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UNITED NATIONS
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PROTEIN-CALORIE ADVISORY GROUP
OF THE UNITED NATIONS SYSTEM

Manual on Feeding Infants

and Young Children

SECOND EDITION

Margaret Cameron and Yngve Hofvander



Sponsored by: Food and Agriculture Organization of the United Nations;
World Health Organization; United Nations Children's Fund;
World Bank; United Nations

Chapter 2

Lactation

All mammals, from mouse to elephant, breast-feed their offspring. That ability is as important as the ability to mate and reproduce, if the species is to survive. Although sometimes other lactating females may take over if the real mother cannot feed her young, for all practical purposes the offspring's survival is completely dependent on its own mother during its first few weeks or months. The lactation period varies from three weeks or less for the mouse, up to many months for the elephant. During the latter part of the lactation period, the young gradually is weaned to "adult" food.

The milk is well adapted to the special needs of each species. Seal or whale milk, for instance, has an extremely high fat content—42 and 53 percent, respectively—as the young animal must quickly develop an insulating layer of fat so it can endure the cold waters in which it lives. Mother's milk for fast-growing animals normally has a higher protein content than does that for animals which grow more slowly.

The human infant, too, is breast-fed and dependent on its mother's milk for survival. Some 5,000 years ago, the cow began to be used as a domestic animal, probably for its milk. But not until about 50 years ago did the baby-food industry start to manufacture refined, milk-based products as alternatives to breast milk. Before then, if the mother failed to produce milk, the only safe way to feed the baby was to find a wet nurse. This is still true today in most poor areas where hygiene is unsatisfactory.

PHYSIOLOGY OF BREAST-FEEDING

The breast is made up of about 20 segments, each of which looks rather like a tree with branches and leaves, and ending in the nipple. The branches are milk ducts and the leaves are the alveoli, in which the milk is produced (see Figure 4). The tissues between the ducts and the alveoli consist of fat, connective tissue, and blood vessels. The amount of fat and connective tissue determines the size of the breast.

