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DIET AND DENTAL CARIES IN CHILDREN - SHOULD BREASTFEEDING BE ENCOURAGED?

by

JOY VERONICA MAK

A thesis submitted in partial requirement for 'DIPLOMA IN PUBLIC HEALTH DENTISTRY'

UNIVERSITY OF SYDNEY
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FOR BEING SO KIND.
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1. INTRODUCTION.

Diet is the total oral intake of substances that furnish nourishment and or calories to the body. The substances that furnish nourishment and calories are chemicals. The nourishment may be desirable or undesirable, depending on the person's particular needs at a given time.

We have assumed that if we consume a normal mixed diet in appropriate amounts we probably receive the necessary amounts of nutrients. The nutrients needed by the body for growth and maintenance of health may be divided into those contributing energy (namely, carbohydrates, fats and protein), minerals, vitamins and water. These essential nutrients are all available when one eats a varied and appropriately selected diet. However, a narrowly defined pattern of food preferences may lead to a deficiency of one or more of the nutrients needed for normal good health.

Starch, sugars and cellulose are examples of carbohydrates which perform some important functions in the body and are required for good health. Carbohydrate also provides glucose, a sugar required for the general system to function. Yet another role of carbohydrate is to aid in the utilisation of fats in the body. With inadequate carbohydrate, ketosis develops because fats cannot be metabolised normally.

Cellulose is a unique carbohydrate in that it cannot be used by humans as a dietary source of energy. This inability to digest cellulose enables humans to use cellulose for bulk in the diet, thus promoting excretion of water materials from the body.

Proteins can be used to provide energy, just as carbohydrates and fats do. However, protein performs very unique functions too. Protein is essential for the growth and maintenance of tissue throughout the body. Hormones, enzymes and antibodies are all protein materials that must be present for normal body function. These are synthesised in the body from the amino acids provided by dietary proteins.
Within the body there is need for regulating the fluids between the various compartments of the body. Plasma protein are important for their role in helping to regulate the balance between the fluid levels in the cells and the blood stream. The relative neutrality of the body must be balanced very carefully and maintained within very narrow limits. Plasma are able to function as either acids or bases, hence, are of considerable significance in maintaining the proper conditions within the body.

Fats serve two major functions in the body: they produce energy and cushion vital organs against shock. The subcutaneous layer of fat insulates the body against heat loss in cold weather.

Mineral salts are inorganic compounds that are used as structural components and regulating substances in the body. Most foods contain them in a natural form, but they may also be liberated during oxidation in the body. There are nineteen principal minerals, some of which are needed in extremely small quantities by the body, and so they are referred to as trace 'elements'. Nine important mineral salts are calcium, phosphorous, sodium chloride, potassium, magnesium, iron, copper, iodine and fluorine.

Calcium is an indispensable component of the structure of the body; the bones and teeth owe their hardness and strength to the presence of this mineral. It is aided in its structural role by its interactions with phosphorous and magnesium. Calcium forms 1.5-2.0% of an adults body weight. 99% of the calcium is found in the skeleton. The largest portion of the remaining 1% is found in the muscles. Minerals in the skeleton serve two purposes: structural and metabolic.

Sodium chloride or common salt is essential for the maintenance of fluid balance and normal osmotic pressure in the body. It is needed for cellular activities. A certain level of sodium chloride must be maintained in the blood, cells and tissue fluid.

Potassium is an indispensable constituent of the body cells. It is needed for all cellular functions. It maintains the alkalinity of bile and blood and stimulates skeletal muscles. It helps in the normal function of the heart.
Iron is an essential constituent of haemoglobin and is responsible for the red colouring of blood. It is necessary for the transportation of oxygen to the tissues.

Insufficiency causes iron deficiency anaemia. So also does copper.

Iodine is required for normal physical and mental growth. It is also required by the thyroid gland for the production of thyroxine which regulates the metabolic rate.

Because of its extreme reactivity, fluorine does not occur free in nature but occurs as a variety of fluoride compounds. The three such compounds which are of interest are sodium fluoride, sodium silicofluoride and fluorsilicic acid. In each of these compounds the extremely reactive fluorine element has reacted to form the extremely stable fluoride ion species in the compound and it is this particular stable ion species which is used to fluoridate water supplies where these are deficient in this trace element. Most diets are also deficient.

Fluoride helps in the formation of bone and teeth with the entry of its ions with the apatite crystal during the mineralisation stage. It is necessary in the prevention of caries. After mineralisation is completed, there is still fluoride uptake by the teeth.

Vitamins are needed for the metabolism of the energy-producing nutrients: carbohydrates, fats and proteins. Coenzymes and or portions of coenzymes often contain one of the compounds. Vitamins must be supplied in the diet. There are two types of vitamins, namely fat-soluble and water-soluble.

The fat-soluble vitamins are A,D,E and K. They are not excreted; any excess is stored in the body. Therefore, deficiency symptoms are slow to develop. These compounds consist of carbon, hydrogen and oxygen, exclusively. They are found in food.

The water-soluble vitamins are B-complex vitamins and vitamin C. There are eleven compounds described as vitamin B (Niacin, Riboflavin, Thiamin, Pyridoxine or B_6, Folic acid, Cobalamin or B_12, Ascorbic acid or Vitamin C), each having totally different and unrelated functions. The water-soluble...
vitamins are generally not stored in the body and are excreted in the urine. Therefore, some daily ingestion of these compounds is necessary.

Since food is the normal vehicle for nutrients, improving nutrient intake means changing food patterns, modifying attitudes towards food, increasing motivation for eating well or improving knowledge of the nutritional value of foods. A study of food habits and behaviour and of the social, cultural and economic factors influencing and sometimes restricting the consumption of foods is therefore a prerequisite to any nutritional programme, whatever its scope and objective.

Malnutrition is an impairment of health resulting from a deficiency, excess or imbalance of nutrients. It includes undernutrition, which refers to a deficiency of calories and or one or more essential nutrients, and over-nutrition, which is an excess of one or more nutrients and calories. There is no generally accepted method of measuring the dietary intake of free-living individuals.

In industrialised countries, where main problems are not under nutrition or clinically identifiable deficiencies, but the result of subtle modifications in food habits, sometimes created by an overabundance of food, which can be identified only by periodic evaluation of diets.

The food that we eat is undoubtedly the most important single determinant of our general state of health and well-being throughout life, of our useful productivity in society, and of our enjoyment of leisure time.

The ideal diet for a given individual will provide him with an adequate amount of each nutrient. There is no guarantee that an individual with a very low requirement for one will not have a very high requirement for one or more other nutrients. The abundance and variety of foodstuff available today make possible the planning of a wide diversity of diets, all of which would easily provide the recommended daily dietary allowance.

As a result of modern technology food is now widely available, both chilled and frozen from supermarkets, served hot from take-away food outlets, as well as from cake shops and milk bars. Little information as to the nutrient composition of the hot take-away foods is available to the consumer.
Carbohydrates are starches and sugars. It is obvious then that exactly which parts of the wheat are eaten is very important, not only to the palate, but for the maintenance of good health. Current milling techniques tend to selectively remove the outer and inner layers of the grain where many of the nutrients are concentrated, while the middle is proportionately richer in starch, is left. White bread is made from refined starch.

The major concentrated source of sucrose is in sugar cane and sugar beets. The juice of the sugar cane is purified with everything taken out except the sucrose. Molasses is one of the byproducts. It is a concentrated residue and contain significant quantities of minerals such as iron, calcium and generous quantities of trace elements such as zinc, copper and chromium. Cane syrup are a step closer than sugar to a whole food since they are subjected to less processing. Only water is removed.

There have been suggestions of poor eating habits, like between meal sweet snacks, that may predispose certain vulnerable groups to nutritional deficiencies and caries. Take the 864 Connecticut schoolchildren studied in 1956, as an example. Their mothers kept complete records of the food they ate for one complete week. Then Drs. M. Potrager, E.G. Morse, F.M. Erlenbach and R. Dall examined the children's mouths and matched examination findings to diet caries. They found that children who liked more between-meal sweet snacks had more cavities than those who ate less. They also found that children who ate more fruit and vegetable treats had fewer cavities than those who liked cookies, candy-cake treats.

The oral cavity plays a vital role in the determination of the overall status of nutrition and health in the human body. The mouth has been likened to a barometer (Nizel, A.E., Nutrition in preventive dentistry: science and practice, Philadelphia, 1972, W.B. Saunders Co.) to be viewed externally and used as an indication of what may be happening internally. The results of nutritional deficiencies or abnormalities sometimes appear in the oral cavity. The soft tissues reflect the metabolic status of the body, often in quicker and more dramatic ways than comparable tissues located elsewhere in the body.

Part of this response may result from the fact that oral tissues are subjected to varied traumatic situations because of their position and function. Stresses such as wide variations in temperature, particle size
and harshness, hydrogen ion concentration, dehydrating ability and osmotic gradients of the food and drink consumed demand the frequent removal of soft tissues than would otherwise be necessary.

The temperature, humidity and food available to the oral cavity also promote the prolific growth of widely varied types of microorganisms with varied sequelae.

While nutritional deficiencies with oral signs are still very common in underdeveloped countries, they do not occur frequently in countries with high economic standards except in certain population groups with extenuating circumstances.

The systemic environment of the developing tooth controls the tooth histologic structure, its chemical composition, and even its general size, shape and cuspal design. In turn, the systemic environment is controlled by the genetic composition, by the health and well-being of the individual, and by the availability of the nutrients required for the adequate growth, development and mineralisation of the tooth.

Mineralisation of the enamel matrix takes place in two stages, although the time interval between the two appears to be very small (Crabb, H.S.M. (1959), The Pattern of Mineralization of Human Dental Enamel, Proc. Royal Soc. Med. 52:118., Crabb, H.S.M., Darling, A.I. (1966), The Gradient Mineralization in Developing Enamel, Arch. Oral Biol. 2 (1960) 308.) In the first stage, an immediate partial mineralisation occurs in the matrix segments and the interprismatic substance as they laid down.

The second stage, or maturation, is characterised by the gradual completion of mineralisation. The process of maturation starts from the height of the tooth crown and progresses cervically.

A considerable amount of mineralisation continues to take place immediately after eruption. If the diet provided during this early post eruptive period is a noncariogenic one, these areas appear to mineralise and to become resistant to tooth decay. If the diet is one with a strong cariogenic potential, however, further mineralisation of these areas does not occur, and they appear to be particularly susceptible to teeth decay.
The continued increase of fluoride in surface enamel in human teeth in both low fluoride and optimal fluoride areas for the decade after tooth eruption may also be indicative of a maturing process and undoubtedly is related to the increased caries resistance with longer exposure to the fluids in the oral cavity (Sognnaes, R.F. (1965) Chairman's Opening Remarks, Caries Resistant Teeth, Ciba Foundation Symposium, 5).


The systemic influences causing enamel hypoplasia are in the majority of cases active during the first year of life. Therefore, the teeth most frequently affected are the permanent incisors, canines and first molars. The upper lateral incisor is sometimes found unaffected because its development starts later than that of the other teeth mentioned.

Ordinarily the healthy individual with a consistently well-balanced and varied diet has no need for supplementary use of protein concentrates or of vitamin and mineral preparations. With wise menu planning, good food preparation procedures and varied food consumption, routinely available foods through normal sources will provide adequate supplied of all the nutrients not only for the teeth but for good general health.

When there is evidence of a prolonged deficit, supplementation is in order. The level of supplementation should be proportional to the degree and the duration of the deficit based on evaluation of the patient's diets and clinical condition.
Once the teeth have erupted into the oral cavity the relationship of the food that we eat are dietary rather than nutritional. Studies begun decades ago indicated that fermentable carbohydrates retained on tooth surfaces were necessary for the initiation and progression of carious lesions.

Various nutritional deficiencies in experimental animals have been shown to adversely influence the integrity of the tissues of the periodontium (Bernier, J.L., Muhler, J.C., Improving dental practice through preventive measures.

In a variety of experimental situations, investigations have demonstrated in laboratory animals that congenital errors can be produced as a result of nutritional deficiencies at critical times during pregnancy. Adequate studies have indicated that the nutriture of the mother is related to the weight of the newborn infant and to the degree of development and mineralisation of the skeleton, including the teeth (Gaunt, W.E., Irving, J.T. (1940) J. Physiol. 99 : 18).

Nutrition assumes a role of added significance during pregnancy for it is the mother's responsibility to consume a well-balanced diet of appropriate proportions to provide the nutrients necessary for the optimum development of her unborn child and for her own needs as well. She can best meet the challenge if she is given adequate information about the special nutritional demands of pregnancy and is shown practical ways of incorporating the recommendations into her daily dietary pattern.

Since the nutritional requirements are rather high in pregnancy and since absorption is likely to be somewhat hampered during the first trimester due to possible nausea, it is often the practice to supplement the food intake of a pregnant woman by the use of vitamins and mineral capsules. Emphasis still needs to be given to consuming adequate amounts of protein through dietary sources.

Nutrition for the lactating mother is an important subject because the nutritional requirements are particularly high during this period. The nutrients that require emphasis (beyond the needs for pregnancy) during the period of lactation in addition to the needs for calories are
vitamins A, riboflavin, niacin, ascorbin acid, iodine and zinc.

Prenatal and early postnatal nutrition appear to be very critical for subsequent growth and development in the individual.

The basic material of the infant's diet is milk. While human infants can be reared on suitably modified milk from other mammals, human milk is unique and uniquely suited for human infants. Breastfeeding is desirable because it has both physiological and psychological values for both the child and the mother. The advantage of mother's milk over commercially prepared formulas is that the former is said to be more digestible. It is always the right temperature and it is more economical in time and energy. It contains natural anti-bodies that can protect the baby from infection.

As the infant's needs increase, a milk diet alone cannot supply all the necessary nutrients, particularly iron and vitamin C. Infact, supplements of vitamins C and D are usually started during the first month of life. Iron is a particularly important consideration because the hemopoietic demands of the infant increase rapidly after three months of age and they cannot be met by milk alone. The current practice is to offer a variety of specially prepared, semifluid baby foods which are rich in iron and other nutrients when the baby is three months old.

In communities in which the water supply is deficient in fluoride it is desirable to provide the child with a supplement of about 0.5 ppm fluoride per day.

Weaning by substituting the cup gradually for the bottle usually takes place between the fifth and ninth month and generally takes two to three months to accomplish. Introduction of solid food may be suggested by the pediatrician at any time from two to three months and the infant should be eating a large variety of foods by six months of age.

The child who may have been ravenous during his first year may develop a diminutive appetite soon after his first birthday. One of the chief reasons for this change in food patterns is that, although growth continues, the rate of growth becomes somewhat slower, consequently, nutritional demands do not increase at as fast a rate as they did during the first year. There
is reason then to be particularly careful about the foods being
eaten so that the total nutrient intake will be adequate.
Milk continues to be an important source of calcium and
phosphorous for bones and teeth formation.

The slower rate continues until he is about nine to ten years
old, and then the growth rate begins to pick up speed until it
reaches its climax during the midteens.

As well as producing food, the aim of school meal programmes
should be to introduce children to a wider variety of foods
than they will obtain at home and to inculcate social manners by
eating in a group.

'Growing bodies have the most innate heat; they therefore
require the most food, otherwise their bodies are wasted'.
Hippocrates: Aphorism.

In this thesis, it is my intention to point out the advantages
of breastfeeding. The foundations for good dental health
begin at birth and there is no better way than through breast-
feeding, but one must consider what dental caries is, and its
relationship to diet.

The next chapter therefore deals with dental caries, its
pathology, factors responsible, resistance and control.
Chapter three deals with diet and includes studies on foods
and their application to body needs. One can find the relation-
ship of diet to dental caries in chapter four. A special study
of human milk and advantages is found in chapter five.
2. **DENTAL CARIES.**

Caries is a complex disease in which there is interplay of a susceptible tooth, bacteria, and a dietary substrate. One of the outstanding features is the long time it takes to develop. This is true not only of the individual lesion of caries, but of the succession of lesions throughout the dentition as a whole, making caries a lifelong disease in most individuals who do not become edentulous at an early age.

There are four main types of caries attack by surfaces. Pit- and fissure caries is not only the easiest to detect, but it is also the first to appear and the easiest to explain in terms of tooth structure. Pits and fissures constitute the most susceptible surfaces in the mouth. Attack commonly occurs fairly early in life.

Proximal caries is the next to appear. It is seen in the deciduous teeth towards the end of their life span, and in the permanent teeth predominantly between the ages of 15 and 35, after which it becomes less frequent. (Dunning, J.M., (1941), A comparison of dental caries on the buccal and proximal surfaces of premolar teeth, J.Dent. Res. 20, 195-201).

Cervical caries is the third type of major importance. It occurs more or less uniformly through life, and can be related logically to the progressive changes in the free margin if the gingivae which increase susceptibility to plaque formation, and hence caries, with the advance of years.

The fourth type of caries is acute root caries in connection with the degenerative processes of old age.

Rampant dental caries is defined as "a suddenly appearing, widespread, rapidly burrowing type of caries, resulting in early involvement of the pulp and affecting those teeth or dental surfaces usually regarded as immune to ordinary decay".
In young people, caries has been seen to be higher in the female to an inconsequential extent, but some studies show slightly higher caries for males at certain ages but not at others.

There is widespread clinical impression that dental caries varies considerably from family to family, and that inheritance of a characteristic tooth structure, either good or poor, is common (Mansbridge, J.N., (1959), Heredity and dental caries. J. Dent. Res. 38, 337-347).

It is believed that emotional disturbances, particularly transitory anxiety states, influence the incidence of dental caries. Salivary changes have been shown to occur in connection with changes in mental health. Thus schizophrenics have been shown to have an increased rate of salivation, and salivary pH has been seen to rise under temporary emotional stress. (Burstone, M.S., (1946), The psychosomatic aspects of dental problems, J. Amer. Dent. Ass. 33, 862-1871, Hyams, I.B., (1948), Personality factors and dental caries, J. Canad. Dent. Ass. 14, 473-474).

So many detailed environmental factors are dependent in one way or another upon geography that it seems of most interest to consider major geographic variations in dental caries. Statistical analysis of data provided by a dental survey, by the U.S. Public Health Service, shows that incidence of caries, in school children, increases steadily throughout the United States, in both rural and urban populations, as the distance from the tropics increases. The interpretation of geographic variations depends on such factors like climate which includes sunshine, rainfall, humidity and temperature. Chemical composition of water supply and urbanization are other important factors.

The probable relation of sunlight intensity is supported by the presence of distinctly less caries in the northern-plains states, where sunlight is more plentiful than in other areas.
Temperature acts to vary the caloric requirements and water intake of human beings. Our knowledge of the etiology of caries, therefore, indicates a way in which this disease may be related to temperature.

Relative humidity is an indication of the dampness of a climate than is actual precipitation. Data from the Australian States showed a higher correlation (0.829) between caries and relative humidity than between caries and any other climatic factor.

Rainfall, leaching minerals from the soil and blocking sunlights is another factor to be considered.

Turning now to nonclimatic factors, fluoride is the one that one would first attempt to relate to geographical variations in dental caries. There seems to be some relation between fluoride maxima and distance from the seacoast. (Burkalow, A.V., (1946), Fluorine in United States water supplies, Geog.Rev. 36, 177-193). Deep-well water supply in a county may provide a high maximum correlation between fluoride and distance, from the seacoast, while the bulk of the county uses surface supplies which are almost always fluoride-free.

