some of my reports.

Nutrition is dependent on three principal food factors: (1) energy-producing elements for maintenance of temperature and energy expenditure, etc.; (2) minerals and other chemicals that are essential for the building and repair of tissues and for tissue function, and (3) activating substances, which seem to

17. Footnote 1 and Footnote 11, second reference.

have a combined rôle of making the minerals and other chemicals available for utilization and also for entering into the structure of different types of tissues.

The general use of the term "diet" has not adequately taken into consideration relative values. I have already referred to variation in values of milk and have reported extensively on this phase of the problem. Too little attention has also been given to this matter of the depletion of cereal foods of their desirable if not essential factors. I recently asked a miller how long he would expect whole wheat flour to be available for use in the summer time if all of the ingredients of the wheat kernel were left in it, he said, "Only a few weeks." When I asked why, he said, "It would be swarming with flour mites."

When we study the civilizations preceding ours and for whom we have too little admiration and sometimes even disdain, we find that they did not take out of the food these substances that would generate life within two weeks. A phase of my program, particularly in cases showing severe nutritional disturbances is not only to provide the minerals in as great or even greater quantities than are found in the whole grains, preferably wheat, but also to add an additional quantity of fresh activators as found in the germ of the wheat by providing additional strictly fresh wheat germ, which, in warm weather, rapidly deteriorates after the grain is broken.

In several of my recent research reports previously referred to, I have presented data relating morbidity and mortality for many diseases to the levels of the vitamins as found in dairy products in various districts when the United States and Canada are divided into sixteen large geographical areas. This implies that other food plants have many factors in common with a stored or growing grass which produced the milk in a given district.

Space here will permit only a summary of the factors which I deem to be of primary importance in the causation of dental caries. The following general statements present my point of view:

1. Dental caries, while considered to be the most widely distributed disease in the world, does not attack the same individuals equally at all periods of life or all the individuals in the community to the same degree at a given time. Therefore, it is not endemic.

2. It has not been controlled or greatly reduced by oral hygiene.

3. There is much evidence of an increase in the severity of dental caries in certain districts in spite of all advances in medical and dental science.

4. It attacks individuals most severely at certain periods which are known as periods of stress, particularly those of rapid growth, sickness, physical and nervous overload and pregnancy.

5. It tends to be seasonal with regard to its periods of greatest severity in given individuals, being most severe in the time of reduction of vitamins in foods and periods of rapid growth in children. Its periods of activity are associated with depression of some of the minerals of the foods, particularly calcium and phosphorus. Activity largely ceases when the balance in blood minerals is changed from a negative to a positive phase. The food factors which produce these changes in the essential blood chemical elements, while related in some degree to most, if not all, the known vitamins, are apparently chiefly related to a group of fat-soluble activators, which includes the known fat-soluble vitamins.

6. The dietary sources of these fat-soluble activators are more limited than are the sources of most of the water-solu-

ble activators. The only liberal sources are certain samples of milk fat and cod liver oils. Milk growth-activators are, in the light of my studies, chiefly produced by animals feeding upon rapidly growing young plant life. For the cow, this means that it is restricted largely to the periods of the year when her diet consists chiefly of rapidly growing young grass or the same cured and stored in such a manner as to retain these factors. The milk-fat products which contain the highest levels of these activating substances can be stored at low temperatures, when properly prepared for storing, for extended periods exceeding one year, and can thus be made available.

7. Water-soluble activators are essential and fortunately are usually easily obtained. They also greatly stimulate the appetite. Working oxen will live on a diet on which calves and cows die.

I can probably best illustrate my procedure and demonstrate the constitutional changes affected by a change in the nutritional program by a practical case which involves several phases of physical evidence of disturbed nutrition, including extensive dental caries with structural change often associated with infection processes.

During the past decade much advance has been made in our knowledge of the relation of infection of the teeth and mouth, particularly apical infection of pulpless teeth, to disturbances in other parts of the body. These studies have shown that inheritance plays an important part in determining the type of tissue that would be affected in a given individual. Susceptibility of an organ and tissue has also been shown to be related to physical overloads and to nutritional stresses. One of the important afflictions that has been associated very closely with dental infections is arthritis. While many persons improved after the removal of dental infections, many did not or experienced only a cessation in the activity of the process.

An important new phase of these studies is the marked improvement in the physical condition of persons who are below par in general health and also, in many instances, a lessening of disturbances in organs and tissues. This improvement has been particularly striking in many cases of arthritis after the use of the activators that are found to be helpful in reducing dental caries.