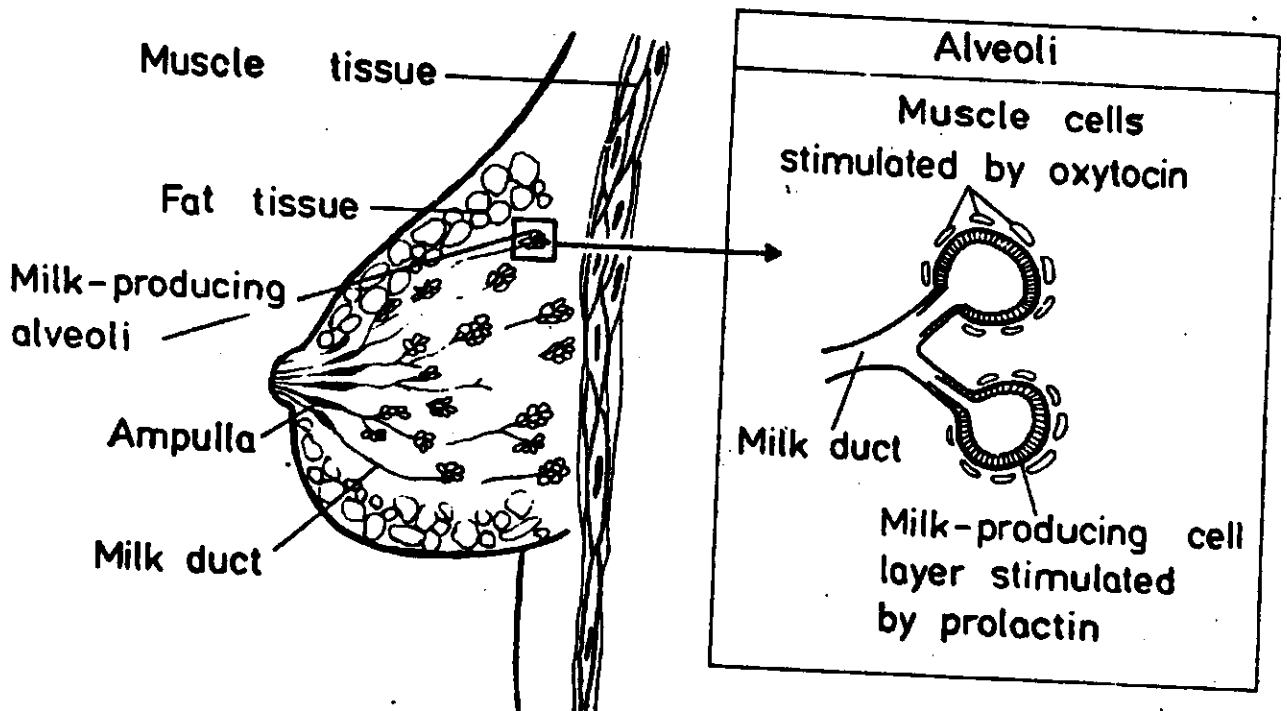


Figure 4. Anatomy of the breast.

During pregnancy, the breast enlarges and the body prepares the ducts and alveoli for lactation. The breast may increase two to three times in weight.^{1,13}

After delivery, a hormone (prolactin) produced in the anterior part of the hypophyseal gland at the base of the brain begins to act on the alveolar cells and milk production begins.

The production and ejection of the breast milk is governed by an intricate interplay of nerve reflexes and hormones. When the child is sucking the nipple, a nerve impulse is sent to the mother's brain. From there, impulses are forwarded to the hypophyseal gland (Figure 5) and the production and release of prolactin are stimulated. This hormone reaches the alveolar cells in the breast by way of the blood stream and promotes milk production. Another impulse is sent to the

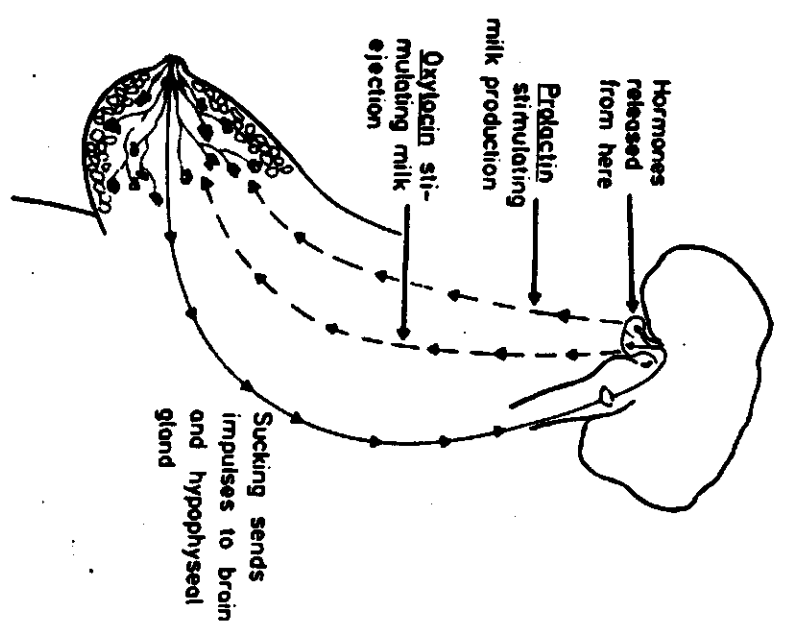


Figure 5. Sucking stimulates the production and ejection of breast milk.