Total water hardness is usually measured in terms of calcium carbonate of Ockerse's data (Ockerse, T., (1949), Dental Caries, clinical and experimental investigations, Department of Health, Pretoria, Union of South Africa) for calcium carbonate are plotted on a map zoned in hundred of miles from the seacoast, a significant correlation coefficient of 0.462 will be obtained for the increase seen as one proceeds inland.

Hadjimarkos found marked increases in dental caries in areas where selenium was high both in water and foodstuffs and the only environmental factor which could not be ruled out was sunshine. (Hadjimarkos, D.M., (1966), Micronutrient elements in relation to dental caries, Borden's Rev. Nutr. Res. 27, No.3, 1-14).
Ludwig, Healy and Malthus (Ludwig, T.G., Healy, W.B. Malthus, R.S. (1962), Dental caries prevalence in specific soil areas at Napier and Hastings, Trans. Joint Mtg. Comm. IV and V Int.Soc.SoilSci, N.Zealand, p.895) noted marked differences in caries between the towns of Napier and Hastings, New Zealand, without any environmental factor other than soil to account for it. The soil of Napier, had higher pH, higher molybdenum, and the children there had lower caries. In Hadjimarkos's work on selenium, the most logical source of this trace element was the local soil.

Ferguson attributed the regional variations he found in caries to the greater frequency of large industrial cities. (Ferguson, R.A., (1935), Some Observations on Diet and Dental Disease, J.Amer.Dent. Ass. 22, pp.392-401).

Nutrition is an environmental factor. An example is that of the Eskimos in their original surroundings. The lack of plant food in the Eskimos' usual habitat makes it necessary to seek animal food and in turn receive a diet consisting largely of protein and fat. The results have been excellent for the Eskimo dentition, as the work of Waugh (Waugh, L.M., (1931), Discussion. Relationship between diet and dental caries, J.Dent.Res.U,pp.570-571) and others testify. Only when civilized transport facilities permit the introduction of foods other than native do the Eskimo teeth break down.

Good economic status and social pressure in the direction of good mouth appearance are both strong factors in creating demand for dental treatment. It is most pronounced and best documented among preschool and young primary children but extending, in one instance at least, up through high school age. In adults, there is a slight trend in the opposite direction (Stadt, Z.M. et al., (1967), Socio-economic status and dental caries experience of 3911 five-year-old natives of Contra Costa County, Cal.J.Publ. Hlth. Dent. 27, 2-6., Szwejda, L.F., (1960), Observed differences in total caries experience among white children of various socio-economic groups, Publ.Hlth.Dent.20, 59-66).
2.1 INCITING FACTORS IN DECAY.

Robertson (Robertson, W., (1939), A Practical Treatise on the Human Teeth, Ed.2.) published the results of critical dental observations which demonstrated that caries begins on certain well-defined "susceptible" surfaces of teeth and then progresses inward toward the pulp. Previously the idea was prevalent that caries arose from within the tooth, as an inflammatory process of systemic origin. Robertson's observations, which have been well substantiated by many investigators since, established that factors which are localized on the tooth surface are of primary importance in the caries process.

Since Robertson's time, the following observations would seem to be of more than historical significance, in that they have been confirmed and greatly extended by many investigators since they were first introduced.

1. The historical observations by Milles and Underwood in 1881 (Milles, W.T., Underwood, A.S. (1881), An Investigation Into The Effects Of Organisms Upon The Teeth and Aveolar Portions Of The Jaws, International Medical Congress, Transactions (7th), vol.3, pp.523-529) that microorganisms are always present in carious lesions, but not normally intact tooth substance.

2. The clinical and microscopical observations of J. Leon Williams (Williams, J.L. (1897) Studies of Enamel, Dental Cosmos. 39, 269-301) and later by G.V.Black (Black, G.V. (1908), Operative Dentistry, Vol.I Medico-Dental Publishing Co., Chicago.) that dense masses of microorganisms (plaques) grow on "caries susceptible" surfaces of teeth.

3. The laboratory observations of W.D. Miller, (Miller, W.D., (1890), The Micro-organisms of the Human Mouth, S.S. White Dent Mfg.Co, Philadelphia.) in 1891, that calcified tooth substance incubated in saliva-food mixtures is attached only
when carbohydrate foods are used and acid fermentation takes place.

4. The bacteriological observations of Kligler, (Kligler, I.J., (1915), A Biochemical Study and Differentiation of Oral Bacteria With Special Reference to Dental Caries, J.Allied Dent. Soc., 10 : 141-166, 282-330) in 1915, that certain types of microorganisms grow frequently on the teeth of individuals with active caries, but infrequently on the teeth of individuals who do not have active caries.

5. Epidemiological observations by Dean (Dean, H.T., (1947), Dental Caries and Fluorine, A.A.A.S. Washington D.C.) and also laboratory and animal experiment data by other investigators which show that an inverse relationship exists between fluoride and dental caries.

Most of the earlier studies on the effect of fluoride ingestion on the incidence of dental caries in rats were concerned with high levels of fluorides fed after weaning when tooth development is essentially complete (Hodge and Sognaes, 1946). Thus Miller(1938) supplemented a caries-producing diet with 250 ppm of fluorides and the drinking water with 4.2 ppm of fluorides for a period of 100 days after weaning. He observed a caries reduction of about 90%. In a subsequent study Arnold and McClure (1941) added 125 ppm of fluorides to the diet for 105 days after weaning and again observed a significant caries-inhibiting effect in this post developmental period.

Together these observations have been interpreted to indicate that the attack on tooth substance in caries is produced by acid fermentation of carbohydrate food material by certain microorganisms growing on or in teeth, and that resistance of teeth to this attack is increased by fluoride in the teeth.

Streptococcus mutans produce dextrans (glucan) and levans (fructan). When dietary carbohydrate is not available, the glucans and fructans are utilized for energy. These storage

Besides those agent factors, there are other factors that depict the multifactorial nature of dental caries, such as host factors and environmental factors.

Race or ethnic group has long been considered to be an important factor in the frequency of dental caries. Both Chinese and Negro populations have shown to have lower caries rates than corresponding white populations. (Mao, H.C., (1950), Some observations on the dental conditions in Peiping, China, J.Canad.Dent.Ass.16, 572-576, Klein, H., Palmer, C., (1941), On the epidemiology of dental caries, University of Pennsylvania Bicentennial Conference, U. of Penn. Press, Philadelphia.).

It used to be generally believed that dental caries was "essentially a disease of childhood," and that its incidence among adults was very low compared with its pre- and post-pubertal onslaught. (Hollander, F., Dunning, J.M., (1939), A study by age and sex of the incidence of dental caries in over 12,000 persons, J.Dent. Res. 18, 43-60). This could be due to the fact that the more susceptible tooth surfaces in the average mouth have already decayed and when the number of remaining attackable surfaces is significantly reduced. It could also be due to the gradual accumulation of fluorides in teeth with advancing age everywhere.
Carbohydrate dust and acid fumes are both known to be deleterious to the teeth, the one promoting caries and the other chemical erosion.

The oral environment is essential in the caries process, since caries can be absolutely stopped by drastic enough alterations in this environment. Coarse consistency of the diet, requiring special mastication, greatly increases resistance to caries, as shown by nutritional experiments with hard bread on orphans over a two-year period; and development of the dental arches is very favourably influenced by the ensuing increased functional stimulation. (Gustav, K., (1938), Dental Clinic, University of Bonn, Bonn, Germany). Food-retention and bacterial fermentation also play a part. (Hollander, F., (1938), Division of Laboratories, Mt.Sinai Hospital, New York City).

2.2. Acid Fermentation Theory.

It was towards the end of the last century that W.D. Miller first enunciated the acid fermentation theory or chemico-parasitic theory of dental caries (Miller, 1890). Although dental caries is primarily a microbial disease, however, there are many secondary factors involved and amongst these, dietary influences are perhaps the most important.

Micro-organisms of many kinds colonize on tooth surfaces which are not readily cleansed by the action of the mobile soft tissue structures of the mouth. These colonies coalesce to form plaque which comprise dense accumulations of bacteria bound together and firmly adherent to the tooth surface by means of extracellular polysaccharines, mainly of the glucan type. The microbial composition of plaque varies from individual to individual but, generally, young plaque comprises mainly of gram-positive, aerobic local forms, whereas older plaque is made up of mainly grammegative and anaerobic rod-shaped forms.
The micro-organisms undergo metabolic activity, the nature of which depends upon the substrate provided by the dietary intake. Many plaque organisms are capable of breaking down sugars to form organic acids capable of "attacking" enamel surfaces. Of the various mono and disaccharides in the diet, sucrose is of especial importance.

Plaque micro-organism enzyme systems appear to be capable of metabolizing sucrose in two ways. First, sucrose is broken down anaerobically to form lactic acid which accumulates and lowers the pH at the plaque-enamel interface sufficiently for the tooth surface to be attacked. Second, sucrose units can be polymerized to form extracellular polysaccharides, mainly of the glucan type. These polysaccharides serve to provide substrate material to the micro-organisms between food intake. In addition, they cause the plaque to thicken and so reduce plaque-permeability to salivary buffer systems. Thus the state of diffusion of salivary buffers is insufficient to neutralize acids accumulating at the plaque-tooth interface.

Caries begins as a sub-surface demineralization of the enamel and it is only when the lesion has extended considerably that collapse of the surface occurs and actual cavitation becomes identifiable. It has been estimated that a period of between 18 and 24 months may elapse between initiation of the lesion and its clinical recognition (Parfitt, 1956). In older individuals the process may be even slower. Indeed, Emslie (1963) reported that radiologically demonstrated interproximal lesions showed no evidence of progressive enlargement over a two-year period.
2.3. PROTECTIVE FACTORS AND IMMUNITY.

Resistance to dental caries is related to both extrinsic and intrinsic factors. As this disease starts on the surface of the enamel and extends secondarily to the deeper layer of this tissue and into the dentine, the structural resistance of teeth to caries must lie mainly in the enamel and its surface.

The gross outer morphology of the tooth crown plays an important role in the caries susceptibility of certain areas such as the fissures and the proximal surfaces, whereas the cuspal, incisal, buccal, lingual or palatal surfaces are relatively resistant to caries. But this resistance is related more to extrinsic factors such as food retention differences and plaque formation than to the enamel surface per se.

Bossert measured the depth and breadth of the mesio-occlusal pits in upper right first permanent molars and found that the prevalence of caries was higher in teeth with deep and narrow pits. Konig found that narrowness and steepness of fissure walls favoured the onset of caries in human premolars and rat molars. The influence of diet during development on the structure and resistance of the teeth was suggested by Lady Mellonby (1934).

The author further concluded, from the results of her experimental and clinical investigations extending over a period of twenty years and from those of others, in conjunction with the distribution of caries, that predisposition to the disease is largely controlled by the original structure of the teeth. There is definite association between tooth structure and susceptibility to caries in man. Using certain defined criteria for good (normal) and poor (hypoplastic) structure, based on evidence obtained from animal experiments rather than just from clinical impressions, the author found that extensive caries
occurred in only 7 percent of well-formed teeth with fairly severe hypoplasia. She did not find, on the other hand, that teeth with gross hypoplasia were more liable to become carious than average teeth without such gross defects.

This conclusion is supported by King who defined "hypoplasia" (gross) teeth as structurally defective, as evidenced clinically by obvious pitting, grooving and deficient enamel substance, but the abnormalities are usually very localized, other areas of the tooth often being of fairly good structure. In the dentin, also localization of defects, is apparent in microscopic preparations. A much more common type of hypoplasia is that in which defective structure of enamel is less evident to the naked eye, but detectable by running the probe over the surface of the tooth. In this second type, the abnormalities are not localized but are more or less evenly distributed over much of the enamel surface. Similarly with the dentin - under microscope, structural deficiencies are more diffuse. The importance of distinguishing between these two types of hypoplasia becomes obvious when their relationship to caries is considered. For example: in the rural districts of the Isle of Lewis, the incidence of caries and the Mellanby type of hypoplasia are relatively low, but in the urban population of the island the incidence and severity of both conditions are much greater.

Calteaux reported from Luxembourg that among 1853 children 9-14 years old showing no enamel hypoplasia, 9.18% were caries-free, whereas of 163 children showing hypoplasia only 3.68% were caries-free.

Enamel hypoplasia is mainly connected with rickets. The extensive studies of E and M. Mellanby have chiefly explored the relationship both in experimental studies in animals and by clinical studies in children. The connection between rickets, hypoplasia and caries has chiefly been studied in children many
years after the typical clinical picture of rickets has disappeared. The diagnosing of rickets may then be uncertain.

The most reliable studies on this subject are probably those of Hess and Abramson. These children have been observed from infancy up to 5 or 9 years of age. A slight increase in dental caries in the temporary teeth was compared with the non-rachitic. Another study by Eliot and co-workers of 451 children 5-12 years old showed hypoplastic teeth in 34% of the moderate or severe rachitic group, compared with 4% in the rickets-free group. Dental caries was observed in 63% of the rachitic children and 43% of the rickets-free children. The authors do not, however, take it as an absolute causal relationship between hypoplasia and caries, in spite of the fact that the hypoplastic teeth were more often carious than were the normal teeth.

Surveys were conducted to evaluate the impact of adverse conditions on the oral health of Aboriginals and to collect baseline data for an oral disease prevention programme aimed at primary school children in the Orana Region of Australia.

130,000 residents are distributed over an area of 346,000 sq.km., where the household water supplies are mostly fluoride deficient.

Dentist ratio population is 1:3000.

As the Aboriginal people were gradually forced to abandon their traditional way of life, their natural diet was replaced by processed foods, mostly of inferior value. Moreover, the new diet contains a large component of readily fermentable and highly cariogenic carbohydrate.

Aboriginal children had 67% higher prevalence of carious teeth and over 90% more carious tooth surfaces than Caucasians; on the average, three of their first four first permanent molars were decayed.
A large number of Aboriginal children appeared thwarted and emaciated and also had defectively formed teeth. This suggests preliminary exploration of possible associations between malnutrition, enamel hypoplasia and increased susceptibility to caries.

Developmental defects of teeth are the consequence of some local or systemic insult during tooth formation. It is recognised that malnutrition is a continued and widespread condition in the Aboriginal child population. The findings suggest that poor nutritional status during early childhood, with concomitantly low resistance to disease are related to defective tooth formation and, in turn, predispose to caries.

Thus, it seems that the high prevalence of dental caries in the Aboriginal population may be attributed in part to socio-economic factors which lead to endemic malnutrition and extend far beyond the variable which are generally recognised as important determinants of caries experience.

The type of structure is related to the diet during the development period. The dietary factors of chief importance to the calcified dental tissues are vitamins D and A, and mineral salts—especially calcium and phosphorus. These factors are essential not only to the offspring during post-natal development, but also to the mother during pregnancy and lactation, if well-calcified teeth and jaws are to be produced. In puppies, the quality and quantity of secondary dentin deposited in response to experimental attrition also depends on the calcifying properties of the diet. This result, in conjunction with the fact that secondary dentin in human teeth varies similarly in quantity and quality in response to attrition and caries, indicates that - even after eruption - diet, directly or indirectly, affects the resistance of teeth to disease.
It is now well established that surface enamel is normally more resistant to caries than subsurface enamel. It is more highly mineralized than underlying enamel and tends to accumulate certain trace elements with time, including fluoride, zinc, lead and iron. It is lower in carbon dioxide than underlying enamel and dissolves at a slower rate in acid. The surface also contains more organic material than subsurface enamel and is normally covered by a pellicle which is believed by some investigators to provide protection. Finally, the surface enamel contains less water than underlying enamel and the greater portion of this water is bound to the mineral phase. Diffusion of acid into the enamel should therefore be restricted particularly in surface enamel.

These factors undoubtedly add to caries resistance and must be partly responsible for the slower disintegration of surface enamel in initial carious lesions.

Available evidence suggests, that the caries-inhibiting effect from ingesting fluoridated water is related primarily to the fluoride deposited pre-eruptively and during the first years immediately following eruption. Since ingested fluoride is deposited in the enamel as fluorapatite, it is believed that the formation of this stable mineral is the principal mechanism by which fluoride inhibits caries.

In addition, extraneous agents present in the decalcifying fluid such as polycharged anions and organic polymers, may retard the rate of decalcification by forming diffusion barriers at the soluble solution interface.

Immunity may be defined as a state of resistance to the development of a disease. Immunity may be due to substances in the blood or in the tissues which assist in destroying the organisms. These substances are called antibodies, and the degree of
immunity to an infectious disease is somewhat dependent upon the concentration of these antibodies in the blood and in the tissues. Enamel being acellular, immunity is obtained indirectly, that is, the antibodies act on the micro organisms in the saliva and plaque.

Various groups have tested the use of vaccines based on streptococcus mutans in animals. In 1972 for example, William H. Bowen, then at the Royal College of Surgeons in London and now Chief of N.I.D.R.'s caries prevention and research branch, reported the results of a study in which he injected live S. mutans in five monkeys. After five years, these animals had developed no caries. On the other hand, five monkeys that did not receive the vaccine but were fed the same diet developed sixty four cavities.

The vaccines were injected near the salivary glands, so that it would produce secretory immunoglobulin A (IgA) antibody that could effectively combat S. mutans. Secretory IgA is present in saliva, as well as such other bodily secretions as tears and milk.

2.4. ALKALINITY AND CALCIUM.

The buffer pH of the saliva shows a marked acidity when saliva calcium is low. Calcium cannot leave the blood stream and appear in the saliva unless it can be mobilized, and pulled out of the body by a suitable acid radical like phosphorous. It has been suggested that saliva from caries-free individuals has higher values than the average for calcium and phosphorous concentrations. (Jenkins, N.G., (1966), The Physiology of Mouth, Blackwell Scientific Publications, Oxford, p.346).

The buffering power (that is, the power to resist changes of pH when acid or alkali are added) of a complex solution like saliva will vary at different pH values because different systems of buffers are effective over different parts of the pH range. Salivary buffers consist of bicarbonates and phosphates. This has been shown by measuring the buffering power of saliva before and after
shown by measuring the buffering power of saliva before and after the removal of bicarbonate by a current of carbon dioxide-free air at pH5, and before and after dialysis, which removed both phosphates and bicarbonate but which, of course, does not affect the proteins. Removal of the bicarbonate greatly reduced the buffer power and dialysis removed the whole of it. He concluded that bicarbonate is the most important buffer, that phosphates play some part. Buffers work by converting any highly ionized acid or alkali which is tending to alter the pH of a solution, into a more weakly ionized substance (that is, one which releases few hydrogen or hydroxyl ions). Bicarbonate release the weak carbonic acid when an acid is added and since this acid is rapidly decomposed into water and carbon dioxide which leaves the solution, the result is not the accumulation of a weaker acid (as with most buffers) but the complete removal of acid. Bicarbonates are therefore very effective buffers against acid.

Ericsson has studied the diurnal variation in buffering power of saliva in five subjects. He found that (1) it was high immediately on rising in the morning, but rapidly fell; (2) it increased about a quarter of an hour after meals but usually fell within half to one hour after meals; (3) there was an upward trend in the buffering power throughout the day until evening when it usually tended to fall.