My assistance was requested by the visiting nurses' association to aid a young girl whose condition was said to have been reported as incurable. She was 17 years of age and bed-ridden, with acute multiple deforming arthritis associated with so much pain that she would cry by the hour day after day from her distress. She could scarcely move a joint of her body, many of them being rigidly ankylosed. Her condition had been getting progressively worse since she was 5 years of age, at which time she had five abscessed deciduous teeth, which, of course, means that she had extensive dental caries. She was brought in in an ambulance. Her parents reported that she had been having on an average of three to four convulsions a week, usually brought on by the pain when she was moved to make her comfortable. At times, she had great difficulty in breathing. Her mouth would open only a short distance but some roentgenograms of her teeth were obtained and many of the teeth had extensive dental caries, some with pulp involvements. It is important that the teeth with pulp involvement showed little apical change. Owing to the spasms of the muscles of the left side of the neck, the head was drawn so tightly into the shoulder that it was difficult to get more than the thick-

ness of a towel between. The spasms of these muscles had continued for months, causing intense pain. The roentgenograms of the chest, neck and head showed that the mouth, instead of being crossways to the spinal column, was parallel with it. The vertebrae of the spine were rigidly ankylosed so that the patient was locked in this position. A lower molar tooth on the left side had serious pulp involvement and the history indicated that the toxic products from this infected tooth and probably other infected teeth of the left side traveled through the lymphatics into the musculature of the neck, producing torticollis. Neck involvement, particularly neuritis, rye-neck or torticollis and neuralgia, are common expressions of the presence of toxic material from dental conditions, which may be without local dental symptoms.

We must ask ourselves what the contributing factors are in such a tragedy. It began at 5 years of age when the patient had the five abscessed teeth. Clearly, there had been nutritional deficiency, for, in the light of our newer knowledge, dental caries is primarily nutritional. The evidence developed indicates an inherited susceptibility in that the mother and the brother have had inflammatory rheumatism, although not in severe form. The convulsions clearly indicated, as did also the unstable condition of the nervous system, a low threshold for calcium, which, on chemical analysis, was found to be 8.3, and the cell calcium one of the lowest we have ever determined, at 0.02. The body was evidently making a heroic effort to maintain levels by utilizing available minerals. The cell volume was exceedingly low at 25 per cent; potassium and magnesium were both low, and sedimentation time of the blood was extremely rapid. Examination of the dietary indicated a lack of minerals and activators. In order to illustrate the long-continued nutritional handicap of this girl, I am showing in Figure 14 a picture of a hand and forearm of a normal girl of 17 and the hand and forearm of the patient for comparison. It will be seen not only that there is marked dislocation and deformity of bony structures but also that there is a marked difference in the size of the bones of the forearm in comparison with that of a normal girl. Doubtless, Nature did the best she could with the scanty and depleted diet available from the refined flour foods and depleted activator content of available dairy products. She was placed on the special activator mixture in capsule form to which I have referred, and given as one of her important food constituents a whole wheat ground freshly every few days, to which, after it was cooked, was added a quantity of fresh wheat germ, about one tenth the volume of the ground wheat. This was added when it was ready to be taken off the stove. It was then allowed to cool on the side of the stove. Milk, fruits, vegetables, whole wheat bread, etc., were advised. The results were most striking. The convulsions which she had been having on the average of once every other day, ceased immediately and she did not have one after starting the capsules and special foods. Instead of eating two meals a day, she ate three or four. The pain was so reduced that she was not disturbed except slightly when lifted. The movement of the joints increased so much that within a month she could open her mouth twice as far as at the beginning, which permitted the removal of one of the infected teeth. Many teeth had been filled. This terrible condition of progressive locking of the joints with acute inflammatory processes was reversed, and she progressively improved. Pains subsided, swelling was reduced and some movement of fixed

joints developed in a few weeks, so that she could feed herself and turn the pages of a book. She again became interested in the world and in living.

Another instructive case is illustrated in Figure 15. This woman, 61 years of age, had suffered severely with arthritis for nine years and, for the past eight years, had not been able to wear shoes or move about except with great difficulty and assistance, part of the time being bedridden. She had not walked without crutches for seven years, except for a period of about three months. Her pain had been so severe that seldom was she able to get to sleep before 4 o'clock in the morning. Her teeth were removed early, many being infected. There was a history of severe dental caries. Much effort had been made to furnish relief. The fingers and thumbs of both hands had been held apart for years. Within a few weeks after starting the treatment, the pain was much reduced and she was able to sleep soundly all night. She now has no pain day or night after being under treatment for eight months. She has resumed her activities as a seamstress and has regained the use of her arms so that she can put her hands behind her head as is shown in the illustration. She now has no use for crutches except to steady herself going up and down the stairs. Physically, she looks greatly improved, and she states that she is perfectly well except for the retained stiffness, chiefly in her back, which is progressively decreasing.