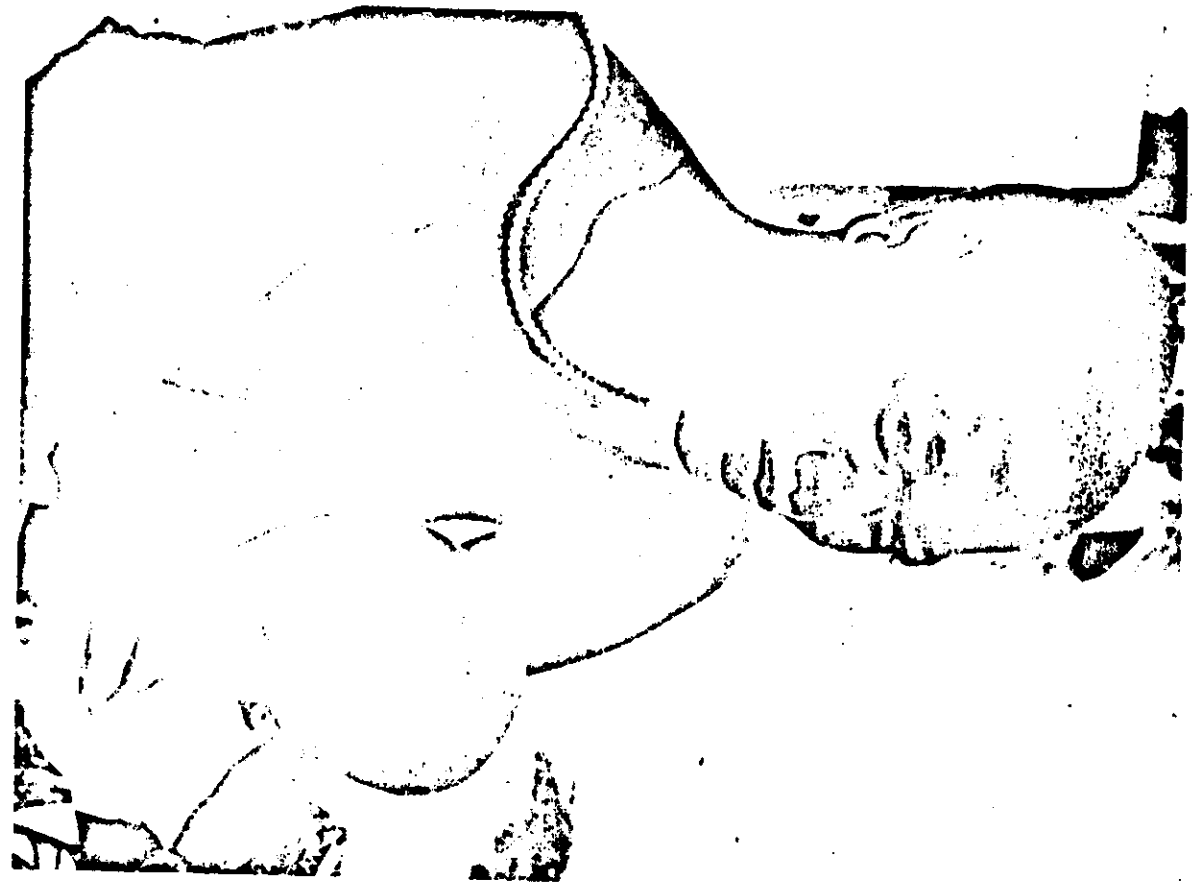


Figure 6. A quiet confidence ensures a successful lactation.



Figure 7. Breast feeding helps to establish a close and happy contact between mother and child.

posterior part of the hypophyseal gland, where it stimulates the release of still another hormone, oxytocin, which acts on the muscle cells that surround the alveoli and the milk ducts. When these contract, milk is expelled down the ducts to the nipple, where the child sucks it. This is called the "let-down reflex." The oxytocin also acts on the muscles in the womb. If the child is put to the breast soon after delivery, contraction of the womb muscles may help to stop bleeding.

The let-down reflex may be disturbed easily by pain from cracks on the nipple, tiredness, or stress. The mother may notice that she "dries up," but may not know why. Quiet confidence insures successful lactation and establishes a close and happy contact between mother and child (see Figures 6 and 7).

AMOUNT OF BREAST MILK

During the last few months of pregnancy, there is a small secretion from the breast. After birth, when the infant starts to suckle, the milk supply increases rapidly. Under normal conditions, about 100 ml is available on the second day.