2.5. **AMOUNT OF SALIVA.**

Saliva has a rinsing effect, removing some carbohydrate from around the teeth. Studies of the oral clearance of sugar indicate that subjects with more decayed, missing, or filled teeth had longer clearance times. (Alfano, M.C., (1979), Understanding the role of diet and nutrition in dental caries. In changing perspectives in nutrition and caries research. Monograph, American Academy of Pedodontics). High caries activity is also related to a longer time for salivary sugar concentration to fall to 0.1%. (Lanke, L.S., (1957), Influence on salivary sugar of

Decreased salivary flow due to atrophied glands because of radiation for Sjogren's disease or to blockage of the glands by calculi is associated with increased caries activity. A dramatic example of this is seen when one side of the mouth suffers from decreased salivation and more caries occur on that side. (Kleinberg, I., Kanapkar, J.A., and Craw, D., (1976), Effect of saliva and salivary factors on the metabolism of the mixed oral flora, Microb.Aspt.Dent. Caries vol.2, p.433-459).

2.6 SUCCESSFUL CONTROL OF CARIES.

Procedures necessary to prevent and control Dental Caries.

Tooth
1. Improve quality and structure.
2. Increase resistance of enamel surface.

Bacteria
3. Decrease dental plaque formation.
4. Interfere with bacterial enzyme formation.
5. Remove dental plaque mechanically.

Saliva
7. Increase ability to neutralize acid.
8. Increase remineralization capacity.
9. Decrease sucrose intake.

Food
10. Decrease frequency of eating.
11. Increase oral clearance:
   A. less sticky.
   B. more firm and detersive.
12. Improve food quality and food practices.
Freedom from caries occurs when antenatal nutrition and postnatal nutrition have been sufficient to promote normal development and calcification. An important complementary local factor is the use of foodstuffs, such as fruits which require mastication and have cleansing action. Increased susceptibility to caries occurs where nutrition has been deficient and use of soft foodstuffs (sugar or starchy), such as sweets and biscuits has been excessive. Detrimental effects of sugary substances are increased by conditions that favour stagnation around teeth, such as mouth-breathing and lack of oral hygiene. Where general nutrition has apparently been satisfactory, local factors are predominant in causation of caries. The combined influence of defective tooth structure and local use or sugar is shown by extensive caries of deciduous teeth in children who have a bad nutritional history and imperfect calcification, and who used baby 'comforters' dipped in sugar.

Endogeneous or systemic fluoride uptake by the tooth via the pulp and other sources of blood supply takes place for the most part while the enamel is mineralizing. Under these circumstances the fluoride ion becomes incorporated with the body of the enamel crystal. Fluoride can be ingested systemically either through the water supply or through food. The salivary fluoride level might be considered as being derived from systemic fluoride, but exerting a toxical effect on the tooth during the early post-eruptive period when the enamel surface can be altered by the chemistry of the oral environment.

Chemically there will be a substitution of the hydroxy ion in the hydroxyapatite by the fluoride ion to produce fluorapatite. When this happens, the fluorapatite is firmly fixed and the reaction is irreversible. It is most desirable to initiate fluoride-vitamin diet supplements as soon after birth as possible if there is no fluoride in the water supply.
Fluoride can be applied topically. It will provide primarily a calcium fluoride coating to the enamel, and secondarily some fluorapatite formation in the surface of the crystal.

'A clean tooth does not decay' defines a clean tooth as one which at all times is free of harmful microorganisms and/or free of media for the organisms to utilize. In two independent hamster studies, brushed controlled animals were compared with unbrushed control animals, and in both studies the brushed hamsters showed less dental caries than the unbrushed animals by 20 percent or more. The two experiments were carried out by Zander and Lazansky.

Mechanical cleansing can be classified into five methods:
A. Prophylaxis by dentist or hygienist.
B. Brushing by patient.
C. Mouth rinsing.
D. Use of dental floss or toothpicks and interdends to clean interproximal surfaces.
E. Incorporation of detergent foods in the diet.

Routine scaling and polishing of the teeth by dentists or hygienists at intervals of from three to six months are of positive value. More important than mechanical cleansing of the teeth in a prophylaxis is the careful polishing of roughened tooth surfaces and the correction of poor restorations already present. This may conceivably reduce the liability of retention of food particles and bacterial plaques and thus reduce dental caries.

If toothbrushing is to be effective, it must remove the food debris immediately after eating and should be done thoroughly. Experiments on three patients showed sharp reductions in numbers of bacteria after toothbrushing and mouth rinsing. Another possible benefit from brushing the teeth may be that it will make them smoother and prevent the collection of food debris and bacterial plaques. There is no doubt that the toothbrush with a suitable polishing agent in a dentifrice will polish enamel.
Value of a nonmedicated mouth rinse as a mechanical cleansing agent, particularly following toothbrushing, has been mentioned by several writers. Fosdick (Fosdick, L.S., (1942), J.A.D.A. 29, p.2132-2139) has suggested it as a simple and fairly unobjectionable method of cleansing the mouth immediately after eating.

Use of dental floss, toothpicks and interdens should be of value where food impaction occurs.

Crowley and Rickert found that after eating food of a detersive nature, there was a reduction of as much as 78% in the numbers of bacteria that could be removed. This finding was also made by Kliger, Wallace, and Knighton and suggests that mastication of food is the best way to reduce the bacterial count of the oral cavity. In fact, Volker had stated that eating of fibrous foods after meals is to be recommended as a method of caries control.

Normal procedures now is to use a therapeutic agent with toothbrushing and mouth washes.
3. **FOOD AND ITS APPLICATION TO BODY NEEDS.**

It is important to know why a particular food is placed in the diet and what changes in body chemistry that food is expected to accomplish.

We must know whether a food is difficult or easy of assimilation. We must know something of its proteins, starch and fat content as well as its mineral and vitamin values. We must know something of the physiological effects of such food. Will it tend to promote dental caries or pyorrhea or cause an allergy, etc? All these facts and more must be known by the one who attempts to regulate a diet or he may correct one condition and aggravate another.

A suitable diet is not just a question of so much protein, starch, fat, minerals and vitamins. Food must come to a species in the particular form to which the species is accustomed.

Primitive man was a hunter and killer of game. Before the period of agriculture only a small amount of vegetable substance was consumed and that in the form of wild, edible roots, berries and leaves.

The amount of protein should vary with the nature of man's work. The more laborious the occupation, the more protein is required. Protein can be obtained from meat, fish or vegetable. Most people have been accustomed to the use of fish and little meat for many centuries and seem to thrive better in that programme. Most races from N.Europe are accustomed to a high fish diet and seem to do better on it than on a high meat regimen.

It is wise to distribute the protein over the day and it is possible to have some protein at each meal. This usually prevents a person getting hungry between meals. About $3\frac{1}{2}$ ozs. or 100 gms. of high quality protein per day is necessary to maintain muscle tone, body vigor and the antibodies against infection. It is usually safer to have animal protein too high than too low.
A normal individual does not need free sugar. All refined carbohydrates either sugar or starch should be practically out of the diets. The incidence of dental caries should be greatly reduced if only the 100% whole grain or cereal foods are used and all free or concentrated sugar and sweets eliminated.

Babies have no or fewer teeth and less versatile digestions than adults. Therefore the food must be fluid and relatively dilute.

The practice of infant feeding is based on knowledge of diets whose efficiency has been established by observing other infants and their diets.

3.1 REQUIREMENTS

During pregnancy additional energy is needed for building new tissues like the placenta and foetus, for the increased work load on the mother and for the increased metabolic rate.

Total protein intake should be increased approximately two-thirds above normal. The protein foods should be consumed at intervals throughout the day rather than at one meal.

She will need to increase her consumption of iron. Care should be taken to use iodized salt during pregnancy to ensure an adequate supply of this mineral. Lack will lead to cretinism or severe mental retardation in the foetus. Other minerals are zinc and magnesium.

Vitamin needs are also greater during pregnancy. Vitamins A, E, thiamin, riboflavin, niacin, folacin, vitamin B₆, Vitamin B₁₂ and absorbic acid all need to be included in the diet in larger amounts than they did prior to conception. The increased need for vitamin D is doubtless the result of the need for bone-building materials for the foetus; the presence of vitamin D is essential for the optimum absorption and utilization of calcium and phosphorous.
Ascorbic acid is necessary for collagen formation, i.e. for the development of connective tissue in the body. Such tissue formation certainly must take place in the development of the foetus. The increased need for the B vitamins (thiamin, riboflavin and niacin) is related to the developmental needs of the foetus, but is also necessitated by the slight increase in the amount of food that must be metabolized by the body. The increased need for folacin and vitamin B₁₂ is to reduce the likelihood of developmental megaloblastic anaemia in the foetus. Vitamin B₆ is needed for the tissue development associated with pregnancy to facilitate healthy development of skin and proper functioning of eyes.

The caloric intake of the lactating woman needs to be increased. Recommended intake of folacin decreases, but is still above the pre-gestation level. The recommended level of protein drops slightly from that for pregnancy, but still is much greater than before gestation. Iron intake returns to normal. Vitamins D, E, thiamine, B₆, B₁₂, calcium, phosphorous and magnesium remain the same as for pregnancy. A quart of milk daily will supply the amount of vitamin D that is necessary.

During infancy a baby's nutritional needs are high. The infant eats proportionally more during his first six months of life than he does in any other six months during the first two years.

With breast-fed babies the milk taken increases little after two months and not at all after four months as the child grows older. Infants decide their own individual needs. During the first few days, the supply of breast milk does not provide as much energy and the infant lives on glycogen stores for a few hours and then mainly on fat deposits.

About 10 K cal./kg. are not used and are excreted in the faeces. A similar amount is used up as fuel for active movements, which increases as the baby gets older. The basal requirements which
are used in maintaining vital processes, comprise about half
the total. The amount devoted to growth is naturally
greatest when this is most rapid, and accordingly in the
young baby, growth takes half the total intake and in the
year-old child only a quarter.

Protein can be used to produce energy or it can be converted
to fat and stored as such; but in infancy it is almost
entirely used for growth.

Carbohydrate is almost the sole source of energy for the
healthy baby on a normal diet. Breast-fed babies take about
12g. carbohydrate per kilogram body weight per day;
artificial feeding often entails a higher intake. After the
age of one year, the need for carbohydrate is somewhat lower
in relation to body weight but until adolescence ends, it
remains at about 10g. per kilogram.

Obesity is too common in children and usually has been present
at one year. Adding sugar to food increases its energy
content without increasing its bulk. It is unwise to train
infants and children to expect foods to be sweet.

Babies store fat which becomes an emergency food - store as
well as insulating them from cold, but normally they use little
of it as a source of energy. Fat in food delays the emptying
time of the stomach, but the amounts present in milk are too
small to have this effect.

It is difficult to say how much fat infants need. Breast-fed
children take two to three times as much energy in fat as in
protein. Newborn infants absorb perhaps 80% of the fat they
swallow, but the figure soon rises to about 95%. The fat of
breast-milk is absorbed most easily and the ceiling for this
is unknown. For cows' milk the critical level seems to be
between three and four gram per kilogram body weight. If the
fat intake is above the critical level, less and less calcium is absorbed, as more and more milk is taken by mouth because the saturated fatty acids which cannot be absorbed remain in the bowel and, combining with the calcium, prevent it too from being absorbed.

Unsaturated fatty acids (linoleic and arachidonic) are essential for infants (B.M.J., 1963). On a diet grossly defective in these, the growth of infants eventually slows down and the skin becomes dry, scaly and thickened, probably because of inability to synthesise highly unsaturated fatty acids. There is more linoleic acid in human than in cows' milk. Also in breast milk only 48% of the fat, as compared with 60-70% in cows' milk is in the form of saturated fatty acids, which are poorly absorbed by babies.

After the first few days of life the infant's requirements of water is usually well satisfied by a fluid intake of 150ml per kilogram body weight (2½ fl.oz/lb.). In very hot weather or in illness more may be needed.

The fluid needs of the infant are affected by the amounts of salts he takes. Breastmilk has a low content of salt and there is no danger of accumulation of salt in the tissues. Cows' milk has a considerably higher content of salts nearly four times that of human milk.

The mineral needs of the infant are not fully known, but both mother's and cows' milk appear to supply enough of all except iron and possibly copper which are needed for blood formation. The deficiency of iron does not matter at first, because in the last month of pregnancy, much iron is stored in the liver for use after birth. After six months when this store is almost exhausted, iron-containing foods have commonly entered the diet, but a child being fed almost entirely cows' milk and highly refined cereal may become anaemic unless extra iron is
Infants, children, expectant and breast-feeding mothers have a greater need for calcium than have adults in general - 600 mg. of calcium, the amount present in 300 ml. for an infant. Babies bottle-fed on unmodified cows' milk have lower calcium and higher phosphorous levels than do breast-fed babies. If too little or too much phosphorous is available in proportion to calcium, further supplies of either substance are withdrawn from the bones.

Phosphate is essential in many of the metabolic processes of the body, notably the release of energy from food by the mediation of adenosine triphosphate. There is much more phosphate in cows' milk than in human milk. A high blood-phosphate acts on the parathyroid glands and induces a relative hypoparathyroidism and hence a low blood-level of calcium. The small infant given cows' milk is more liable to develop hypocalcaemic tetany.

Potassium, magnesium, sodium chloride and sulphur are also needed elements. Cows' milk contain an amount of sodium-chloride. The infant may become oedematous or, if there is a low intake of fluid, excess salt intake or excess water loss by sweating then the level of sodium in body tissues will rise. This hypernatraemia can cause serious injury to the brain.

Very small amounts of iodine, fluorine, cobalt, zinc and manganese are essential for metabolism. Strontium falls in breast-fed infants but rises in bottle-fed infants as cows' milk contains six times as much as breast-milk. Strontium can be radioactive and an unduly high level in the body can be undesirable.
Milk contains only small quantities of vitamins, but some of the B group and vitamin K are formed in the intestine by bacteria. In the past certain proprietary dried milk powders were deficient in pyridoxine because it was removed in the manufacturing process.

It is considered necessary to give, from the age of one month, supplements containing respectively the fat-soluble vitamin D and the water-soluble vitamin C. Breast-milk contains 2-6 mg. vitamin C/100 ml. (0.5 - 2mg/fl.oz.). Breast-fed babies almost never get scurvy.

There is less vitamin C in cows' milk and as ascorbic acid is destroyed by light heat or oxidizing agents, there is very little in the milk that finally reaches bottle-fed babies.

Breast-fed babies are not immune to rickets. Human milk contains only 0.4 - 10 units vitamin D per 100 ml. and cows' milk contains 0.3 - 4 units per 100 ml. Whether breast-fed or bottle-fed, babies need a total intake of 400 units vitamin D daily.

Growth rate slows down after the first year. The child's appetite will diminish. Particular care must be taken about the foods being eaten so the total nutrient intake will be adequate. Milk should continue to be a part of his diet. Meat and fish should be given. Also fruit and vegetable high in vitamins A and C.

Fluoride should be available from birth throughout life. The most practical way to provide fluoride is to fluoridate the City water supply (or use fluoride bottled water).

To promote good dental health and to avoid excessive weight gain, it is wise to reduce markedly the amounts of candy in diet and increase the consumption of milk, fruits and vegetables.
3.2 FOOD VALUE OF CEREALS AND POTATOES.

The distribution of nutrients in a cereal grain is as follows:- The outer bran layer contains cellulose, some B complex vitamins and iron. The outer aspect of the inner portion of the cereal grain, or endosperm, has some protein, phytic acid and niacin; the inner aspect contains mostly starch and some protein. At the lower end of the grain is the germ, which is the heart or embryo of the wheat. It is rich in protein, fat carbohydrate and particularly B vitamins, fat soluble vitamin E and minerals, especially iron. These are all grain products, which when they are refined, are characterized by their high content of starch (70 - 80%) and moderate content of protein (7.5 - 14%). The bread, flour products for cereals manufactured from these refined grain products are required by law to be enriched with thiamine, riboflavin, niacin, iron and sometimes with calcium and vitamin D. Consequently, unrefined cereal grain products are nutritious in that they provide many nutrients as well as rich source of carbohydrate for energy. Similarly with rice which is the staple cereal food of Orientals.

Potatoes yield more calories per acre than any cereal crop. They contain 75 - 80% water and yield 70 - 90 K cal/100 gm., most of which is from the starch part of the potatoes. Potatoes contain a little protein, minerals and B complex vitamins. They are not rich in ascorbic acid, but if eaten in large quantities can contribute a significant amount of ascorbic acid to the diet.

3.3 FOOD VALUE OF MEAT AND FISH.

Animal foods are the best source of protein of high biological value. Because meat consists not only of muscle and connective tissue but also of fat, it is also an important source of energy. Meat is rich in phosphorous, niacin and riboflavin. Red muscle meat is a good source of iron. Pork is especially rich in
thiamine.

The organ meats like liver, kidney and spleen have significant nutritional value; for example, liver contains more vitamins and more iron than even muscle meat.

Fish supplies 5 to 10 percent of the animal protein consumed by some humans. On the other hand, they may serve as the major source of animal protein among a few population groups like islanders. Fish contains about 18 per cent complete well balanced protein that is almost entirely digestible. Depending on the type of fish, the fat content can vary from 1 per cent in cod and haddock to 20 per cent in salmon and mackerel. There are some fish that have large amounts of unsaturated fatty acids which can reduce, or at least not increase the level of cholesterol in the blood stream.

The vitamin content of fish varies. An average serving of salmon or mackerel, for example, will provide 10 per cent of the daily requirement of vitamins A and D, 10 per cent of the thiamine, 15 per cent of the riboflavin, and 50 per cent of the niacin.

The minerals found in the edible part of most fish are magnesium, phosphorous, iron, copper and iodine. The softened edible bones in canned fish are good sources of calcium and phosphorous. A serving of six average oysters supplies more than the minimum daily need of iron and copper.

3.4 **FATS. MORE THAN AN ENERGY FOOD.**

Fats are found in such foods as meat, butter, margarine, salad dressing, and oils. Other foods containing fats are olives, avocados, and nuts. Fats serve two major functions in the body; they produce 9 K cal./gm of energy and they cushion vital organs against shock. The subcutaneous layer of fat insulates the
body against heat loss in cold weather. They provide fatty acids which are indispensable for health, particularly normal growth and skin health. They are carriers and facilitate absorption of the fat soluble vitamins A, D, E and K.

Generally animal fats contain a higher percentage of saturated fatty acids and, accordingly, a higher melting point; but there are exceptions: poultry and fish fat are highly unsaturated. Vegetable fats contain a greater percentage of polyunsaturated fatty acids and therefore have a lower melting point than do animal fats.

The difference in consistency at room temperature of the different fats is due to the different types of fatty acids that go to make up the fat. Saturated fats which are composed of fatty acids that cannot take up any more hydrogen and have only single bonds between carbon atoms in the chain. Unsaturated fatty acids have one or several double bonds between C and can add on more hydrogen than the double bonds are reduced to single bonds. In short, these fatty acids are saturated with respect to hydrogen as shown below.

\[
\begin{align*}
&\text{H} &\text{C} &\text{H} \\
&\text{H} &\text{C} &\text{H} \\
&\text{H} &\text{C} &\text{H} \\
&\text{H} &\text{C} &\text{H} \\
&\text{HOC} = 0
\end{align*}
\]

\[
\begin{align*}
&\text{Saturated Fatty Acid.} \\
&\text{H} &\text{C} &\text{H} \\
&\text{HOC} = 0
\end{align*}
\]

Unsaturated Fatty Acid.
When the term essential is used in relation to fatty acids, it refers to the ability of the fatty acid to prevent deficiency symptoms that occur in the absence of the fatty acid and to the inability of the body to synthesize the fatty acid when not supplied by the diet. Linoleic acid, linolenic acid, and arachidonic acid were considered essential fatty acids. Later, it was found that arachidonic acid could be synthesized from linoleic acid with the aid of vitamin B₆ and panthothenic acid.