All that has been done is to add to her diet the vitamin concentrate and a small quantity of high vitamin cod liver oil. The latter had been used alone before at various times without success. There was little movement in the left elbow joint when the treatment began, the arm being in a nearly straight position. The present range of movement is shown by the two roentgenograms and the photograph in Figure 15. The patient states that she has never felt better since she was 30 years of age. No considerable changes were made in her diet because it was found to be quite ample.

A difficult and serious phase of the problems is this: we cannot write out a formula to be taken to the grocer's to obtain the cereal products containing both high minerals and their natural activating substances as found in the germ, or to obtain butter and milks that are known to be amply high in their activating substances. And least of all can we go to the drug store and buy these as chemicals, since the very nature of animal life is such that the tissues are built of substances that first must be constructed by a plant and therefore are organic. We cannot substitute inorganic chemicals.

Accumulating evidence indicates that dental caries and the lowering of levels of fat-soluble activators in dairy products are progressing simultaneously in those districts that have been longest under cultivation without mineral replenishment and enrichment of the soils, and that these conditions are accompanied by an increase in morbidity and mortality suggesting, if not indicating, a relation that is not a simple coincidence. From data obtained from the analysis of dairy products, chiefly butter, from many places throughout the world and the correlation of these data with the morbidity cycles of the same districts, I find conditions which I interpret to indicate that the degenerative diseases in many of their other expressions are largely if not chiefly the same in their seasonal expressions, as the tides in the vitamin content of foods. Even the demand for beds in hospitals for medical cases reflects this same cycle. It is also exceedingly significant that the increase in certain of the mortality rates

can apparently be explained on this same basis. I have presented data dealing with these phases in reports entitled "Why the Annual Pilgrimages to the Hospitals?"[18] and in "A New View of Health and Disease Based on a Rise and Fall in Vitamin Tides."[19] It is important that persons who tend to develop heart trouble in childhood (and 90 per cent of all heart cases begin before 10 years of age) as a rule, have been very susceptible to dental caries. We see direct evidence as to why dental caries and rickets together of all problems offer the greatest challenge to civilization and why these evils are the foremost enemies of the Nordic race in the temperate zone. This is another way of stating that our greatest problem is the supply and utilization of minerals.

If my interpretation of the data available is correct, diets as built by name for different communities do not necessarily provide the same nutritional factors. This may also be true of the same place at different times of the year owing to the different values of the same foods. Accordingly, in the light of these observations and clinical experiences, it will be necessary to reinforce given foods with adequate activators, when they are not present in sufficient quantities in those foods. The best means that I have found for accomplishing this, and which is supported by clinical, laboratory and experimental data, is to select milk fats that are high in these activators and preserve them either in natural form or in concentrated form for periods of stress and vitamin shortage in the available foods.

The means I have found most readily available for identifying milk, creams and butters that are sufficiently high in the activating substances with which we are concerned has been the use of both animal-feeding tests and chemical tests for the activating substances. I have used the antimony trichlorid method of Carr and Price,[20] adapted to butter products for vitamin A, and the hydriodic acid method of Yoder[21] for vitamins in the D group. The vitamin content of the cod liver oil should be over fifteen Lovibond units for vitamin A on the standard suggested by Drummond and Hilditch. A good technic is described in their report before the Empire Marketing Board entitled "The Relative Values of Cod Liver Oils from Various Sources."[22] I have reported at length, at various times, details regarding the many thousands of samples of butter that are tested each year from all over the world, largely from the same places regularly each month or fortnight. When butters of high vitamin content are located and secured, the low melting factors are removed by centrifuging at a proper temperature. This product is what I term the high vitamin concentrate. It is liquid in ordinary room temperature. The high vitamin milk is produced by dairy animals best, if not only, when the animals are on a rapidly growing plant life, such as succulent young grass. One of the best that I have found of the few pasturages that are especially good is rapidly growing young green wheat. The butter product is mixed with about equal parts of a very high vitamin cod liver oil with variations in proportions according to clinical conditions. This combination

18. Footnote 10, sixth reference.

19. Price, W. A.: New View of Health and Disease Based on Rise and Fall in Vitamin Tides, Am. J. Pub. Health, 21:605 (June) 1931.