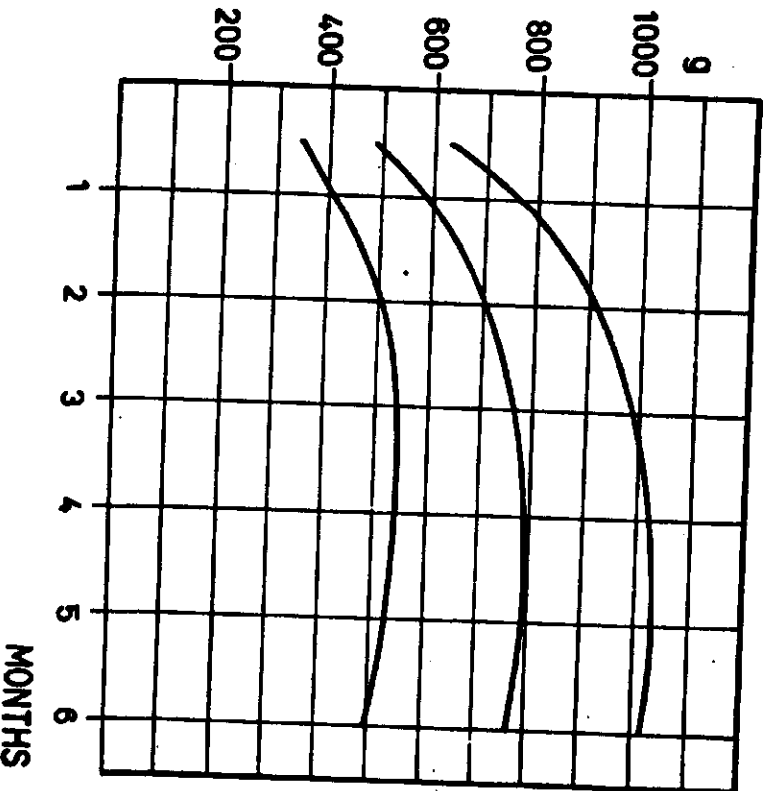


Figure 8a. Breast-milk consumption by infants of well-nourished mothers at different ages.¹⁴

and increases to about 500 ml by the second week.¹³ Effective and sustained milk production is achieved 10 to 14 days after delivery. On average, about 600 ml is consumed at one month and about 800 ml at three months,⁴ but there are large variations in the amounts (see Figure 8a).

In European countries, some infants continue to consume 750-825 ml of breast milk for at least six months and, until recently, it was thought that breast-fed infants in developing countries also were receiving breast milk in these amounts.

If the infant is getting enough milk, it grows well. Quite often, however, even in fully breast-fed, healthy infants, weight falters at three to four months. This correlates with an insufficient supply of breast milk—500 ml or less—which cannot provide the energy the child needs in order to grow properly.^{17,21} Small amounts, therefore, are not enough on their own, but, by the end of the first year, any breast milk available is an excellent supplement for various weaning foods. On the other hand, some mothers may continue to lactate for a year or two, and often can supply substantial amounts of milk.

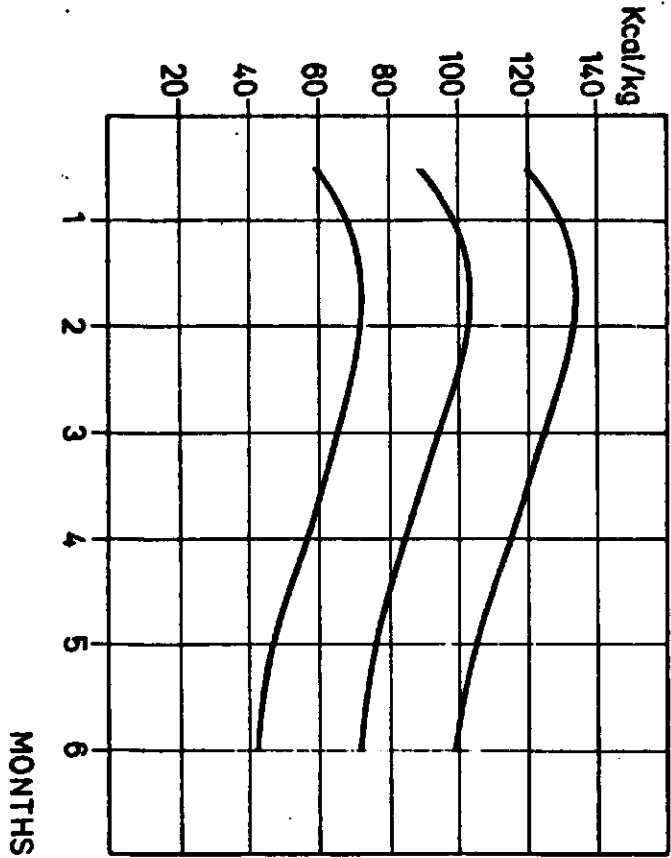


Figure 8a. Breast milk consumption expressed as average energy intake/kg body weight.

COMPOSITION OF BREAST MILK AND ITS ADVANTAGES FOR THE INFANT

Immediately after delivery, breast milk is yellowish and sticky. This is called colostrum, and is secreted for 10 to 14 days. Thereafter, the mature, white milk is produced. Colostrum differs from mature milk in that it contains less water-soluble vitamins, fat, and lactose; protein, fat-soluble vitamins, and minerals are present in larger amounts. The protein, which is about 1 percent in mature milk may be as high as 10 percent in early colostrum, and transfers to the newborn infant certain factors that protect it from infection, particularly during the first few days.