3.5 Food Value of Raw Vegetables and Fruit.

Most vegetables have a high vitamin and mineral content. Ascorbic acid, the B vitamins and A are the chief vitamins, calcium and iron are the chief minerals. If vegetables are overcooked, the vitamins will be lost. Therefore it is better to eat vegetables raw. Raw carrots and celery are fibrous and can exert a detergent action during mastication that is valuable in preventing caries. The increase in salivary flow which these foods stimulate should help to flush away or to neutralize undesirable material adjacent to and within the dental plaque, and in addition should exert a cleansing effect on smooth surfaces by direct mechanical friction.

The most popular fruit grown is the apple. Second in popularity are the citrus fruits - oranges, lemons, limes and grapefruit.

Besides ascorbic acid in which citrus fruit are especially rich, fruits are good sources of cellulose, which is necessary for normal peristaltic activity. Fructose and glucose are found in equal proportions in most fruits. The sourness of unripe fruits is due to organic acids like citric, malic and tartaric acid. The mineral content of citrus fruits and peaches yields an alkaline ash, whereas plums rhubarb and cranberries contain benzoic acid and contribute to an acid reaction.
Apples, although perhaps without effect on plaque removal directly, have been shown to remove food particles and accelerate the clearance of sugar from the mouth. They could also have a much more significant role in reducing caries if they could be used to blunt the appetite for sweets and confectionary, as also could all the other fibrous foods.

3.6  **TABLE SALT.**

The ingestion of salt in addition to what is normally consumed with the meal is not only unnecessary, but excessive sodium chloride can aggravate hypertension.

In countries where salt intake is high, there is a high rate of hypertension, stroke and coronary heart disease. Communities that eat little salt do not have elevated blood pressure or significant levels of stroke or heart disease. Studies have also shown that mildly elevated blood pressure can be reduced to normal by moderate restriction of salt intake.

However, if there is continuous excessive sweating day after day and the water intake exceeds four quarts per day, then a gram of salt may be taken with each additional quart. Otherwise 5 gm. a day is sufficient.

3.7  **FOOD TO RESTRICT.**

In order to reduce the consumption of sugar, one must:-

i) reduce the amount of sugar added to foods at the table that is in beverages, on cereals etc.

ii) reduce the intake of foods with a high content of sugar - soft drinks, confectionary, jams, syrups, presweetened cereals, cordials, cakes, biscuits, pastries and fruits canned in heavy syrup;
iii) eat sparingly those foods to which large amounts of salt have been added - salted meats and fish, etc.

3.7.1. Study of Different Sugars.

Sweetness is an important sensation to humans. Although the relative importance of taste or of calories in determining sucrose ingestion may be difficult to quantify, it is certainly clear that the enormous consumption of sucrose is largely because people like its sweet taste.

There is scarcely any area of food habits today that does not in some way involve sweetness. Our use of sugar and sweetness has increased and with the diversity of natural and fabricated products available commercially, the use of sweet-tasting additives promises to increase even more.

Most of the sugar is produced in North and Central America. Then follows, in terms of production volume, Asia, Eastern Europe, Western Europe, S.America, Africa and Oceania. The production of the different regions does not correspond to their actual consumption. Thus, production exceeds consumption in North and Central America, S.America, Africa and Oceania. The surplus is exported to Asia and to Western and Eastern Europe. At the beginning of the twentieth century, about the same amount of cane sugar and of beet sugar was produced. Thereafter, the production of cane sugar has risen and was 58% of the total sugar production in the year 1970.

The sugars which occur in foods are either natural constituents of the food, are generated during processing, or they are intentionally added. In either case, many different sugars are either monosaccharides or simple sugars. Monosaccharides cannot be hydrolyzed to a simpler form. Trioses, tetroses, pentoses, hexoses, heptoses are monosaccharides consisting of
two, three, four, five, six and seven carbon atoms respectively. They are named according to the number of carbon atoms they possess, with the suffix xose attached. The hexoses, glucose, galactose, and fructose have the greatest physiological importance (Table below).

<table>
<thead>
<tr>
<th>Table 1</th>
<th>The Four Hexoses.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sources</td>
<td>Physiological role</td>
</tr>
<tr>
<td>Glucose (dextrose)</td>
<td>Fruit juices, hydrolysis of starch, cane sugar, maltose, and lactose.</td>
</tr>
<tr>
<td>Fructose (levulose)</td>
<td>Fruit juices, honey; hydrolysis of sucrose.</td>
</tr>
<tr>
<td>Galactose</td>
<td>Hydrolysis of lactose</td>
</tr>
<tr>
<td>Mannose</td>
<td>Derived from gums; not found free in foods.</td>
</tr>
</tbody>
</table>

Adapted from: Shallenberger, R.S. - Occurrence of Various Sugars in Foods, Sugars in Nutrition.

Alcohol derivatives of the monosaccharides glucose and mannose have been used as sweeteners. The absorption rate of these compounds in the intestine is low, preventing little of the compound from being converted back to glucose in the body.

Disaccharides are sugars containing two monosaccharides. The three major disaccharides and their monosaccharide units are as follows:

Sucrose = Glucose + Fructose.
Lactose = Glucose + Galactose.
Maltose = Glucose + Glucose.
In each disaccharide, glucose is at least one of the monosaccharide units. Sucrose is found in cane and beet sugars, sorghum, maple syrup, molasses, pineapples, and carrot roots. In the highly refined pure carbohydrates form, sucrose is white table sugar (containing only calories). Lactose or milk sugar is found in milk of mammals. It is the only carbohydrate of animal origin that has nutritional significance. Its function is to supply carbohydrate to the nursing young. Compared to sucrose in sweetness, lactose has only one sixth the sweetening power. Maltose is an intermediary product in the hydrolysis of starch. It is present in barley and germinating cereals. The malt flavour of beer is characteristic of maltose.

Polysaccharides are long chains of repeating monosaccharides of the polysaccharides, starch, glycogen and cellulose are important to humans, starch being the most important.

Amylose and amylopectin are two types of starch. Plants manufacture starches from simple sugars and store them in fruits, in roots (potatoes), and in seeds (rice, wheat, corn, millet, rye, peas, nuts). Glycogen is a storage product of glucose in the liver and muscle tissue of animals. It is available for conversion to energy for muscular activity, or it may provide blood glucose when converted in the liver. Cellulose is a polysaccharide synthesized by the plant for stems, leaves, grain coverings, and hulls. This type of polysaccharide is not digestible by humans but is an important source of bulk or fibre in the diet, aiding in the stimulation of peristalsis and the elimination of waste.

 Sugars and sugar dehydration products are generated during the production of food substances and during the processing and storage of many foods. These are generally described as reversion products and sugar anyhydrides.
The sugars intentionally added to foods for sweetening, texturising preservation, and other purposes are sucrose (cane or beet-sugar) and dextrose (\(-D\)-glucose). The sugars intentionally added to food for various purposes are essentially those which occur naturally in the plant kingdom and in foods.

Further research is needed on reactions of sugars in foods and the occurrence and distribution of their reaction products. This is particularly true for foods to which sugars have been intentionally added.

In many countries, sugar - sucrose, is an essential part of the dietary content. Its nutritional and medical significance has been the subject of exhaustive discussions during recent years. The reason for this has been, among other things, the demonstration of the connection between sugar and dental caries and the decrease in essential nutrients in the diet, which occurs when sugar forms an increasing part of the energy supply.

3.8 DIET SHEET WITH CLASSIFIED FOOD LISTS.

The following is an average diet programme based on the amount and type of food found necessary to secure normal chemical levels in individuals free from serious pathology. An average diet schedule can be successful only when assimilation and elimination are average. The following diet sheet will not meet the requirements necessary to maintain a normal chemistry where metabolism is very far removed from average. The food schedule shown makes a good starting point in diet regulation.
Food Schedule.

Protein.

Meat - 6-12 times/week - beef, lamb, poultry, ham, rabbit (which includes each week one meal of liver, kidney, heart or chicken giblets).
Restrict - fresh pork, veal and bacon.

Eggs - 7 eggs/week - either as a plain egg or in the cooking.
Restrict - fried eggs and omelets.

Cheese is desirable.

Fish - 1-12 times per week - fresh fish, clams or oysters.
Restrict - shrimp, crab and lobster.

Carbohydrate.

Cereals - one medium helping of breakfast cereal (whole grain cereals only)

Bread - 3-5 slices of whole grain bread per day (wheat or corn)
Restrict - Toasted bread as the amino acid is lost.

Potatoes - white or sweet, usually once per day (baked, mashed or creamed). Avoid all forms of fried potatoes.

Legumes - peas about 3 times/day. Baked beans - not over once per week.

Sweets - consumption of sugar and candy should be kept very low.

Dried fruits - Figs, raisins and dates in cooking or salads only.
Fats.

Butter - very much to be desired. If substitutes are used, be sure they contain vitamins A and D. As a rule the amount should be low.

Vegetables.

Salads - 1-2 raw salads/day (lettuce, endive, celery, carrots, avocados, etc.). Tomatoes should be kept low. Cooked vegetables - 1-2 non starch cooked vegetables per day (spinach, carrots, asparagus, string beans, turnips, etc.). As a general rule, never cook any vegetables that can be eaten raw.

Dessert.

Fruit - favour the raw fruit over cooked or canned fruit. Acid fruits should be somewhat restricted - oranges, grapefruit, pineapple, grapes and berries. The sub-acid fruits can be used more liberally, as pears, apples, bananas, figs, melons, cherries, peaches and apricots.

Puddings - vary with custards, tapioca, sago, cornstarch, pumpkin, rice and bread puddings. Ice cream - not over twice a week.

Nuts - almonds, walnuts, pecans and Brazil nuts in cooking or salads only.

Gelatins - not over once per week.
Liquid.

Soups - in moderation.
Restrict - tomato soup as it is acidic.

Milk - low fat whole milk or buttermilk - a quart per day
(use raw milk if safe, not homogenized milk).

Juices - do not exceed 2 ozs. of fruit or vegetable juice per
day. As a rule the use of juice is not desirable. Use whole
raw fruit instead.

Salt.

As a rule keep table salt low.

**Acid Foods**
All grain foods.
All meat, fish and eggs.
Coffee, tea, chocolate, cocoa, cereal, coffee.
Most soft drinks.
Gelatine.
All foods containing high benzoic and oxalic acid - prunes, plums, cranberries, rhubarb and sour cherries.
Acid starch - crackers, macaroni, noodles, rice and pastry.
Tomato.

**Alkaline Foods**
All fruits and vegetables except tomato.
Alkaline starch - potatoes.
Peas
Beans (baked, soya).
Alkaline drinks - whole milks, skim milk, buttermilk, vegetable juice except tomato.
Sugar.
Fats and oils.
Tapioca.
Sago.
Nuts.
The following page shows a recommended daily dietary allowance for maintenance of nutrition of healthy children in the United States. It gives us some idea of the proportion of food to weight.
|         | 0.1   | 0.2   | 0.3   | 0.4   | 0.5   | 0.6   | 0.7   | 0.8   | 0.9   | 1.0   | 1.1   | 1.2   | 1.3   | 1.4   | 1.5   | 1.6   | 1.7   | 1.8   | 1.9   | 2.0   | 2.1   |
|---------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|
| 18      | 166   | 180   | 195   | 210   | 225   | 240   | 250   | 265   | 280   | 295   | 310   | 320   | 330   | 340   | 350   | 360   | 370   | 380   | 390   | 400   |
| 16      | 165   | 180   | 195   | 210   | 225   | 240   | 250   | 265   | 280   | 295   | 310   | 320   | 330   | 340   | 350   | 360   | 370   | 380   | 390   | 400   |
| 14      | 165   | 180   | 195   | 210   | 225   | 240   | 250   | 265   | 280   | 295   | 310   | 320   | 330   | 340   | 350   | 360   | 370   | 380   | 390   | 400   |
| 12      | 165   | 180   | 195   | 210   | 225   | 240   | 250   | 265   | 280   | 295   | 310   | 320   | 330   | 340   | 350   | 360   | 370   | 380   | 390   | 400   |
| 10      | 165   | 180   | 195   | 210   | 225   | 240   | 250   | 265   | 280   | 295   | 310   | 320   | 330   | 340   | 350   | 360   | 370   | 380   | 390   | 400   |
| 8       | 165   | 180   | 195   | 210   | 225   | 240   | 250   | 265   | 280   | 295   | 310   | 320   | 330   | 340   | 350   | 360   | 370   | 380   | 390   | 400   |
| 6       | 165   | 180   | 195   | 210   | 225   | 240   | 250   | 265   | 280   | 295   | 310   | 320   | 330   | 340   | 350   | 360   | 370   | 380   | 390   | 400   |
| 4       | 165   | 180   | 195   | 210   | 225   | 240   | 250   | 265   | 280   | 295   | 310   | 320   | 330   | 340   | 350   | 360   | 370   | 380   | 390   | 400   |
| 2       | 165   | 180   | 195   | 210   | 225   | 240   | 250   | 265   | 280   | 295   | 310   | 320   | 330   | 340   | 350   | 360   | 370   | 380   | 390   | 400   |
|         | 165   | 180   | 195   | 210   | 225   | 240   | 250   | 265   | 280   | 295   | 310   | 320   | 330   | 340   | 350   | 360   | 370   | 380   | 390   | 400   |

Table 2

Recommended Daily Dietary Allowances, designed for the maintenance of good nutrition and practically all health.
4. DIET AND DENTAL CARIES

Certain components of the diet have a marked effect on the erupted tooth and, as such, play a significant role in the aetiology of dental caries. The particular dietary components concerned are those carbohydrates capable of being fermented to acid by the bacterial aggregates localized on the sheltered surfaces of the teeth. Dental caries, which is characteristic of civilized man, and which there is a clearly established, direct relation between its occurrence and living standards throughout the world, is certainly the most common dental disease affecting those in the Western world under the age of twenty five.

The early observed fact that teeth decay at precisely those locations where food adheres and where various impactions occur has given rise, since early times, to the idea that food on the outside of the tooth causes caries. We are indebted to the classical experiments of Miller carried out towards the end of the last century for giving the first scientifically acceptable description of the carious process, when he showed that teeth could be decalcified during incubation with saliva and bread. It was also first realized at about this time that it was only the bacteria occurring locally within these impactions (glutinous microbic plaque) that were responsible for the destruction of the tooth immediately adjacent to them and not those occurring within the oral environment in general.

The initiation of the carious lesion is a surface phenomenon occurring at the interface between the enamel surface and the base of the dental plaque. Although food debris can often be present in these sites, it is not the debris itself that has any direct role in the carious process, but only those components that are capable of being released from it in a soluble form and are able to diffuse into the plaque and be metabolized by the bacteria. The organisms in the plaque can convert fermentable carbohydrate to organic acids, and it is these acids that, by lowering the pH locally, cause the initial breach and subsequent dissolution of the mineralized enamel.
There are three major factors required simultaneously for the production of caries: (i) a tooth surface, (ii) a dental plaque, and (iii) substrates for use by the plaque micro-organisms.

The factors controlling the onset of the disease are primarily of environmental origin, but local circumstances may be influenced by the physical and chemical nature of the tooth surface and the anatomical arrangement of the teeth in the jaw.

The two major sources of carbohydrate in contemporary western diets are starches and sucrose in various forms. The summation of the composite information that is now available from human epidemiological studies, together with animal and laboratory experimentation of various dietary components, can justifiably incriminate sucrose as the "arch criminal" of dental caries (figure 1). The starches of high molecular weight are not immediately available substrates for microorganisms; it is necessary that they be hydrolysed to smaller units before they can enter plaque. This can be done, but it takes time. The small sucrose molecule on the other hand, provides an immediate source of substrate for the plaque bacteria.

It was found that the caries incidence among the South African Bantu was higher among town-dwellers living on westernized food than among similar quarters living in their native kraals. It was suggested that the refinement of carbohydrate foods removed protective factors from them, and laboratory experiments carried out on the dissolution of whole teeth incubated in saliva confirmed this view.

Experiments carried out in Vipeholm in Sweden showed that there was a direct correlation between increased caries and the consumption of sugar between meals. Caries activity was greatest when sugar with a strong tendency to be retained in the mouth was eaten between meals frequently. When sugar was consumed in solution at meals, in amounts twice the average consumption no increase in dental caries was observed.
Figure I. CARIOGENICITY OF DIFFERENT CARBOHYDRATES.

Adapted from: NIZEI, A.E., (1972), Nutrition in Preventive Dentistry.
Gustafsson's and Lundquist's studies above proved several points:
(1) sugar exerts its caries-promoting effect locally in the mouth;
(2) starchy foods like bread are not so cariogenic as sucrose;
(3) the amount of sugar is not of paramount importance;
(4) the form and composition of the sweets is critical (retentive worse than non-retentive); and (5) the frequency of usage is a prime factor in caries activity.

Hence the adoption of the practice of giving "comforters" or small "feeders" containing sweetened drinks or sugary vitaminized syrups is to be deprecated as the deciduous teeth are exposed to a potentially cariogenic environment.

Certain factors may be found in foods that are somewhat caries inhibiting rather than caries generating.

The Eskimos, whose conventional diets were almost solely of animal origin and furnish about 70-80% of their total calories as fat, experienced little if any decay. There is indirect evidence that dietary fats may have an anticariogenic effect in humans.

When vitamin D was administered as cod liver oil in children, it was found to exert a greater caries-inhibiting effect than similar amounts of vitamin D given in the form of irradiated ergosterol. (McBeath, E.C., Verlin, W.A., (1942)). Further studies on the role of vitamin D in the nutritional control of dental caries.) These findings suggested that the local effect of oil on the tooth surface rather than the systemic effect of vitamin D was the mechanism for this greater anticariogenic finding.

Most animal experiments have shown that increasing the fat component of the diet (usually at the expense of sucrose) will reduce experimental caries. For example, Gustafsson fed groups of common laboratory rats purified diets containing as much as 25 per cent fat and was able to reduce caries 66 per cent less than the control group.
At high concentrations, fatty acids such as oleic, linoleic and linolenic inhibit growth of lactobacilli and, streptococci. (Critchley, P.) (1970), Effects of foods on bacterial metabolic processes, J.Dent.Res.49; p.1283.)

From these various studies one might conclude that the mechanisms whereby fats act to reduce dental caries are as follows: (1) Coating of the tooth surfaces with an oily substance would mean that food particles will not be so readily retained; (2) a fatty protective layer provided to go over plaque would prevent fermentable substrate from getting in or acids getting out; (3) high concentrations of fatty acids might interfere with growth of cariogenic bacteria; and (4) increased dietary fat will decrease the amount of dietary fermentable carbohydrate necessary for organic acid formation.

Protein may serve a cariostatic function by elevating salivary urea levels. Some European studies (Geddes, D.A., Edgar, W.M., Jenkins, G.N., and Rugg-Dunn, A.J. (1977), Apples, salted peanuts and plaque pH. Br.Dent.J. 142, p.317) indicate that the consumption of cheese, nuts, and other foods with a high protein and fat content following ingestion of carbo- hydrate effectively raises the palque pH. Cocoa products may inhibit plaque growth and synthesis of extracellular dextrans because of the tannins and theobromine.

In animals the addition of phosphate compounds to cariogenic diets has rendered the diets non-cariogenic. The mechanism of action for caries prevention in animal studies has been postulated as an interference with dental plaque adherence to enamel, possibly by some type of detergent action and dental caries has been studied in animals and humans. Pyridoxine added to cariogenic diets appears to provide some protective effects to the teeth. This protection may be related to an alteration of the cariogenic oral flora.