20. Carr, F. H., and Price, E. A.: Biochem. J., 20:497, 1926.

21. Yoder, L.: J. Biol. Chem., 70:297 (Oct.) 1926.

22. Drummond, J. C., and Hilditch, T. P.: Relative Values of Cod Liver Oils from Various Sources (published by His Majesty's Stationery Office, London, December, 1930).

is placed in a capsule containing about 0.6 gm. (the 0 size). Two or three of these capsules are administered with each meal with a dietary adjusted to provide minerals and other nutritional factors, including the water-soluble vitamins. Since these are food products and are used to reinforce the available foods with nutritional factors, I deem it proper to say that we have by this means, and perhaps other dietary means, found a method for the control of dental caries.

I have undertaken to check the incidence of dental caries in various communities against the vitamin content of the foods in the communities. One of the studies in this connection which I have in process is being made in Switzerland. During the past summer, after the International Dental Congress at Paris, I made a limited study of dental caries in Switzerland, where I found the record of the observations of the dentist to indicate that this condition was very prevalent. I was advised by a government official that dental caries was the most serious disease in Switzerland. Through this official's assistance, I was able to locate a group of people that had little access to the various food resources of the country, and who for centuries have provided nearly all of their nutritional elements in their own high valley. I examined a large number of children in this valley which was quite difficult of access, and found their teeth almost completely free from dental caries. They live largely on their native grains, plant foods and dairy products, the latter forming an important part of the diet. The dairy products are obtained from both cows and goats. Samples that I am obtaining from that valley indicate that this butter is of exceptionally high vitamin content.

I examined children reared in other valleys, but where the trains bring modern dietary products, and found dental caries rampant. This study will be reported in detail in another communication and is being extended.

I cannot include here, as would be desirable if space permitted, data concerning the most available forms of the minerals and other nutritional factors.

The activators essential for the utilization of the various minerals and other chemicals for the building and maintenance of bodily tissues are provided in an ideal milk as designed by Nature. Since we all start life on that food as provided by Nature for all mammals, it is the most natural source of these activators.

An illustration of the consistency and efficiency of the nutritional program which is developing as a result of my research is found in the following case (Fig. 16), which indicates its helpfulness in the development of the child during fetal life, his nourishment during lactation and early childhood and the protection of the physical welfare of the mother, including complete freedom from dental caries. This boy, 2½ years of age, has never received directly or indirectly any cod liver oil. He has obtained fat-soluble activators through his mother during gestation and lactation from milk and butter of high vitamin content as determined and selected by the tests indicated and, since weening, he has obtained his additional fat-soluble activators entirely through the use of high vitamin butters. He won a prize at 10 days of age for being the best developed, having the best disposition and being the best nourished infant in a group of forty that were in the maternity hospital at that time, and this notwithstanding the fact that he was a first child and that the mother was frail. The excellent structure of his bones is shown in the accompanying roentgenogram. In physical development, he has always been

exceptional. He was the only child on this dietary program.

Many of the children who have been on my nutritional program through their entire life, some of whom have all their deciduous teeth, have never had a sign of dental caries. The joints are well formed and seem to justify the belief that the addition of fat-soluble activators in suitable quantity and adequate quality is capable of reinforcing available foods sufficiently to assure a physical development of a high standard.

SUMMARY

The data presented are interpreted to indicate the following:

1. Dental caries can be largely prevented or controlled.

2. This result can be obtained by the selection of particular samples of foods that are sufficiently high in minerals and activators to provide the nutritional requirements of the human child and adult, including the expectant and nursing mother.

3. While some of the necessary activating substances are found in certain samples of dairy products, milk, cream and butter, many of the readily available products are not adequately high in these activating factors.

4. Cod liver oil is available as a source of reinforcement of dairy products, plant and animal foods. While it has great value, it may contain and probably often does contain substances which are undesirable; therefore, it should be given in small doses, and only products of the highest natural vitamin content be used.

5. The available data strongly suggest, if they do not indicate, that dental caries is primarily an expression of nutritional disturbance in which the teeth become susceptible to attack by the products of acid-producing bacteria. The progress of this decalcification is inhibited by the presence of proper chemicals in the blood and the saliva. Many dietaries provided for children and adults are deficient in activators, chiefly the fat-soluble. While a deficient food may become adequate by increasing the quantity of fat-soluble activators, we must always realize that the water-soluble activators must be present and must also be supplied if not present.

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