Protein: It can be seen in Table 5 that unmodified cow's milk has about three times more protein than human milk. Most of the protein is casein; a lesser amount is soluble whey protein. The abundance of casein causes a relatively tough

TABLE 5. AVERAGE VALUES/100 ml WHOLE MILK

Constituent	Mature human milk	Cow's milk
Energy*	Kcal 67	66
Total solids	g 12.4	12.7
Protein	g 1.2	3.3
Casein: Whey ratio	1:1.5	4.7:1
Lactose	g 7.0	4.8
Fat	g 3.8	3.7
Vitamin A (retinol)	µg 53	34
Carotenes	µg 27	38
Vitamin D	µg 0.01	0.06
Vitamin C	mg 4.30	1.80
Thiamine	mg 0.16	0.42
Riboflavin	mg 0.43	1.57
Niacin	mg 1.72	0.85
Pyridoxine	mg 0.11	0.48
Pantothenic acid	mg 1.96	3.50
Folic acid	µg 0.18	0.23
Vitamin B12	µg 0.18	0.56
Iron	mg 0.15	0.10
Calcium	mg 33	125
Phosphorus	mg 15	96
Potassium	mg 55	138
Sodium	mg 15	58
Chlorine	mg 43	103

*Calculated from protein, fat, and carbohydrate (lactose), using the factors of 4 calories per gram, proteins and carbohydrates: 9 calories per gram for fat. (Adapted from I.C. Macy, et al., 1953; published in *The Mammary Gland and its Secretion*, S.K. Kun and A.T. Cowie (eds), Volume 11, 1961).

curd to form in the stomach. Human milk has less total protein, but a much higher proportion of whey. This forms a softer curd, easier to digest, and more suitable for the infant.

Fat: About half the energy in human breast milk comes from fat that is absorbed much more easily by the infant than is the butterfat of cow's milk. Vitamins A and D are also carried in the fat of milk. The total fat content varies considerably from one woman to another, from one phase of lactation to another, and even during feeding. The first milk to flow during suckling, and called "foremilk," has a fat content of only about 2 percent, and looks "thin"; the last fraction, called "hindmilk," contains three times as much fat.

Lactose: This sugar is the only carbohydrate in milk. The content in human milk is higher than in cow's milk and varies little. In addition to providing an easily digestible source of energy, it is converted in the intestine to produce lactic acid. This acid medium helps to prevent the growth of undesirable bacteria and aids absorption of calcium and other minerals.

Minerals: Human milk contains much less calcium than cow's milk but, because it is more easily absorbed, it satisfies the bodily needs of the baby. Both cow's milk and human milk contain only small amounts of iron. Human milk also contains less sodium, potassium, phosphorus, and chlorine than does cow's milk, but this is beneficial for the suckling infant.

Vitamins: If the mother's diet is adequate, all the vitamins, with one exception, that are needed for nutrition and health during the infant's first four to six months are supplied in her milk. Vitamin D content, however, is low, and rickets may occur even in successfully breast-fed infants if their skin is not exposed to sunshine. The amounts of thiamine, vitamin A, and vitamin C have been found to vary according to the mother's diet. The values given in Table 5 presuppose that the mother's diet is a good one; low values have been recorded in several areas of the world where the maternal intake of these vitamins is inadequate.

ANTI-INFECTIVE PROPERTIES OF BREAST MILK

Antibodies against various microorganisms are transferred from the mother to the fetus via the placenta and help to protect the infant against certain diseases, the most important of which is measles, during the first four to six months.

Antibodies, or immunoglobulins, are also found in large amounts in colostrum and, during the first few days after birth, protect the infant against invasion of bacteria from the birth canal.¹² The immunoglobulins are not absorbed in the intestines in significant amounts, but provide protection against viruses, such as poliomyelitis, or bacteria that may cause infection. For instance, breast milk promotes the growth of certain types of protective bacteria, such as *Lactobacillus bifidus*, which dominates in the infant's intestine during the early weeks. These bacteria produce acids from lactose, making the stools acid and providing a hostile environment for several types of seriously infective bacteria and parasites. Infants fed on cow's milk have neutral or alkaline stools. The level of the immunoglobulins in maternal milk decreases rapidly after birth.