In general, deterve foods (raw fruits and vegetables rich in cellulose and water) are non plaque formers and therefore are desirable anticaries foods. These foods are non retentive and, because of their firmness, require vigorous chewing over a sustained period time which stimulates salivary flow, - a desirable oral clearance mechanism which can have an anticaries influence.
Fluoride is an essential nutrient for optimal dental health. In small concentrations of about 1 ppm, which is the level recommended for communal water supplies, fluoride benefits teeth.

The average daily fluoride intake from food where water supplies contain negligible amounts of fluoride is approximately 0.2 to 0.6 mg. Meats, fruits, vegetables and cereals contain very small amounts of fluoride. The rich sources of fluoride are seafoods like fish, especially those with small bones such as sardines and salmon, which tend to take up fluoride very readily. The amount of fluoride in fresh fish may be about 1.6 ppm, whereas in canned salmon, sardines and mackerel it may be as high as 7 to 12 ppm.

Tea leaves contain 75 to 100 ppm, fluoride. But the average cup of tea infusion that one drinks may contain only 0.5 to 2.0 ppm; most of the fluoride is extracted when the tea is first steeped in the hot water. The table shows the presence of fluoride in certain fresh foods and beverages.

<table>
<thead>
<tr>
<th>Food</th>
<th>Range of F in PPM</th>
</tr>
</thead>
<tbody>
<tr>
<td>Beer</td>
<td>0.15 - 0.86</td>
</tr>
<tr>
<td>Cereals</td>
<td>0.18 - 2.8</td>
</tr>
<tr>
<td>Citrus Fruits</td>
<td>0.07 - 0.17</td>
</tr>
<tr>
<td>Coca Cola</td>
<td>0.07</td>
</tr>
<tr>
<td>Coffee</td>
<td>0.02 - 1.6</td>
</tr>
<tr>
<td>Instant (Powder)</td>
<td>1.7</td>
</tr>
<tr>
<td>Fish without bone or skin</td>
<td>80.0 - 250.0</td>
</tr>
<tr>
<td>Milk</td>
<td>0.04 - 0.55</td>
</tr>
<tr>
<td>Non-citrus Fruits</td>
<td>0.03 - 0.84</td>
</tr>
<tr>
<td>Sardines</td>
<td>8.0 - 40.0</td>
</tr>
<tr>
<td>Shrimp Meat</td>
<td>0.4</td>
</tr>
<tr>
<td>Shrimp Shell</td>
<td>18.0 - 48.0</td>
</tr>
<tr>
<td>Tea</td>
<td>0.5 - 2</td>
</tr>
<tr>
<td>Instant (solution)</td>
<td>0.2</td>
</tr>
<tr>
<td>Vegetables and tubers</td>
<td>0.02 - 0.9</td>
</tr>
<tr>
<td>Wine</td>
<td>0.0 - 0.3</td>
</tr>
</tbody>
</table>

The ashes of different foods decrease the incidence of caries for example, corn (Harris, R.S., and Nizel, A.E., (1959). J.Dental Res.38; pp.1142-1147) and bone.

Minerals in foods and drinking water have an important role in dental caries. Trace elements can be incorporated pre-eruptively and post-eruptively into tooth enamel and change its physico chemical properties, affect the remineralization process on the enamel surface, and influence the implantation and metabolism of cariogenic microorganism. Some elements promote caries, such as selenium, magnesium and cadmium, while others, such as molybdenum, vanadium, and strontium are mildly cariostatic.

Even though there is a definite relation between dietary trace elements and dental caries, there is no certain knowledge of the mechanism through which these elements influence caries. Some of the possible ways in which they could act are the following:

1. Incorporating trace elements pre-eruptively into the tooth mineral to change its physico-chemical properties.
2. Influencing the cellular enzyme systems involved in the mineralization of the teeth.
3. Altering pre-eruptively the nature of the calcifying organic matrix of the tooth.
4. Enhancing or inhibiting the deposition of mineral elements such as fluoride or phosphorous on the enamel surface and thereby influencing the post-eruptive maturation of hypomineralized enamel areas.
5. Changing the physical and chemical characteristics of saliva.
6. Interfering directly with the reproduction, metabolism, and implantation of the cariogenic microorganisms on the tooth surface.

Vitamins contribute to both the pathogenesis and prevention of dental caries. During the formation period, vitamins A, C and D are essential for proper deposition and calcification of tooth structure. Post-eruptively, the vitamin-dental caries relationship is mediated primarily through the oral acidogenic microorganisms. The B vitamins nicotinic acid, pantothenic acid, and biotin are necessary growth factors for most
if not all of the oral acidogenic flora. Some strains also require an exogenous source of thiamine and riboflavin. As components of the coenzymes which participate in anaerobic glycolysis, thiamine and nicotinic acid promote acid production by microbial action on locally retained ingested carbohydrates. Unfortunately, none of the B vitamins can be deleted safely from the diet for caries prevention without impairment of human health.

Caries can be controlled if sweets are not included in the diet. When one examines the data of studies in Boston (Figure 2) that dealt with the effect of nutritional supervision on dental caries, the general conclusion reached is that, the incidence of caries can be reduced significantly by restricting sweets intake.
Figure II. EFFECT OF NUTRITIONAL SUPERVISION UPON INCIDENCE OF DENTAL CARIES

BOSTON

Adapted from: Nigel, A. E., (1972), Nutrition in Preventive Dentistry.
5. MILK

Milk is a complex mixture consisting of an emulsion of fat and a colloidal dispersion of proteins, together with the milk sugar (lactose) in the solution. These major constituents are accompanied by various minerals (notably calcium and phosphorous), vitamins, enzymes and various minor organic compounds such as citric acid, some of them introgenous in nature. The characteristic opaque colour of milk is due mainly to the dispersion of the milk proteins and the calcium salts.

Tables 4 and 5 give representative values for the main constituents of nutritional importance of the milk of humans and the milch animals. The composition of milk not only differs from species to species but varies widely within any one species and even within breeds or races of one species. Many factors determine composition: physiological variability of the individual, nutrition, stage of lactation, age, season of the year, amount of milk produced - to name only a few. The main milk animals have been bred for centuries to produce quantities of milk far in excess of the amounts needed by their young. The milk of these domesticated and highly specialized animals retain the main characteristics of that of the wild stock. The cow is more generally used throughout the world than any other milch animal and more is known about its milk.

5.1. MILK COMPOSITION

The fat of milk, like other animal or vegetable fats, is a mixture of chemical combination of many different fatty acids with glycerol.

Milk proteins consist of casein, a phosphoprotein found only in milk and forming the curd when milk is acidified or together with the soluble proteins, mainly lactalbumins and lactoglobulins. Like all proteins, those of milk are composed of amino acids. There are over twenty individual amino acids in the milk proteins.

Lactose, or milk sugar, is a disaccharide; that is, it consists of two simple sugars in combination, in this instance, glucose and galactose. When lactose is taken the production of lactic acid by the acid-forming components of the flora controls the
growth of other organisms, and in digestive orders, lactose is often beneficial.

Milk is a relatively poor source of nicotinic acid.

Much of what will be said about the milk of the cow and changes in its composition applies to the milk of the other ruminant milch animals.

For the cow two examples are given in Tables 4 and 5 to represent the range of composition of milk among dairy breeds of the world. The Friesian, a popular breed in Europe and North America typifies the high-yielding cow of many countries. As an example of breeds yielding "richer" milk, the Guernsey has been chosen which, together with the other Channel Island breed, the Jersey is very widely distributed. Its milk is more concentrated in fat and nonfatty solids. The composition of the milk of most dairy breeds of the world probably falls within the range shown by these two examples.

All vitamins of the B group are synthesized in the paunch of all ruminant animals through microbial activity, and ruminant animals are therefore largely independent of their supply in the diet. For this reason the level of these vitamins in the milk of ruminants varies on the whole much less than in human milk and is determined primarily not by the diet but by factors such as breed and stage of lactation. Thus, there is more riboflavin in the milk of Channel Island breeds than in the milk of high-yielding breeds represented by the Friesian; the content of biotin decreases with the length of lactation, whereas that of nicotinic acid decreases and then rises again.

In the breakdown of cellulose and starch during bacterial fermentation starch during bacterial fermentation in the paunch, volatile fatty acids are formed in which acetic acid predominates, and is to a large extent from this acetic acid that milk fat is built up
in the udder. For this reason the milk fat of ruminants contains lower fatty acids, such as butyric acid, not found in human milk.

In the ruminant bred for milk production, dietary inadequacy or imbalance may be reflected in the major constituents of the milk to a much greater extent than, for example, in man.

The vitamin C of the diet, which may amount to some 20 or 30 grammes daily when the cow is on pasture, is destroyed in the paunch, but the cow makes vitamin C somewhere in her tissues and passes it into the milk at a steady rate independent of the amount that is eaten. The position is quite different with the fat-soluble vitamin A which the cow must derive from carotene, the yellow pigment of grass and green fodders. This pigment is converted in the intestinal wall into vitamin A, but some of it passes into the milk and gives it a yellow tinge, most marked when the cows are on pasture. Breeds differ in the efficiency with which they convert carotene into vitamin A. The Guernsey cow, for example, is less efficient than the Friesian; she puts more carotene into the milk and less vitamin A, so that the colour of milk or butter is no certain guide to its vitamin A activity. Not all the yellow pigment in cows milk is of value to man; some 20 percent consists of inactive carotenoids. The vitamin A and carotene content of milk varies greatly with the diet of the cow; stall-fed cows receiving poor hay or roughage and little or no green fodder may produce milk containing only half, or even much less, of the vitamin A activity.

In common with other milks, cow's milk contains only very little vitamin D. The cow obtains it by the direct action of the sun on vitamin D precursors in her skin and from the small quantities of vitamin D in hay, also formed by the action of the sun during wilting. Fresh green fodders contain only traces of vitamin D. Milk produced under tropical conditions contains no more than milk from temperate regions, and no milk can be considered to supply on its own enough vitamin D for the needs of the infant or young child.
Buffalo's milk is almost the same as cow's milk except that it contains much more fat and nonfatty solids than cow's milk but less riboflavin. The buffalo converts carotene into vitamin A more efficiently than the cow, and its milk contains only traces of carotene.

Goat's milk contains more nicotinic acid but markedly less vitamin B\textsubscript{12} than cow's milk. This probably causes "goat's milk anaemia", sometimes observed in infants reared on goat's milk.

The fat content of Ewe's milk is much higher than in cow's milk. There are also more nonfatty solids, notably protein and calcium, and decidedly more riboflavin, nicotinic acid and vitamin C than in cow's milk.

The horse and the ass are entirely herbivorous but are not ruminants. Of all the milch animals, their milk is nearest in composition to human milk. It has the same high lactose content and relatively little protein but, the protein and minerals are higher than in human milk though low in comparison with those in other milks. The protein composition of these two milks is also close to that of human milk, in that they too contain relatively less casein than the milk of other milch animals. The milk fat of the mare and the ass contains, though to a lesser extent than that of ruminants, the lower fatty acids absent from human milk fat. Other noteworthy features are low fat content, and hence lower energy content, low content of riboflavin and high content of vitamin C, which in mare's milk is relatively stable. This stability may be connected with the low riboflavin content. Unlike cow's, goat's and ewe's milk, where the riboflavin is mainly in free form, it is chemically bound in mare's milk. Mare's and ass's milk is believed by many to be very suitable for infants.
The major constituents of camel's milk are very much like those of cow's milk. It is characterized by a high content of vitamin C.

Yak's milk closely resembles ewe's milk. It is rich in fat and total solids and hence in energy. It is rich yellow in colour. Thus, like the cow, it converts carotene incompletely into vitamin A.

The reindeer has a very high fat content in its milk, surpassed only in the milk of aquatic mammals: the seal, the dolphin and the whale.

5.2 MILK TREATMENT

Under natural conditions milk passes directly from mother to offspring and the problem of keeping does not arise. When used otherwise, as a foodstuff, milk is very perishable since its liquid state and nutritive composition make it particularly prone to spoilage by micro organisms either originally present or introduced in handling. Moreover, milk may originally contain organisms which are harmful to man - such as those of tuberculosis or brucellosis - or acquire noxious germs during handling.

The rapid decomposition of untreated milk has from very early times led man to devise means of preserving some or most of its nutrients, and modern bacteriology and technology have found many ways of making milk safe and stable.

Heat treatment preserves milk by destroying certain enzymes that might otherwise cause spoilage through development of taints. The fat-splitting enzyme, lipase (the cause of bitter milk), is particularly undesirable.

The forms in which milk is used are many and various. Cow's milk is the one that is used normally. They range from liquid milk virtually unchanged in its composition, but heat-treated to make it bacteriologically safe and give its keeping qualities sufficient
for transport and delivery, to the separate constituents of milk such as fat, lactose or casein. To these must be added many products in which milk is combined with other foods. These products differ enormously in nutritive value among themselves. They all have a useful place in human dietaries, provided their nutritive contribution is correctly assessed.

The assessment depends on the purpose for which the product is used. If it is for the artificial feeding of infants for whom it will be virtually the sole food, the standard should be stringent. To replace breast milk adequately, the original nutrients of milk should be preserved as far as possible, those missing or inadequately added or restored and the total balance adjusted. For children, adolescents, pregnant and nursing women, and for adults generally, the function of milk and its products is to contribute to the total value of a mixed diet. According to circumstances, the most desired supplement may be the valuable proteins, the high calcium content, riboflavin, or the calories supplied by the fat and sugar.

Pasteurized milk.
Pasteurization is a treatment which consists in heating milk at a sufficiently high temperature for an appropriate length of time to destroy the pathogenic organisms and weaken the others, so as to enable the product to be safely transported, distributed and consumed as liquid milk.

With commercial milk supplies the chief sufferer is vitamin C, with losses amounting to some 20 percent of the content in the original product. Some 10 percent of thiamine - the other heat-labile vitamin in milk - and vitamin B₁₂ are lost in pateurization. The biological value of the proteins is only very slightly diminished. The other milk nutrients are virtually unaffected by the treatment.
Reconstituted milk
This is obtained by mixing powdered milk (whole or skim) with an adequate volume of water.

Addition of reconstituted skim milk to locally produced milk, in order to reduce its fat content to a predetermined standard while maintaining or increasing the content of nonfatty solids, is known as toning.

Skim milk, also known as separated milk, is milk from which most of the fat has been removed. The amount left is usually about 0.05 to 0.1 percent, consisting of the smallest globules that do not rise to form a cream line. Such milk is unsuitable for babies, unless adequately supplemented with vitamin A, but otherwise retains all the valuable nonfat solids.

Homogenized milk is milk in which the fat globules have been broken up mechanically to such an extent that they do not rise to the surface to form a cream layer. The method consists in forcing the milk, heated normally to about 60°C (140°F), through a very small orifice at high pressure.

The main advantages of homogenized milk are its uniformity of composition - which may be of special value in large scale catering in restaurants, schools and so on - and palatability, which many believe is improved by the process. The disadvantage is that the cream cannot be removed. In keeping quality and nutritive value the milk does not differ from ordinary pasteurized milk.
Evaporated and condensed milk. Milk from which water has been removed, and which has been heat-treated to render it bacteriologically safe and stable, has for long been a very popular product. There are two main methods of preparing concentrated milk, which can be applied to both whole and skim milk.

The preparation of evaporated milk consists in preheating the milk to about 95°C (203°F) for some 10 minutes and then concentrating it in vacuum pans at a temperature around 50°C to 55°C (122°F to 131°F), homogenizing the product and canning it. The cans are then sterilized in a steam autoclave at about 115°C (239°F) for not less than 15 minutes.

The ratio of concentration of milk solids in evaporated milk is about 2 to 2.75:1. It is now known that in its preparation evaporated milk loses some vitamin B₆ and possible dangers of vitamin B₆ deficiency must be considered. Evaporated milk loses lysine and histidine with long storage periods.

With sweetened condensed milk, stability and bacteriological safety are achieved not by application of sterilizing temperatures, but by the addition of sucrose which acts bacteriostatically. Whole milk is preheated for some 15 minutes at 80°C (176°F) before or after the addition of the requisite quantity of sugar, condensed under reduced pressure as in the manufacture of evaporated milk, and cooled to bring about crystallization of lactose in small crystals that do not cause grittiness. It is then sealed in cans or tables.

Sweetened condensed milk keeps well at moderate temperatures with no change in vitamin A, carotene or riboflavin, but with progressive loss of thiamine and vitamin C. At 37°C (99°F) the deterioration in palatability and vitamin content is rapid.
Sweetened condensed skim milk is prepared in the same way as the full-cream product and retains most of the nutrients of the skim milk from which it was made. The ratio of concentration is close to 3:1 and the sucrose amounts to about 45 percent. This large quantity of sugar increased the energy content of the milk but significantly reduces its nutrient content. For this reason, and particularly because the product is lacking in vitamin A, sweetened condensed skim milk is a dangerous food for infants and in most countries has to be labelled as unsuitable for them.

Dried milks.
Micro organism cannot multiply in the absence of water so that its virtual removal enables milk to be kept for long periods. Water can be removed by applying cold or heat. Removal by cold may take the form of freezing out the water and centrifuging off a paste of milk solids which is then dried under reduced pressure with moderate heat.
5.3 HUMAN MILK AND ITS ADVANTAGES

Teeth, like other organs, are continuously affected by numerous metabolic activities in the body, succumbing to adverse conditions and being protected by favourable ones. Consideration of the cause of caries, with due regard for systemic conditions, includes:

(1) variations in structure of teeth during development - accounting for differences in resistance to caries - due not only to macroscopic malformation (non-coalesced pits and fissures, hypoplasia, hyperplasia, or other irregularities), but also to micro-anatomical or microchemical abnormality (frequently overlooked in explanations of such clinical conditions as decalcification on only one of two contacting proximal surfaces); (2) fluctuating environmental effects of salivary components (inorganic and organic, soluble and suspended unformed constituents, and cellular entities) acting individually or collectively.

Notwithstanding the role of local factors (tooth structure microscopic flora, local dental hygiene), general dental health and specific resistance to caries are resultants of conditions that maintain life and health for the body as a whole. All requirements for good health in mother-to-be, and in child throughout life, should be safeguarded.

The infant therefore should be started off right from the time of birth. Mother's milk is the most natural food for him. No one can argue that breast milk is not the most perfect food for the baby from a nutritional point of view. Perfect nutrition is necessary for perfect jaws and teeth. The baby on a breast doesn't just take the nipple into his mouth and suck out the milk. He has to work harder than that for his meal and the hard work, it turns out, is good for normal growth of the jaws.
The values given in Tables 4 and 5 are those characteristic of the milk of an adequately nourished woman in full lactation. Milk is secreted continuously in the breasts. The carbohydrates constitute about 40% of the energy content in human milk and 26% in bovine milk. The dominant component is lactose. The lactose content of human milk is 6-7g per 100 ml. The carbohydrate fraction in milk also comprises oligosaccharides (polymers of D-glucose, fructose and galactose) and compounds such as glycoproteins and glycosphingolipids. The bovine milk contains only a few oligosaccharides, whereas human milk contains a great number of various oligosaccharides which constitute about 1.2-1.3g per 100 ml in mature milk, while cow's milk only contains 0.1g per 100 ml. But it is still difficult to explain the physiological significance of the various compounds. The bifidus factors which are found in the N-containing oligosaccharides in human milk seem to play an essential role for the growth of the bifidus flora in the intestines of the breastfed infant. The bifidus flora provide a greater resistance to gastrointestinal infectious. Cow's milk contains practically no activating factor of this type. The glycopeptides in the human milk are of interest as they are related to blood group constituents.