Human milk also has a high content of lysozyme, an enzyme that acts with antibodies against bacteria by breaking down certain of those that might be harmful. Cow's milk has a much lower lysozyme content.¹⁵

During the first two weeks, human milk contains considerable numbers of white blood cells (1000-4000/mm³), which may carry anti-infective properties from the mother to the infant. They are thought to act by destroying bacteria.

Lactoferrin, a special protein in human milk, has been shown to prevent the growth of certain harmful bacteria by denying them iron.

LACTATION AND ANTICONCEPTION

Menstruation usually returns to lactating women about 12 weeks after delivery.¹² There are wide variations, however, and at least one-third of the mothers who have nursed their babies continuously for nine months have not resumed menstruation at that time. Ovulation—the release from the ovary of an egg that can then be fertilized—usually recurs a little after the first menstruation, on average about 18 weeks after the birth. Ovulation might, however, start even before the postpartum menstruation.

Thus, although there is less chance of becoming pregnant before menstruation has returned and the mother has been nursing her baby and giving it no supplemental food, lactation should not be relied upon as a safe contraceptive.

LACTATION AND CANCER OF THE BREAST

Studies in industrialized countries have shown that the rate of cancer of the breast is lower among married than unmarried women, but there is no positive difference in the cancer rate between those who have lactated and those who have not. However, in developing countries, where lactation periods are longer and the birth rates higher, the rate of breast cancer is considerably lower.¹⁶ It would therefore seem that lactation, particularly if prolonged and repeated, may diminish the risk of cancer of the breast. However, factors other than lactation may have a preventive influence.

DIFFICULTIES IN BREAST FEEDING

In a developing country, and particularly in rural areas, breast-feeding causes little trouble and concern for the new mother. She has learned from her own mother, and watched relatives and neighbors. It is natural for her to put the newborn to the breast immediately after delivery, and to let it suck on demand. Often, she does not know about bottle-feeding as an alternative, although this practice is spreading even in remote rural areas. If the mother should fail to lactate, the infant's grandmother, a relative, or a wet-nurse may take over, but in

some areas a "nonmother" is reluctant to offer her breast as a substitute. The vast majority of women can breast-feed their infants, but a small percentage is unable to do so even temporarily. There are various reasons for this condition, some of which can be traced to the mother, some to the infant.

Causes Related to the Mother

Inverted nipples: Nipples usually start to protrude at the end of pregnancy and the beginning of lactation, but occasionally they do not, and so make it difficult for the child to suckle. In rare instances, and provided the mother can be taught and supervised properly, the milk can be extracted and fed to the baby by cup and spoon. Alternatively, the child may suck from an artificial teat that is fixed to the breast.

Cracks and fissures: If these appear on the nipple during the first few days, they are very painful and might make it impossible for the infant to suckle. Milk can then be expressed by hand for a day or two while the nipple is allowed to heal.

Breast-milk congestion: This can occur a few days after delivery or at any other time during lactation. The whole breast, or even part of it, might be tender or swollen and infection may develop in the congested segment, and high fever can result. In this case, it is important to continue to empty the breast. This can be done by hand or, if the mother has no fever, by the infant. Gentle massage can be given to the breast and, if available, a cooling bandage applied to it.

Size of breast: If the breasts are very small, they might produce only limited amounts of milk. On the other hand, if the breasts are large and have big nipples, infants, particularly if undersized, might have suckling difficulties.

Chronic or severe illness: The mother may be chronically or acutely ill with tuberculosis (TB), for instance, another type of lung infection, or malaria. If the mother is under treatment for TB, there is no reason she should not breast-feed, although the infant is sometimes given prophylactic medication in addition to a BCG vaccination. Severe illness usually reduces the milk volume considerably, but if the mother's illness is treated promptly and the baby continues to suck, the milk usually returns. Undernourished or starving mothers produce less milk than the well-nourished, and it has been shown that supplementation of a poor diet will increase milk yield.^{17,21}

Causes Related to the Infant

If the infant is born prematurely or has a low weight at birth, it may be too weak to suck properly. An infant ill or with fever suffers in a similar way. A cleft lip or palate also might make suckling difficult or impossible. In these situations, it is even more important that clean, nutritious milk is available to help in the baby's recovery. The only alternative is to express the milk and feed the infant by cup and spoon.