The fat concentration is approximately the same in human milk and cow's milk. Fat represents the major energy source in the human milk as well as the source of fat-soluble vitamins and essential fatty acids. There are, however considerable diurnal changes in the lipid and cholesterol content. (Hall, B. (1979), Uniformity of human milk, Am.J. Clin. Nutr., 32, p.304). The triglycerides (esters of 3 fatty acids - simple lipid) are the major constituents of the milk lipids. The quality and quantity of the fatty acids found in triglycerides are of importance as well as the structure of the triglycerides. The occurrence of the fatty acids in human milk seems to reflect the fatty acid composition of the dietary fat ingested by the mother.
Table 4: Representative Values for Some Major Constituents of Good Quality Milk of Different Species.

<table>
<thead>
<tr>
<th>Species</th>
<th>Fat (non-fat)</th>
<th>Solids (NX6.38)</th>
<th>Protein</th>
<th>Lactose (drams)</th>
<th>Calcium</th>
<th>Water</th>
<th>Physiological energy</th>
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</thead>
<tbody>
<tr>
<td>Human</td>
<td>4.62</td>
<td>8.97</td>
<td>1.23</td>
<td>6.94</td>
<td>0.03</td>
<td>89</td>
<td>73</td>
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<tr>
<td>Cow:</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Friesian</td>
<td>3.50</td>
<td>8.65</td>
<td>3.25</td>
<td>4.60</td>
<td>0.115</td>
<td>87</td>
<td>62</td>
</tr>
<tr>
<td>Guernsey</td>
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<td>9.10</td>
<td>3.65</td>
<td>4.70</td>
<td>0.13</td>
<td>75</td>
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<td>Buffalo, Indian</td>
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<td>9.32</td>
<td>3.78</td>
<td>4.90</td>
<td>0.19</td>
<td>68</td>
<td>100</td>
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<tr>
<td>Goat</td>
<td>4.50</td>
<td>8.70</td>
<td>3.30</td>
<td>4.40</td>
<td>0.13</td>
<td>82</td>
<td>71</td>
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<td>Ewe</td>
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<td>10.90</td>
<td>5.60</td>
<td>4.40</td>
<td>0.20</td>
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<td>105</td>
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<td>6.00</td>
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<td>Ass</td>
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<td>6.20</td>
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<td>8.70</td>
<td>3.70</td>
<td>4.10</td>
<td>'-'</td>
<td>87</td>
<td>70</td>
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<tr>
<td>Yak</td>
<td>7.00</td>
<td>10.90</td>
<td>5.20</td>
<td>4.60</td>
<td>'-'</td>
<td>'-'</td>
<td>100</td>
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<tr>
<td>Llama</td>
<td>3.20</td>
<td>10.30</td>
<td>3.90</td>
<td>5.30</td>
<td>'-'</td>
<td>'-'</td>
<td>65</td>
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<tr>
<td>Reindeer</td>
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<td>14.20</td>
<td>10.30</td>
<td>2.40</td>
<td>'-'</td>
<td>68</td>
<td>250</td>
</tr>
<tr>
<td>Pig</td>
<td>7.0</td>
<td>-</td>
<td>5.0</td>
<td>3.0</td>
<td>'-'</td>
<td>85</td>
<td>'-'</td>
</tr>
</tbody>
</table>

'In the tables a dash(-) denotes lack of information or unreliable information.

## Table 5: Representative Value for some Vitamins in Good Quality Milk of Different Species

<table>
<thead>
<tr>
<th></th>
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<tbody>
<tr>
<td>Human</td>
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<td>7</td>
<td>4</td>
<td>8</td>
<td>7</td>
<td>5</td>
<td>2</td>
<td>9</td>
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<td>8</td>
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<td>5</td>
<td>2</td>
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<td>0.3</td>
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<td>0.1</td>
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<td>7</td>
<td>4</td>
<td>8</td>
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<td>5</td>
<td>2</td>
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</tr>
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<td>4</td>
<td>8</td>
<td>7</td>
<td>5</td>
<td>2</td>
<td>9</td>
<td>0.3</td>
<td>0.4</td>
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<td>10</td>
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<td>Indian Goat</td>
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<td>7</td>
<td>4</td>
<td>8</td>
<td>7</td>
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<td>9</td>
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<td>10</td>
<td>0.1</td>
<td>2.0</td>
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<td>4</td>
<td>8</td>
<td>7</td>
<td>5</td>
<td>2</td>
<td>9</td>
<td>0.3</td>
<td>0.4</td>
<td>8</td>
<td>10</td>
<td>0.1</td>
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</tr>
<tr>
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<td>2</td>
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<td>10</td>
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<td>Llama</td>
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<td>0.1</td>
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<tr>
<td>Yak</td>
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<td>8</td>
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<td>2</td>
<td>9</td>
<td>0.3</td>
<td>0.4</td>
<td>8</td>
<td>10</td>
<td>0.1</td>
<td>2.0</td>
</tr>
<tr>
<td>Pig</td>
<td>10</td>
<td>7</td>
<td>4</td>
<td>8</td>
<td>7</td>
<td>5</td>
<td>2</td>
<td>9</td>
<td>0.3</td>
<td>0.4</td>
<td>8</td>
<td>10</td>
<td>0.1</td>
<td>2.0</td>
</tr>
</tbody>
</table>

**Note:** Data is approximate and may vary depending on the quality and source of the milk.
The fatty acids in bovine milk do not seem to reflect the dietary fat to the extent which has been described, due to the activity of the cow's rumen flora which seems to be of primary importance for the fatty acid distribution in the milk.

There are differences with respect to the fatty acid composition of human milk and bovine milk. The short-chain fatty acids (less than 10 carbons) are present in smaller quantities in human milk than in bovine milk, while the polyunsaturated fatty acids are dominated by the linoleic acid which may be another effect of the mother's diet. It has been suggested that the long-chain polyunsaturated fatty acids in human milk are of importance for the biochemical development of the central nervous system. Interestingly, the cholesterol concentration is considerably higher in the fat globules of human milk than in those of bovine milk. It has been postulated that the intake of a high cholesterol diet through the breastmilk during the first neonatal period makes it easier for the human to metabolise cholesterol later in life and adapt to the diet of the adult human. (Reiser, R., O'Brien, B.C., Henderson, G.R., Moore, R.W., (1979), Studies on a possible function for cholesterol in milk, Nutri, Rep. Int. 19., p.835).

Without any doubt, the protein components of the milk provide some of the most essential nutrients for rapid neonatal growth. The protein composition of human milk can be analysed from the physiological and immunological point of view and as a source of amino acids for protein synthesis in the newborn.

As much as 25% of the nitrogen in human mature milk is derived from non-protein nitrogen. This non-protein nitrogen is composed mainly of urea but there are also free amino and both these components could be utilised, at least to a certain extent, by the infant. Human milk and cow's milk contain almost the same amount of non-protein nitrogen (40-50 mg per 100 ml). The total amount of nitrogen, however, is much lower in human milk than in cow's milk, being only about 200 mg per 100 ml in human milk.
versus 540 mg per 100 ml in cow's milk. Human milk seems to have the lowest protein content of any mammal milk and the protein fraction only comprises about 7% of the energy of milk. Not only is the protein content of human milk much less than that of bovine milk, the protein composition is quite different as the whey proteins constitute 70-80% of the total proteins in human milk whereas the caseins dominate in the bovine milk, constituting about 80% of the total proteins.

Casein is a very milk-specific protein which occurs in both human and bovine milk. It is a very heterogeneous moiety of various phosphoproteins, $\alpha_1$, $\beta$, $\gamma$ and $\kappa$-caseins which represent some of the few naturally occurring in phosphoproteins. The caseins have a unique molecular structure and form micelles containing calcium and phosphorous which makes casein also a valuable source of these minerals. The casein micelles of human milk are much smaller than those of bovine milk. Human casein has a lower phosphorous content than bovine casein but is richer in amino sugars, sialic acid and reducing non-amino sugars.

The whey proteins represent a mixture of soluble proteins which remain when casein has been precipitated by acidification to pH4.6 or by using the enzyme rennin. There are major differences in the composition of the whey proteins of bovine milk and human milk. The whey proteins of breastmilk can be classified into three groups. The $\alpha$-lactalbumin, $\beta$-lactoglobulin and lactoferrin, in addition to most of the enzymes, seem to be both organ- and function-specific as they are synthesized in the mammalian gland. Serum albumin, transferrin and ceruloplasmin are non-specific as they are more or less passively transferred from the blood, whereas the immunoglobulins and lactoferrin are proteins of mixed origins as they are both transferred from blood and synthesized in the mammary gland.
The $\kappa$-lactalbumin is one of the three dominant components in human milk while it only constitutes 3-4% of the protein in cow's milk. $\kappa$-lactalbumin content is related to the lactose content in various mammals but not in human milks as the $\kappa$-lactalbumin content falls and the lactose content increases during lactation.

$\beta$-lactoglobulin is the dominant whey protein component in bovine milk but it is absent in human milk. There have been, however, recent reports of minor amounts occurring. (Liberatori, J., Morisio Guidetti, L., Conti, A. (1979), 'Immunological evidence of $\beta$-lactoglobulin in human colostrum and milk', Bull.Soc.Ital. Biol.Sper., 55, p.822). It has been postulated that the $\beta$-lactoglobulin may be the responsible factor for the increased incidence of milk allergy in infants fed formulas at an early age where the whey protein to casein ratio is 40 to 60.

Lactoferrin is the other dominant component in the whey protein fraction of human milk. It is a single-chain, iron-binding glycoprotein which is only partly saturated with iron. It has been shown to possess some bacteriostatic activity in vitro which is due to the fact that lactoferrin prevents the growth of harmful bacteria in the gut and their participation in the defence of the infant against infection.

The immunoglobulins are glycoproteins of high molecular weight. They are divided into IgA, IgD, IgE and IgM. IgA occurs in a special form in human milk where it is called secretory IgA which is composed of two IgA molecules combined with a glycoprotein component and a ploypeptide called the junction chain which is covalently linked. The secretory IgA component is very much a component of the human whey proteins whereas the content is much less in bovine milk where IgG dominates.

Among the number of various enzymes found in both human and bovine milk, lysozyme, which occurs in significant amounts in human milk and in higher concentrations than in bovine milk,
seems to play an essential role in the defence against gastrointestinal infections. There are two different types of lipases. In addition there are a number of proteins of more or less known function which occur in minor amount i.e. various glycoproteins, folic and vitamin B binding proteins.

The protein intake is of interest not only for the physical development, i.e. growth rate, but also with regard to brain development and its impact on mental development; too low protein intake will result in lowered cellular immunity, cellular growth, slow wound healing and brain damage. Protein deficiency manifested by kwashiorkor in Nigerian children encounter delayed eruption and hypoplasia of teeth (deciduous). Children who suffer from protein-calorie malnutrition have crowded and rotated teeth. This might be interpreted as being the result of an inadequate development or retarded growth of jawbone matrix. The amount and quality of protein are important factors in influencing dental caries development. The qualitative aspects not only relate the proteins as such (where quite a number of immunological aspects are of interest), but also to the amino acid composition and the metabolic capacity of the amino acids and to changes throughout development.

The amino acid composition is also one of the major factors which influence the nutritional value of the dietary protein. It is known that the metabolic capacity of the liver in the neonate is limited with respect to some amino acids and there is some evidence that high concentrations of some amino acids may cause damage, essentially to the neurological system, during the postnatal life. Two amino acids, cysteine and tryptophan, occur in much smaller concentrations in cow’s milk than in human milk. This is of nutritional interest. Cysteine is an essential amino acid for the preterm infant and probably also for the neonate as cystathionase is still lacking or is present in low concentration.
Cow's milk has a much higher tyrosine content than in human milk. It has also been shown that increased levels of tyrosine in blood and urine may occur in 90% of pre-term and 10% of full-term neonates when fed certain formulas based on cow's milk. This is of special interest as an increased tyrosine level during the neonatal period has been suggested to be deleterious to the intellectual development. Thus breastfeeding in mature and premature infants is one way of avoiding the risk of a pathological increase of tyrosine and its metabolites in serum and urine.

Famine has been of special interest during the last few years. Gaul and his collaborators have elucidated its importance in metabolism during the neonatal period. Laurine occurs in human milk as a free amino acid and the concentration is much higher than in bovine milk which only contains negligible amounts.

Human milk contains about one-quarter of the mineral salts in cow's milk. This, in addition to the lower content of nitrogenous metabolites, creates a low metabolic solute load in infants and a low urinary osmolality which is important considering the infant's immature renal function. The total intake of calcium of the breastfed infant is less than before birth, resulting in a marked fall in deposition of calcium in bone after birth. On the other hand, cow's milk, which is much richer in calcium and phosphorous, promotes a higher retention of calcium than in late foetal life. As calcium retention before birth is high, pre-term infants are at a considerable disadvantage and studies seem to indicate that they show a defective skeletal mineralization and even negative calcium balances.

The iron content of human milk is low, being 0.3-0.5 umol per ml. Nevertheless there is little evidence of iron deficiency during the first four months of life. This might be due to a high bioavailability of the iron in human milk, where 75% or even more is absorbed in the gut, which is more than the absorption from any other iron source in the diet. (Saarinen,
U.M., Sumes, M.A., (1979), 'Iron absorption from breast milk, cow's milk and iron supplemented formula: an opportunistic use of changes in total body iron determined by hemoglobin, ferritin and body weight in 132 infants, Ped. Res., 13, p.143). The low protein, high lactose and low phosphorous content of breast-milk has been assumed to favour the bioavailability of iron. A minor milk is bound to lactoferrin under normal conditions, whilst about one-third is bound to the fat fraction and another one-third to some low-molecular compounds.

Zinc is another example of a mineral where the bioavailability seems to be higher in human milk than in bovine milk. The physiological implications of these differences has still not been fully understood, although curative effect of human milk in acrodermatitis enteropatica, a hereditary zinc malabsorption syndrome, has been described. (Hurley, L.S., Sonnerdal, B., Stanislowski, A.G.(1979), 'zinc citrate, human milk and acrodermatitis enteropathica, Lancet 1, p.677).

Vitamins are essential and this especially applies to the growing child. Of the fat-soluble vitamins, special interest has been devoted to vitamins A and D. Both human and cow's colostrums are rich in vitamin A. As vitamin D is low in human milk as well as in bovine milk, milk has never been considered to be a significant source of this vitamin.

Retinol is the main component with vitamin A activity in the milk. The retinol precursor - carotene is also present especially in bovine milk.

Vitamin E represents a group of fat-soluble tocopherols which have an antioxidative function. It promotes and maintains stability of biological membranes, together with selenium. There is a close correlation between vitamin E and the unsaturated fatty acids in metabolism. Clinical evidence of vitamin E deficiency is almost exclusively found in premature infants.
given artificial feeds with increased content of polyunsaturated fatty acids in relation to the vitamin E content.

Human milk contains less vitamin K than cow's milk and breastfed children may consequently run a higher risk of neonatal haemorrhage during the first few days of life. When the intestinal flora has been sufficiently developed this will furnish the infant with vitamin K.

With the exception of nicotinic acid, cow's milk contains more of all the B vitamins than human milk. There is, however, little evidence that breastfed infants develop deficiencies of water-soluble vitamins. The content of vitamin C is higher in human milk than in cow's milk. The human milk obtained from well-nourished mothers also seems to furnish the infant with acceptable amounts of vitamin A and E, provided adequate amounts of milk are consumed. The vitamin content of human milk does seem to be closely related to the vitamin balance of the mother.

The following tables give comparisons of the components of human milk and cow's milk; human milk being that of mature milk. Special mention should be given to colostrum which is a yellow translucent fluid secreted by the human breast in the first few days after parturition. In certain countries, colostrum is expressed away because of custom or taboo.

Colostrum contains more proteins, more electrolytes and more fat-soluble vitamins, but less fat than mature milk. Much of the protein is immunoglobulin in which IgA predominates. Its antibody content is high. The antibodies present in colostrum, transitional and early milk can, in the human infant, act in the lumen of the bowel against viruses and bacteria. Colostrum changes to milk between third and sixth day, the protein content remaining rather high.
Fluoride is a natural constituent of human milk. A negligibly small fraction of the daily fluoride intake are excreted in milk. The concentrations in human milk range from less than 0.1 to about 0.2 ppm.

Elevated fluoride concentrations in the drinking water or supplemented fluoride intake may increase somewhat the fluoride content of milk in lactating women. Increased by about 15-40% by daily supplements of 5mg F. The same applies to cows (minimal or elevated according to intake).

Trace quantities of fluoride in milk (both human and cows) are bound to fat and to the albuminglobulin fraction, whereas casein contains quarter of the total fluoride in the whole milk.

Supplements of fluoride will have to be given to the child if the mother is taking in 1ppm. in drinking water (Table 6).

**Table 6: Recommended Dosage of Fluoride (mgF) according to Age and Natural Fluoride Content in Water Supplies.**

<table>
<thead>
<tr>
<th>Age</th>
<th>Natural Fluoride Ion Content in Water (mg/litre or ppm)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>0-0.25</td>
</tr>
<tr>
<td>0-1 year</td>
<td>0.25</td>
</tr>
<tr>
<td>1-4 years</td>
<td>0.50</td>
</tr>
<tr>
<td>4-8 years</td>
<td>0.75</td>
</tr>
<tr>
<td>8-12 years</td>
<td>1.00</td>
</tr>
</tbody>
</table>

Estimates in this table are based on the average computed fluoride intake of children of comparable ages living in temperate areas where water contains 1 ppm of fluoride.