Chapter 3

Weaning

The term wean is from an ancient word that means "accustom"; thus it has come to mean the period during which an infant gradually becomes accustomed to foods other than breast milk. This also has been called the "transitional period," and in many developing countries it covers the time between six months and about 2½ years, when the incidence of protein-energy malnutrition and other deficiency diseases is at its height.

The well-being of the infant during weaning depends on: the environment in which the baby lives; the length of the period on breast feeding alone; whether the weaning is abrupt or gradual; the quantity and quality of weaning foods.

FACTORS INVOLVED IN WEANING

The intimate relationship between mother and infant, which starts in the womb and continues after birth, starts to break up after breast-feeding ceases. Then interactions are weakened between mother and baby, and the effect of the reduced contact might have serious consequences if weaning is too abrupt. In some cultures, for instance, the break occurs when the mother again becomes pregnant and, more particularly, when the young child is separated from her completely and sent away to grandparents.

One of the greatest dangers of the weaning period can be the results of the change over from sterile breast milk and its anti-infective factors to animal milk, semisolid and solid foods, often acquired, stored, and fed in unhygienic and unsanitary fashion. In fact, the weaning process is associated with the highest rate of infection, particularly of the gastrointestinal tract, that the child will encounter in its entire lifetime. Infections, in turn, prepare the way for malnutrition and increase the bad effects of dietary deficiencies.

Weaning starts at various times, and is considered to end when breast-feeding is stopped completely. As we have mentioned, weaning may not begin until well into the second six months of life and may be extended for more than two years. In exceptional cases, it might last up to four years. In the poor urban communities, on the other hand, there is a clear-cut tendency to start weaning when the infant is only a few months old. Sometimes the process may be extended to a year or more, but often breast-feeding stops before six months of

age, and from them on the young child must depend solely on foods other than breast milk. This is critical, and often leads to early marasmus or frank undernutrition.

Among urban families, if the women are in the labor force, they might be entitled to paid maternity leave for a month or two and breast-feeding might be replaced with bottle-feeding by the time the infant is just a few weeks old. Arrangements should be made at a mother's place of work to enable her to breast-feed her baby for a suitable length of time.

Many different patterns lie between these extremes. Numerous reports from industrialized countries indicate a decline and a change in the pattern of breast-feeding. In North America and Europe, there has been a steady decline since the 1930s, and today only a small percentage of infants are breast-fed for as long as six months. Previously, breast-feeding was most common in the lower social classes, but today women of the higher social classes and of good education are found to breast feed their babies more often.

Unfortunately, in the developing countries there seems to be the same trend toward shortening the duration of lactation and making more extensive use of "breast-milk replacers." This tendency is spreading from the privileged to the less-privileged classes in developing countries, especially in towns. Jelliffe remarks that "the trend away from breast-feeding toward artificial feeding with cow's milk, usually employing a bottle, is one of the most disastrous exports from the western world in recent times."¹⁸

Early cessation of breast-feeding is generally related to one or more of the following:

1. Loss of confidence, or feeling that the child does not get sufficient food, even though no signs of underfeeding are apparent. If alternative supplies are available, bottle-feeding is often started, particularly if the child cries at night.
2. Intensive and repetitive advertising that many mothers are unable to resist. Skilled commercials show a smiling, fat, healthy child, presumably the result of having eaten formula X.
3. Economic factors. Because an increasing number of urban women must work, the child is left with a relative. In only a few countries are lactating mothers guaranteed, by law, short pauses in their factory work-time for breast-feeding.
4. Education. All too often, western-trained doctors and other health workers lack interest in the method of feeding. Often, they even promote artificial feeding.
5. Status. The use of tinned milk products as a status symbol.
6. Social factors. The concern that breast-feeding in public is immodest and/or will spoil the mother's figure.

IMPORTANCE OF BREAST-FEEDING

The advantages of breast-feeding have been widely recognized, particularly for the infant in developing countries. Some of the more important advantages are:

1. Breast milk is clean and readily available. It is convenient, has the right composition at any moment, and is relatively inexpensive.
2. Breast-fed infants tend to contract infections later than do bottle-fed babies. They also have fewer and milder infections and show a lower mortality rate. This has been confirmed in many studies in developing countries, and was true in Europe half-a-century ago.
3. Breast-feeding gives the mother an emotional satisfaction. Because she feels indispensable, a close and happy contact between her and her infant is established.