<table>
<thead>
<tr>
<th>Fatty acids</th>
<th>Human milk</th>
<th>Cow's milk</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Saturated</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>10.0 Capric</td>
<td>1.4</td>
<td>2.8</td>
</tr>
<tr>
<td>12.0 Lauric</td>
<td>5.4</td>
<td>3.5</td>
</tr>
<tr>
<td>14.0 Myristic</td>
<td>7.3</td>
<td>11.2</td>
</tr>
<tr>
<td>16.0 Palmitic</td>
<td>26.5</td>
<td>26.0</td>
</tr>
<tr>
<td>18.0 Stearic</td>
<td>9.5</td>
<td>11.2</td>
</tr>
<tr>
<td>Others</td>
<td>trace</td>
<td>2.1</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>50.1</td>
<td>63.2</td>
</tr>
<tr>
<td><strong>Mono-unsaturated</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>14.1 Myristoleic</td>
<td>trace</td>
<td>1.4</td>
</tr>
<tr>
<td>16.1 Palmitoleic</td>
<td>4.0</td>
<td>2.7</td>
</tr>
<tr>
<td>18.1 Oleic</td>
<td>35.4</td>
<td>27.8</td>
</tr>
<tr>
<td>Others</td>
<td>1.1</td>
<td>1.8</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>40.5</td>
<td>33.7</td>
</tr>
<tr>
<td><strong>Poly-unsaturated</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>18.2 Linoleic</td>
<td>7.2</td>
<td>1.4</td>
</tr>
<tr>
<td>18.3 Linolenic</td>
<td>0.8</td>
<td>1.5</td>
</tr>
<tr>
<td>20.4 Arachidonic</td>
<td>trace</td>
<td>trace</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>8.0</td>
<td>2.9</td>
</tr>
</tbody>
</table>

Adapted from: Hambreus, L. (1982), Food and Growth in Children with Special Reference to Breastfeeding Versus Formula Feeding.
Table 8: Whey Protein Composition in Human Milk and Cow's Milk
(The values are given as mg protein/mL)

<table>
<thead>
<tr>
<th>Protein</th>
<th>Human Milk</th>
<th>Cow's Milk</th>
</tr>
</thead>
<tbody>
<tr>
<td>( \alpha ) - lactalbumin</td>
<td>1.6</td>
<td>0.9</td>
</tr>
<tr>
<td>( \beta ) - lactoglobulin</td>
<td>-</td>
<td>3.0</td>
</tr>
<tr>
<td>Lactoferrin</td>
<td>1.7</td>
<td>0.012</td>
</tr>
<tr>
<td>Lysozyme</td>
<td>0.4</td>
<td>0.0001</td>
</tr>
<tr>
<td>Serum albumin</td>
<td>0.4</td>
<td>0.3</td>
</tr>
<tr>
<td>Immunoglobulins</td>
<td></td>
<td></td>
</tr>
<tr>
<td>IgA</td>
<td>1.4</td>
<td>0.03</td>
</tr>
<tr>
<td>IgG</td>
<td>0.01</td>
<td>0.6</td>
</tr>
<tr>
<td>IgM</td>
<td>0.01</td>
<td>0.03</td>
</tr>
</tbody>
</table>

Table 9: Essential Amino Acid Content of Human and Cow's Milk
(the values refer to mg amino acid per g total nitrogen)

<table>
<thead>
<tr>
<th>Amino acid</th>
<th>Human Milk</th>
<th>Cow's Milk</th>
</tr>
</thead>
<tbody>
<tr>
<td>Isoleucine</td>
<td>320</td>
<td>350</td>
</tr>
<tr>
<td>Leucine</td>
<td>580</td>
<td>640</td>
</tr>
<tr>
<td>Lysine</td>
<td>430</td>
<td>510</td>
</tr>
<tr>
<td>Methionine</td>
<td>91)</td>
<td>180)</td>
</tr>
<tr>
<td>Cysteine</td>
<td>120)211</td>
<td>60)240</td>
</tr>
<tr>
<td>Phenylalanine</td>
<td>230)410</td>
<td>340)620</td>
</tr>
<tr>
<td>Tyrosine</td>
<td>180)</td>
<td>280)</td>
</tr>
<tr>
<td>Threonine</td>
<td>275</td>
<td>310</td>
</tr>
<tr>
<td>Tryptophan</td>
<td>140</td>
<td>90</td>
</tr>
<tr>
<td>Valine</td>
<td>415</td>
<td>460</td>
</tr>
<tr>
<td>Histidine</td>
<td>150</td>
<td>190</td>
</tr>
</tbody>
</table>

Both tables adapted from: Hambreus, L. (1982), Food and Growth in Children with Special Reference to Breastfeeding versus Formula Feeding.
### Table 10: Mineral Contents of Human Milk and Cow's Milk
(the values refer to mg per 100 mL milk)

<table>
<thead>
<tr>
<th>Mineral</th>
<th>Human Milk</th>
<th>Bovine Milk</th>
</tr>
</thead>
<tbody>
<tr>
<td>Calcium</td>
<td>30</td>
<td>120</td>
</tr>
<tr>
<td>Magnesium</td>
<td>4</td>
<td>12</td>
</tr>
<tr>
<td>Sodium</td>
<td>15</td>
<td>45</td>
</tr>
<tr>
<td>Potassium</td>
<td>51</td>
<td>150</td>
</tr>
<tr>
<td>Chlorine</td>
<td>41</td>
<td>106</td>
</tr>
<tr>
<td>Phosphorous</td>
<td>14</td>
<td>94</td>
</tr>
<tr>
<td>Sulphur</td>
<td>14</td>
<td>33</td>
</tr>
</tbody>
</table>

### Table 11: Trace Element Contents of Human Milk and Cow's Milk
(the values refer to ug per 100 mL milk).

<table>
<thead>
<tr>
<th>Trace Element</th>
<th>Human Milk</th>
<th>Cow's Milk</th>
</tr>
</thead>
<tbody>
<tr>
<td>Copper</td>
<td>42</td>
<td>11</td>
</tr>
<tr>
<td>Iron</td>
<td>74</td>
<td>60</td>
</tr>
<tr>
<td>Cobalt</td>
<td>1</td>
<td>0.08</td>
</tr>
<tr>
<td>Molybdenum</td>
<td>0.2</td>
<td>5.5</td>
</tr>
<tr>
<td>Manganese</td>
<td>3</td>
<td>5</td>
</tr>
<tr>
<td>Zinc</td>
<td>251</td>
<td>337</td>
</tr>
<tr>
<td>Selenium</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>Iodine</td>
<td>20</td>
<td>8</td>
</tr>
<tr>
<td>Chromium</td>
<td>4</td>
<td>2</td>
</tr>
</tbody>
</table>

Adapted from: Hambreus, L., (1982), Food and Growth in Children with Special Reference to Breastfeeding Versus Formula Feeding.
Table 12: Fat-soluble Vitamin Contents of Human Milk and Cow's Milk
(the values refer to ug per 100 mL)

<table>
<thead>
<tr>
<th>Vitamin</th>
<th>Human Milk</th>
<th>Cow's Milk</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vitamin A</td>
<td>54</td>
<td>30</td>
</tr>
<tr>
<td>- carotene</td>
<td>24</td>
<td>18</td>
</tr>
<tr>
<td>Vitamin D</td>
<td>0.05</td>
<td>0.061</td>
</tr>
<tr>
<td>Vitamin E</td>
<td>520</td>
<td>88</td>
</tr>
<tr>
<td>Vitamin K</td>
<td>3.4</td>
<td>17</td>
</tr>
</tbody>
</table>

Table 13: Water Soluble Vitamin Contents of Human Milk and Cow's Milk
(the values refer to ug per 100 mL)

<table>
<thead>
<tr>
<th>Vitamin</th>
<th>Human Milk</th>
<th>Cow's Milk</th>
</tr>
</thead>
<tbody>
<tr>
<td>Thiamin</td>
<td>15</td>
<td>37</td>
</tr>
<tr>
<td>Riboflavin</td>
<td>38</td>
<td>180</td>
</tr>
<tr>
<td>Pyridoxine</td>
<td>13</td>
<td>46</td>
</tr>
<tr>
<td>Cobalamine</td>
<td>0.05</td>
<td>0.42</td>
</tr>
<tr>
<td>Niacin</td>
<td>170</td>
<td>90</td>
</tr>
<tr>
<td>Folic acid</td>
<td>0.19</td>
<td>0.29-6.8</td>
</tr>
<tr>
<td>Pantothenic acid</td>
<td>210</td>
<td>350</td>
</tr>
<tr>
<td>Ascorbic acid</td>
<td>4400</td>
<td>1700</td>
</tr>
<tr>
<td>Biotin</td>
<td>0.58</td>
<td>3.5</td>
</tr>
</tbody>
</table>

Adapted from: Hambreus, L. (1982), Food and Growth in Children with Special Reference to Breastfeeding Versus Formula Feeding.
Advantages of Breastfeeding

Breastfeeding has many advantages as will be seen. There are serious health and economic consequences of bottle feeding which are particularly relevant to developing countries.

Malnutrition is common in bottle-fed infants.

Morbidity and infections of all sorts, but especially gastro-enteritis, are also more common in artificially fed infants.

Mortality rates and the number of illnesses are higher in bottle-fed than breastfed infants (in developed as well as developing countries) (Table 14).

Breast feeding increases the period of post-partum amenorrhoea which is associated with a long birth interval and is a most important form of natural family planning in many traditional societies.

Babies who are breast-fed are less likely to become overweight than those who are bottlefed. It may be related to differences in activity between breast and bottlefed infants. Breastfed infants have been found to spend more time sucking at the breast (which is in itself hard work), more time awake, and more time being stimulated by their mother than bottlefed infants.

Breastfeeding is beneficial from the psychological aspect.

Breastfeeding causes less work: no modification of milk, no cleaning of pans and bottles, no heating of feeds.
### Table 14: Breast and Artificial Feeding, Morbidity and Mortality Rates.

Liverpool, England 1936-1942

<table>
<thead>
<tr>
<th></th>
<th>Number</th>
<th>Illness/1000</th>
<th>Death/1000</th>
</tr>
</thead>
<tbody>
<tr>
<td>Breast-fed</td>
<td>971</td>
<td>223</td>
<td>10.2</td>
</tr>
<tr>
<td>Bottle-fed</td>
<td>854</td>
<td>574</td>
<td>57.3</td>
</tr>
</tbody>
</table>

Punjab, India 1954-1959

<table>
<thead>
<tr>
<th></th>
<th>Number</th>
<th>Neo-Natal Deaths</th>
<th>Post neo-Natal Deaths</th>
<th>Infant Mortality/Rate</th>
</tr>
</thead>
<tbody>
<tr>
<td>Breast-fed</td>
<td>739</td>
<td>34</td>
<td>55</td>
<td>120</td>
</tr>
<tr>
<td>Artificially-fed</td>
<td>20</td>
<td>15</td>
<td>4</td>
<td>950</td>
</tr>
</tbody>
</table>

Adapted from: Nutrition in Developing Countries (1977), A Seminar for German Technical Assistance Personnel, Limuru, Kenya.

It is much cheaper to breastfeed the baby. It was calculated, in India (1975) that the potential loss due to a fall of 10% in the number of mothers breastfeeding would be Rs.596 mill. ($33m) per year (Mukarji, 1976).

Similarly with Egypt and Pakistan, it was found that the cost of bottle-feeding a 6 month old child would be 60% of the minimum wage (Müller, 1974). Medical fees must be added to the calculations as bottle-feed babies are more prone to infections and may suffer from malnutrition.
A survey of the nutritional status of New Guinea was made in 1947. When the dietary, medical and biochemical data secured by the survey party were considered in relation to the dental data, it seemed permissible to make the following observations on some aspects of diet and nutrition commonly held to exert an influence on the initiation and progress of dental disease.

(1) The main difference between the general diet of the New Guinea people as a whole and white people in urbanised societies lies in the complete absence of soft, sweet food made from refined (denatured) ingredients, (e.g. white flour and sugar).

(2) A second difference seems to be that the natives' natural foods are consumed in a fresher state than are many similar foods eaten by white people (e.g. green vegetables).

(3) A third difference lies in the fact that human milk is the only milk available to the indigenous population.

(4) A native child is breastfed for a longer period (12-18 months) than is the white child.

(5) The average calcium-intake for the population seems to be low by U.S.A. standards (N.R.C.), yet only a few cases of mild rickets were observed (radiological evidence).

From (3) and (4) it will be seen that the native child is breastfed for a longer period and that the only milk available is mother's milk. The incidence of caries was observed to be much lower than "civilized" people.

Tank and Storvick have shown the importance of breastfeeding in the ultimate health of the teeth. In two Oregon cities, children who were breastfed more than 3 months had fewer cavities than those breastfed less than 3 months, who had fewer cavities than those not breastfed at all. (Table 15). The two cities were "fluoride-free in Albany and fluoridated in Corvallis. The children examined were aged from 1 to six years.
Table 15: Effect of Breast Feeding on Incidence of Decayed, Missing, and Filled Deciduous Teeth in Children One to Six Years Old.

<table>
<thead>
<tr>
<th>Extent of Breast Feeding</th>
<th>No. Examined</th>
<th>Mean DMFT at 1 - 6 years</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Albany</td>
<td>Corvallis</td>
</tr>
<tr>
<td>None</td>
<td>109</td>
<td>132</td>
</tr>
<tr>
<td>&lt;3 Mo.</td>
<td>82</td>
<td>110</td>
</tr>
<tr>
<td>&gt;3 Mo.</td>
<td>38</td>
<td>80</td>
</tr>
</tbody>
</table>


Dental caries showed a lower incidence in children who were breastfed according to Moss and Picton. This may be, in part, because breastfed babies escape neonatal hypocalcaemia which, if it produces symptoms, seems to be associated with enamel hypoplasia.

One hundred under five children have been examined in the Child's Polyclinic at the General Hospital, Medan, Indonesia, in December 1977.

Fifty four children suffered from dental caries of which 48 had caries similar to bottle caries. No sugar was added to the milk.

Among those 48 children 35 were breastfed for a short while and then bottle fed.

In children who were breastfed for more than a year, there was no incidence of caries. (Table 16).

From parents, it was discovered that most of the children slept with the milk bottle in their mouths. At the end this became a habit with the children. In such cases, there will be pooling of milk around the upper incisors (primary) and upper and lower first molars.
Milk usually has a low carbohydrate content, but the greatly reduced rate of swallowing occurring during sleep plus the diminished flow of saliva allow the carbohydrate already present in the mouth to remain in contact with the teeth in the presence of acid-forming microorganisms for a greatly diminished period of time. There is diminished dilution and buffering action from the saliva, and little or no clearance of the fluid from the oral cavity with the result that even the small amount of carbohydrate in the milk exerts a greater cariogenic effect. In many instances the nursing bottle remains in the mouth for a great portion of the time spent by the child in sleep, and some of the milk from the bottle continues to ooze into the mouth.

Clinical examination discloses that all of the primary upper anterior teeth, upper and lower primary first molars, and the lower primary canine teeth are undergoing various states of decay ranging from severe in the upper anterior teeth to mild in the lower canine teeth. Contrary to what would be expected in a case of rampant caries, the lower four anterior teeth are either unaffected or are very slightly carious. The older the child is, the more severe the lesions seem to be. The upper primary incisors are most seriously involved with deep carious lesions apparent on the labial and lingual surfaces of the teeth. The mesial and distal surfaces may or may not be carious, but if they are, the carious process is continuous, with the carious labial and lingual surfaces. This leathery decay is readily removed with an excavator, revealing a softened remnant of tooth structure which leaves very little of the tooth crown.

The first primary molars are next most seriously affected, revealing deep occlusal caries, less deep buccal surfaces damage, and milder damage on the lingual surface. The primary canine teeth seem less affected, with lesions found on the labial and lingual surfaces. The second primary molars, if present, are relatively unaffected and where caries is found, the occlusal surfaces are
the most seriously involved.

Radiographic examination of the teeth reveals the extent of the damage. The upper primary incisors are the most severely affected teeth, even to the extent where periapical involvement may already be revealed radiographically.

Another sequel to the nursing bottle habit is the possible development of a perverted swallowing habit in some of the children, an infantile pattern in which the tongue is thrust forward between the lips which are closed tightly in the performance of the swallowing reflex. Children who have lost the upper primary central and lateral incisors prematurely tend to keep their tongues in the space thus created. In addition there is the possibility that the children may develop a lisp or some other speech impediment as a result of the early loss of these teeth.

Table 16: Caries in Breastfed and Bottlefed Children.

Age distribution and method of suckle of children who were suffering from bottle caries.

<table>
<thead>
<tr>
<th>Age (in months)</th>
<th>Method of Suckle</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Breast</td>
<td>Breast and Bottle</td>
</tr>
<tr>
<td>6-12</td>
<td>-</td>
<td>1</td>
</tr>
<tr>
<td>12-18</td>
<td>-</td>
<td>3</td>
</tr>
<tr>
<td>18-24</td>
<td>-</td>
<td>5</td>
</tr>
<tr>
<td>24-30</td>
<td>-</td>
<td>5</td>
</tr>
<tr>
<td>30-36</td>
<td>-</td>
<td>4</td>
</tr>
<tr>
<td>36-42</td>
<td>-</td>
<td>1</td>
</tr>
<tr>
<td>42-48</td>
<td>-</td>
<td>5</td>
</tr>
<tr>
<td>48-54</td>
<td>-</td>
<td>7</td>
</tr>
<tr>
<td>54-60</td>
<td>-</td>
<td>4</td>
</tr>
<tr>
<td></td>
<td>-</td>
<td>35</td>
</tr>
</tbody>
</table>

Alternatives to breastfeeding.

For some reason or other if an infant cannot be breastfed, then he will have to be artificially fed.

The question arises in artificial feeding as to whether it is essential to modify the composition of cow's milk to make it as near breast milk as possible. The answer to this, shortly, is that all attempts have failed to produce a food which the infant metabolises as well as it does breast milk. The primary aim, then, is that the artificial food should be metabolised as efficiently by the infant as breast milk. The baby is normally the best judge as to whether it is receiving adequate feeds.

The methods of artificial feeding may be stated to be -

1. Whole Milk Feeding. This method has been practised successfully in various countries for many years, and it has been shown that premature infants could be reared successfully on whole boiled milk. A fact which is often forgotten is that the infant who is given a full-cream dried milk, such as Alaxo or Cow and Gate, when this is made up in the usual proportion, i.e. a heaped teaspoonful, or measure, to an ounce of water, is virtually being fed on whole milk.

Advantages:

a) A small concentrated feed of high caloric value can be given.

b) Its preparation is extremely simple.

c) The biological value of the protein is certain to be sufficient for the infant's needs.

Disadvantages:

a) It lacks the physiological balance of foodstuffs, i.e. the protein is too high and the sugar too low.

b) When an infant is fed on breastmilk it requires 2½ oz. per pound body weight per day. When fed on cow's milk with sugar added it requires only 1½ oz. per pound body weight and is, therefore, considerably short of fluid.
c) The secretion of hydrochloric acid in the healthy infant's stomach is sufficient to digest adequately the protein present in breast milk, but is insufficient when whole cow's milk is given.

It is considered that in the first three months of life, at least, the disadvantages of whole-milk feeding outweigh its advantages.

2. Humanised Milk Method. Single Formula. This method of artificial feeding depends on the use of a single formula, by means of which a mixture is made of cow's milk which is said to be adequate for all infants at all ages. The total quantity of mixture required for any infant is based on the known fact that a normal healthy infant requires 2½ oz. of breastmilk per pound body weight per day. Knowing the weight of an infant, the total quantity of mixture for the day is calculated, e.g. one 10 lb. baby requires 25 oz (2½ oz x 10 oz) of mixture. This is made up of milk and water equal parts, the dilution which brings the protein of cow's milk to the level of that in human milk (2%). To each pint of the mixture 1 oz of sugar is added - making the percentage of sugar about 7%. Fat in the form of cream or cod-liver oil is also added to the mixture to make up any deficiency in this component.

Disadvantage:

a) by keeping the percentage of protein low the biological value of this constituent may fall below the needs of the infant.

b) the 50% dilution may result in giving a mixture which is too low in calcium content.

c) Although suitable for the first two months of an infant's life, when older, the amount of mixture calculated as shown by weight requires the addition of so much carbohydrate in the presence of a low protein content that there is a grave risk of gastro-intestinal upset from the excess of sugar given. Thus a 12 lb baby by this method would be given 2½ x 12 = 30 oz. of mixture, and to this would have to be added 1½ oz of sugar. Most infants
will not tolerate carbohydrate in this quality daily unless
the curd content of the feed be raised.

3. Percentage Feeding. This method is based on an attempt to
modify cow's milk so that the percentage composition closely
approximates to that of human milk. Cow's milk contains 4% of
protein, whilst breast milk has only 2%. The percentage mixture
is made by adding water to cow's milk to dilute the protein and
the adding of carbohydrate as milk sugar or as "Dextrimaltose".
Fat in the form of cod-liver is also added. The quantity of the
mixture to be given to the infant is calculated by estimating
the number of "calories" it requires in the day, and knowing the
number of calories each ounce of the mixture produce when
metabolised by the infant.

The addition of water to cow's milk may dilute it so that the
protein is lowered to the same percentage as that found in human
milk, but it is seen that the proportion of casein to lactalbumen remains immmodified. Again, the value of a protein depends
ultimately on its amino-acids, and these obviously are not
affected by the simple addition of water. Cow's milk protein is
not, and never can be, a true substitute for human protein.

4. Calorie Feeding. The term "calorie" means a unit quantity of
heat.

One gram of protein or of sugar yields to about 4 calories,
whilst 1 gm of fat yields about 9 calories when utilised by the
body. 1 oz. of cow's milk is equivalent to 20 calories and 1 oz.
of sugar is equal to 120 calories. The calorie requirements of
an infant are altered by those factors which modify the infant's
metabolism.

It must be realised that the estimation of the number of calories
required by an infant in the day can only be calculated roughly,
and it is impossible without consideration of age, activity,
state of nutrition, and the temperature of the environment, to use this method as more than a rough guide to control the artificially-fed infant. It has a use in preventing gross over- or underfeeding.

5. Simple milk dilution with addition of carbohydrates - the method of choice.

Individual babies vary in their food requirements although of the same weight, nevertheless the weight of an infant is the most valuable guide in prescribing a feed and is certainly of more help than its age. The fatter and more above average weight the infant is, the less food he requires per pound body weight per day. Some infants are active, cry a lot, and require more food to make them thrive. Others sleep well, do not show much activity and will thrive on lesser quantities. In warm weather all infants require less food than in a cold stimulating climate.

The individual infant, then, must be studied, and no rule can ever be made absolutely applicable to all infants. It cannot be too strongly emphasised that the baby itself is the final judge of the adequacy or not of its feeds. Some indication, however, may be gained of the food requirements in the twenty-four hours of an infant by considering the quantity upon which a normally healthy baby will thrive, and expressing it in terms of the amounts necessary for each pound of weight of the infant.
6. **DISCUSSION**

The teeth are a living memorial to the defects of the previous diets. Too often by middle age a few crumbling and unstable tombstones are all that remain to commemorate the past errors. This is a misfortune. General dental health and specific resistance to caries are resultants of conditions that maintain life and health of the body as a whole. The infant therefore should be started off right from the time of birth. Human's milk is the most perfect food for the baby from a nutritional point of view and no one can argue on that. The baby on the breast has to work harder for his meal. The process of sucking is good for normal growth of the jaws.

Human's milk contains the same immunoglobulin antibody that was produced by the vaccine for immunity. The immunoglobulin antibody produced by the vaccine that could effectively combat S. mutans. The immunoglobulin antibody from human milk could act the same way. Prolonged breast-feeding could give this benefit to the child.

Unfortunately the progress in food technology in addition to developing substitutes for breastmilk for feeding infants of mothers who for various reasons do not breastfeed, has included an extensive commercial promotion of the proprietary formulas. This has led to a decline in breastfeeding. This has been further aggravated by the change in lifestyle which has followed industrialization and the changing status of women in Western societies.

The most serious effect, however, is that it also has influenced the decline in breastfeeding in the developing countries where from socio economic reasons the use of infant formula is no realistic alternative but instead has led to an increased incidence of malnutrition in newborns. Breastfeeding is imperative if the survival of the baby is to be ensured.

Manufacturers convince mothers by sending their "health educators" to them, may give out free samples and at the same time point out the suitability of the product for babies.
Promotion of breast-feeding should be a national matter. There has been some support internationally. On May 21st the 34th assembly of the World Health Organization in Geneva adopted the International Code on Marketing of Breast-Milk Substitutes.

The code was endorsed by 118 countries with the exception of the United States of America. Third World countries like Malaysia formed the Malaysian Code in 1979. But this code is weak and continuously broken by certain companies which actively promote their infant formula products.

Parents normally do not know which product to buy or what to do. They get their information through friends who may be just as ignorant as themselves on infant feeding.

The decline in dental health that took place in the last century was due to altered eating habits of country people coming into the new industrial towns. The important changes were (1) the general use of refined sugar and (2) the introduction of rolled milled white wheaten flour which kept better but was softer and less nutritious than the traditional wholemeal stone-ground wheat.

It has been confirmed that raw cane juices and molasses caused less decalcification of teeth than more refined sugar products such as brown sugar, honey, and syrup. Some attributed this to calcium present and others to the cleansing action of the coarse particles of molasses.

It was found that there was anticaries activity present in unrefined cereals that may protect the tooth against enamel decalcification. It was found only in wheat bran but not in the germ fraction. It was concluded that organic phosphates were the main factors that prevented enamel dissolution when unrefined flours were incubated with saliva.

Malnutrition will interfere with the development of normal teeth. Defective teeth are susceptible to caries.

It is the trend now to buy food from those take-away shops. The consumer normally will not know the nutrient contents of the hot take-aways which may be deficient in one or two of the necessary nutrients.
Where the growing child is concerned particular attention should be paid to his diet so that he does not lack any nutrient. This is not the case in many homes where the mothers also work and therefore is not around to supervise the children's meals or they themselves are ignorant of food nutrients.

Something will have to be done as a country can only progress if her people are healthy.
7. SUMMARY

Dental caries is a complex disease in which there is interplay of a susceptible tooth, bacteria and a dietary substrate. Other factors are host factors like race, age, sex, familial heredity and emotional disturbances and environmental factors like climate and pressure of minerals in soils. Dental caries was found in greater frequency in large industrial cities. Children from better social economic group are able to get better treatment. The oral environment is essential in the caries process. The Eskimos who lived on animal food that required mastication and who received a diet consisting of protein and fat, had excellent dentition then, until transportation introduced foods other than native to them.

In W.D. Miller's Acid Fermentation Theory, micro-organisms of many kinds colonize on unclean tooth surfaces. These micro-organisms undergo metabolic activity, depending on the substrate provided by dietary intake. Many plaque organisms are capable of breaking down sugars to form organic acids capable of "attacking" enamel surfaces.

Resistance of the teeth and influence of diet during development on the structure was suggested. From the results of experiments the conclusion was that there was a definite association between tooth structure and susceptibility to caries in man. Incidence of caries was higher in severe hypoplasia than in well-formed teeth. Hypoplasia is evidenced clinically by obvious pitting, grooving and deficiency of enamel substance. The abnormalities may be localized or evenly distributed over much of the enamel surface.

The type of structure of the tooth is related to diet during the development period. The dietary factors of chief importance to the calcified dental tissues are vitamins D and A, mineral salts especially calcium and phosphorous and trace elements like fluoride.

Immunity with vaccines was found to be effective from experiments carried out in monkeys, as these vaccines produced immunoglobulins A (IgA) antibody that could effectively combat S.mutans. This antibody is present in saliva.
Calcium and phosphorous are important as they have been shown to be in higher salivary concentrations in individuals who are caries free. Salivary buffers which consists of carbonates and phosphates resist changes of pH of the saliva by preventing the alkalinity of saliva to that of an acidic one. Saliva has a rinsing effect removing carbohydrate from around the teeth. In subjects studied, flow rate was significantly related to a lower incidence of caries.

Successful control of caries can be brought about by increasing the resistance of the enamel surface, by decreasing or removing plaque formation by stimulating flow rate of saliva when the amount is low and by decreasing the intake of sugar, and frequency of eating. The consistency of the food also plays a part. Ingestion of fluoride while the enamel is undergoing mineralization is most desirable or application of fluoride post-eruptively.

A clean tooth can be brought about by mechanical cleansing by the dentist or hygienist, brushing by individuals, mouthrinsing and by the use of dental floss or interdens. Incorporation into the diet of food that requires mastication like carrots or celery helps in cleansing the teeth. Nowadays therapeutic toothpaste and mouth washes containing fluoride can be obtained.

It is important to know why a particular food is placed in the diet and what changes in body chemistry that food is expected to accomplish. Different people require intakes of food. Protein should be distributed over the day as this will prevent a person from getting hungry and having a tendency to nibble in between meals. As babies have no or few teeth, and less versatile digestions than adults, the diet therefore must be fluid and dilute.

For an expectant mother, her total protein intake should be increased. So also with iron, vitamins, minerals and fluoride. The lactating mother requires more of the same nutrients though her protein intake drops slightly.
The baby's nutritional needs are high in infancy. Milk is the ideal food for babies. Proteins in it is used partly as energy but mostly for growth. Carbohydrates supply the energy, together with fat. Babies have their own storage of fat, which becomes an emergency food. Mother's milk has fat which is easily absorbed.

The fluid intake of an infant depends on the amount of salts he takes. In very hot weather or in illness more may be needed.

Both cow's and mother's milk supply enough minerals except iron and copper.

Infants, children, expectant and breast feeding mothers have a greater need for calcium. Phosphate is essential in many metabolic processes of the body. So also are potassium, magnesium, sodium chloride and strontium and iodine, fluoride, cobalt, zinc and manganese in small amounts.

Both cow's and mother's milk contain small quantities of vitamins, but some of the B group and vitamin K are formed in the intestine by bacteria. Supplements of vitamins C and D must be given as both cow's and mother's milk are deficient in D but mother's milk contains more vitamin C.

Growth rate of the baby slows down after the first year and there is diminished appetite. The child is able to eat solid food now. Particular care then must be taken to ensure that he gets the right nutrients. Milk should still form a part of his diet. Sweets should be restricted. Where there is no fluoridation of water, fluoride tablets should be given from birth.

Unrefined cereal grain products are nutritious as they provide many nutrients. The outer layer and the outer of the inner layer are rich in vitamins. The inner aspect contains mostly starch and some proteins. Refined bread and flour are from this part. The lower end of the grain is the richest part.
Potatoes contain little proteins, minerals and B complex vitamins. They are not rich in ascorbic acid but if eaten in bulk can contribute a significant amount of ascorbic acid to the diet.

Animal foods are the best source of protein. Meat is also rich in phosphorous, niacin, riboflavin and iron. Pork is rich in thiamine. Liver contains more vitamins and more iron.

Fish supplies 5-10% of the animal protein consumed by humans. But for some it may form the bulk of the major source of protein. Fat contents vary with different types of fish. Some have large amounts of unsaturated fatty acid which reduce or not increase the level of cholesterol in the blood stream.

The vitamin and mineral contents vary with different parts of the fish.

Fats, found in meat, butter, margarine and some fruits and nuts produce energy and cushion vital organs against shock and insulate the body against heat loss, in cold weather. They provide fatty acids necessary for health and facilitate the absorption of the fat soluble vitamins of A, D, E and C.

Generally animal meat contains a higher percentage of saturated fatty acids with the exception of poultry and fish fat.

Essential fatty acids are linoleic, linolenic acid and arachidonic acid. Essential refers to the ability of the fatty acid to prevent deficiency symptoms that occur in the absence of fatty acids and to the inability of the body to synthesize the fatty acid when not supplied by the diet.

Most vegetables have a high vitamin and mineral content, ascorbic acid, the A and B vitamins, calcium and iron being the chief. Overcooked vegetables lose all the vitamins. Vegetables should be eaten raw if possible.
Fructose and glucose are found in equal proportion in most fruits. The mineral content of citrus fruits and peaches yields an alkaline ash, whereas plums, rhubarb, cranberries contribute to an acid reaction.

Excessive consumption of salt aggravates hypertension. 5gm/day is sufficient unless there is excessive sweating.

The intake of sugar should be restricted and can be done by reducing the amounts of sugar in food and drink.

Restrict the intake of fat by avoiding fried food and drippings.

Eat sparingly those foods to which large amounts of salt have been added like salted meats and fats.

Sweetness is an important sensation to humans and probably to many species of animals as well.

There is scarcely any area of food habits today that does not in some way involve sweetness and our use of sugar has increased.

The sugars in food are either natural constituents of the food, are generated during processing or they are intentionally added. The latter are sucrose and dextrose.

Certain components of the diet have a marked effect on the erupted tooth. Teeth decay precisely at those locations where food adheres and where various impactions occur, has given rise, since early times, to the idea that food on the outside of the tooth causes caries.

The two major sources of carbohydrates are starches and sucrose in various forms. From various experiments, sucrose has been known as the "arch criminal" of dental caries as its molecules are smaller and provide an immediate source of substrate for the plaque bacteria. The amount of sugar is not as important as the form and composition and frequency of usage of the sweets. Hence "comforter" or "small feeders" containing
sweetened drinks should not be used on infants. Neither should the milk bottle be left too long in the mouth.

Fats seem to reduce dental caries by (1) coating the tooth surfaces with an oil substance by which food particles cannot adhere so readily, (2) a fatty layer over the plaque prevents acids from going in and out, (3) interfere with the growth of the cariogenic bacteria.

Protein elevates salivary urea level. It inhibits plaque growth and synthesis of extracellular dextrans.

Additions of phosphate to cariogenic diet renders it less cariogenic.

Fluoride is essential for good dental health. It is present in certain foods and beverages like tea, vegetables, cereals and fish to name a few.

Certain trace elements are either caries promoting or inhibiting. The ashes of different foods decrease the incidence of caries - like corn and cocoa.

Vitamins A, C and D are essential for proper deposition and calcification of tooth structure.

A study was carried out in Boston on a group of children from age three to twelve to see if caries could be controlled through nutritional supervision and the answer was positive. Caries could be reduced significantly by restricting sweets intake.

Milk is a complex mixture consisting of an emulsion of fat and a colloidal suspension of proteins, together with the milk sugar (lactose) in the solution. The rest of the constituents are minerals like calcium and phosphorous, vitamins, enzymes and various minor organic compounds. The opaque colour is due mainly to the dispersion of milk proteins and calcium salts.
The composition of milk differs from species to species and even within breeds or races of one species. Many factors determine composition namely, physiology, variability of the individual, nutrition, stage of lactation, age, season of the year and amount of milk produced.

Animals have been bred for centuries to produce quantities of milk. The cow is more generally used.

Buffalo's milk is almost the same as cow's milk except that it contains much more fat and nonfatty solids than cow's milk and less riboflavin.

Goat's milk contains less vitamin $B_{12}$ but more nicotinic acid.

Of all the milk animals, the milk of the horse and the ass are nearest in composition to human milk as it has the same high lactose content and protein composition in which there is less casein.

Under natural conditions milk passes from mother to offspring. The rapid decomposition of untreated milk has from early times led man to devise means of preserving some or most of its nutrients.

With pasteurization vitamins C and $B_{12}$ are lost. With sweetened condensed milk, stability and bacteriological safety are achieved by addition of sucrose which acts bacteriostatically. Thiamine and vitamin C are lost with time in storage.

Sweetened condensed skim milk (with most fat removed) is not suitable for infants as the large quantity of sucrose added (45%) increases the energy content but reduces its nutrient content.

Human milk is the most natural food for the infant. Milk is secreted continuously in the breasts.
The positive factors in human milk composition are as follows:

1. The protein composition with a high content of whey proteins provides the infant with proteins of specific physiological importance as well as with an optimal supply of essential amino acids. Whey proteins can be classified into three groups, the - lactalbumin, -lactoglobulin and lactoferrin which prevents the growth of harmful bacteria in the gut and their participation in the defence of the infant against infection.

2. The carbohydrate fraction contains not only lactose but also some glycoproteins and oligosaccharides which may have an important function.

3. The lipids contain polyunsaturated fatty acids as well as the intermediate chain - unsaturated fatty acids which are readily absorbed.

4. A special bivudus factor promotes the bifidogenous flora of the infant's intestine and helps against other infectious agents.

5. A number of more or less specific immuno proteins play an essential role in the defence against other infectious agents. Immunoglobulin IgA is one of those immuno proteins.

6. A low solute load, low osmolality reduce the metabolic renal load.

From the nutritional survey carried out in New Guinea, it was found that the incidence of dental caries was lower than that of whites. One of the reasons given was that human milk was the only milk available to the population and the native child was breast-fed for a longer period i.e. 12-18 months, than the white child in America who gets more calcium.

A comparison was made in two cities in Oregon between children who were breastfed for 3 months, less than 3 months and none at all. It was found that those who were breastfed for 3 months had fewer cavities than those breastfed less than 3 months who had fewer cavities than those not breastfed at all.
Besides there are other advantages of breastfeeding.

1. Breastfeeding is a natural form of birth control.
2. Malnutrition, mortality rates and the number of illnesses are higher in bottle-fed children.
3. It is more economical to breast-feed. In India (1975) it was calculated that the potential loss due to a fall of 10% in the number of mothers breastfeeding would be Rs.596 mill. (£33M) per year (Mukarji, 1976).

In Egypt and Pakistan, the cost of bottle feeding a 6 month old child would be over 60% of the minimum urban wage (Muller, 1974). The additional cost of medical care for bottle-fed babies with infections and malnutrition should be added to the calculation.
8. **CONCLUSION**

The main need is for conviction on the part of the health profession, the economist, and the administrator. Programmes to promote breast-feeding in a community should be based on overall policy decisions. They should be interdisciplinary and supported by funds for implementation and evaluation. Internationally concerned groups are slowly recognizing that such approaches are feasible and, in many areas, of the highest priority.


- Halt all promotion of formulae directly to the public.
- Halt the distribution of free samples.
- Halt the use of "mothercraft" and company paid "health educators".
- Require improved labelling and educational material to emphasize breast-feeding, and display the risks and costs of artificial feeding.

This code was endorsed by 118 countries. The only nation which voted against the code was the United States of America.

This process is reported to be already underway in many Third World countries, including Malaysia which formed the Malaysian Code in 1979. But the Malaysian Code is weak and not legally binding. Certain companies were found breaking codes by actively promoting their infant formula products. The code should be made legally binding and heavier penalties and sanctions be imposed on milk companies contravening this code. Some developing countries have already introduced laws to prohibit promotion of baby milk, including Sri Lanka and Papua New Guinea. If babies could speak, they would approve.
Working mothers could breast-feed whenever they were at home and in between, the babies could be bottle-fed.

Talks could be given to mothers at Mother and Child Care Centres, Health Centres and Sub-Health Centres by both the Health and Dental Nurses on the advantages of breast-feeding.

Talks could also be given to teachers who attend Health Seminars every year so that they in turn can talk to parents on Parents' Day or some other suitable day.

Film shows could accompany such talks. Surely no parent would like his child to look like the Marasmus child.

Concerning the transitional child, the situation remains largely the problem of convincing mothers in industrialized countries not to introduce semi-solids too early. The mother will have to be told the types of food that is nutritious for the growing child. Once again the Health and Dental nurses have to play their parts.

The mothers should be asked to:-

a) restrict sugars in the diet;

b) restrict snacks;

c) to start brushing her child's teeth as soon as they start erupting. She should also be taught the proper technique of brushing so that she can impart this knowledge to the child;

d) to take the child to the dentist when caries first appear and subsequently regular check-ups, regardless of presence of caries;

e) at the clinic, supplemental fluoride should be recommended if the water supply is not fluoridated.
Conservative treatment to be carried out for the children, which is done by the Dental Nurse in Malaysia.

The Dental Nurse also plays a big role in Dental Health programmes by carrying out toothbrushing campaigns in schools. This is now carried out extensively in Malaysia.

Manufacturers should display the constituents of their foods clearly.

An alternative sweetener should be used in highly cariogenic foods, such as chewing gum and sticky candies. Xylitol ingestion has been found to produce dramatic reduction in the incidence of dental caries as compared to sucrose or fructose.
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To Professor Martin

for inclusion in copy of
J Mak’s thesis if it is in your office.

If thesis is in Library then attached to Librarian.

Yours sincerely

22/6/83