Many disadvantages and dangers confront an infant, particularly one from a poorer section of society in tropical and subtropical countries, if breast-feeding is ended during the first few months of life. Most importantly, harmful bacteria grow in animal milk if it is not handled in a hygienic way, and powdered milk or fresh cow's milk is expensive, and so might be overdiluted or given in insufficient amounts as an economy measure.

Mothers who deliver at a hospital or a delivery clinic are exposed to the practice of bottle-feeding. "Milk-nurses," who are representatives of milk or baby-food companies, often make regular rounds, distributing feeding bottles and, often, sample tins of breast-milk replacers free of charge. Many poor and uneducated mothers do not realize that once bottle-feeding is introduced and the infant satisfies its hunger, thirst, and energy needs in this way, breast-milk production decreases.

COST OF REPLACING BREAST MILK

Breast-milk replacers are expensive. If bottle-feeding is practiced, probably the nutritional needs of the infant in a lower-income group will not be met, because replacers take too much of the food budget available for the entire family. More details of costing are given in Chapter 11 and Table 16.

CUSTOMARY WEANING FOODS

Weaning usually is not difficult in industrialized countries, where it often is interpreted as the changeover from cow's milk formulas to a mixed diet, including cow's milk. Prepared weaning foods are commonly obtained in con-

venient cans or glass containers. An increasing number of mothers in developing countries follow, or try to follow, this type of weaning schedule, an outline of which is shown in Figure 28. This explains how weaning may be arranged in a country with high economic and hygienic standards. This is sophisticated and appears complicated. In developed countries mothers have frequent contact with nurses who work in Maternal and Child Health Centers (MCH), and who give them continuous advice and instructions. In developing countries, a wide variety of foods is used during the weaning process, and breast milk is also given daily. Many foods are prepared according to local custom and tradition, but seldom specifically for the young child.

In most industrialized societies, the infant is scheduled to have about four regular meals a day during the second half-year of life, including one or two milk feeds from either the breast or a formula. In many tropical areas, the baby nibbles, so to speak, and sucks the breast or is given a bottle frequently, maybe 10 to 20 times a day, in response to crying or restlessness. The same is often true with the additional food, for the young child may be given small portions more or less continuously throughout the day. It is difficult for even the mother to estimate the total amount of food intake, but investigations have shown that often the baby is not given enough food, and what there is, is of poor quality. Therefore, it is important to teach mothers that *enough* food of the *right kind* must be given or the infant will become undernourished. Chapter 15 has a number of recipes suitable for use during weaning, based on the staple foods available in various parts of the world.

WHEN TO WEAN

Provided the infant is growing well, the mother is properly nourished and has an adequate flow of milk, additional food should not be given before the child is four- to six-months old. Up to that time, the breast milk contains all necessary nutrients except vitamin D, which the infant will get if exposed to daily sunshine. At about six months of age, when the first teeth begin to appear, and during the next six months, the baby can more easily manage well-cooked, mashed, and chopped foods.

In the poor sectors of developing countries, weaning should be extended over one to two years, if possible. This will provide the young child with valuable breast-milk protein to supplement other foods.

HOW TO WEAN

Weaning should always be gradual. It takes time for a young child to become accustomed to the new and different tastes of mashed foods, vegetable mixes, paps, porridges, or other milks. It also takes time to learn how to handle a mouthful of solid or semisolid foods after being accustomed to liquids. In addition—and this is easily forgotten—the baby should be weaned very gradually from constant, close, comforting contact with the mother.

ON WHAT TO WEAN

Conditions vary from country to country and from rural to urban areas, so it is not possible to formulate a weaning schedule that will suit all conditions and all young children. Therefore, weaning schedules best-suited to each region should be worked out locally by the appropriate health personnel. This requires knowledge about breast-feeding patterns, existing weaning practices, and the available foods, either those produced by the family or purchased at the local market. It is a good rule to try to modify existing feeding practices, rather than condemning them. The same applies to those weaning foods that have poor nutritional value; that is, modify them so that they are more nutritious and suitable for the young child.

A simplified weaning process for a mother in a developing country has been devised and is shown as Figure 29, Chapter 14. It was planned on the assumption that the mother is breast-feeding fully for more than six months, and that double and multimirxes are introduced only in the second half of the year, starting with small portions of soft fruits and mashed vegetables at about four months. These mixtures will be described in detail in later chapters.