Chapter 5 Breast Feeding

Infants normally thrive on their mother's milk. The period of neonatal life and early infancy is characterized by rapid growth, so that the average baby at 4 months of life weighs twice as much as at birth, and three times as much when 12 months old. This increase in growth includes increased muscle mass, growth of organs, expansion of blood volume and linear increase in the long bones. The nutrients required to sustain such a rapid growth are all supplied by breast milk alone in the first 3-4 months of life, in all infants. The composition of human milk should therefore provide a clue to the physiological needs for energy and nutrients in infants.

PROTEIN REQUIREMENTS

Many of the components in human milk have dual roles, one as a nutrient source or to facilitate nutrient absorption and the other as an enhancer of host defense or gastrointestinal function. The composition of human milk is also remarkable for its variability, as the content of certain nutrients changes during lactation or throughout the day or differs among women. This variability in component composition probably adapts the nutrient composition to specifically meet the needs of the infant, while the lack of homogeneity possibly allows better acceptance of new flavors and foods. A comparison of the composition of human milk and bovine milk is depicted in Table 5.1.

Table 5.1 Composition of Mature Human Milk and Bovine Milk

Component, unit/L	Human milk	Bovine milk
Energy, kcal	680	680
Protein, g	10	33
% Whey/casein	72/28	18/82
Fat, g	39	38
% MCT/LCT	2/98	8/92
Carbohydrate, g	72	47
% Lactose	100	100
Calcium, mg	280	1200
Phosphorus, mg	140	920
Magnesium, mg	35	120
Sodium, mg	180	480
Potassium, mg	525	1570
Chloride, mg	420	1020
Zinc, µg	1200	3500
Copper µg	250	100
Iron, µg	300	460
Vitamin A, IU	2230	1000
Vitamin D, IU	22	24
Vitamin E, IU	2.3	0.9
Vitamin K, ug	2.1	4.9
Thiamin (vitamin B,), ug	210	300
Riboflavin (vitamin B_2), µg	350	1750
Pyridoxine (vitamin B_6), ug	93	470
Niacin, mg	1.5	0.8
Biotin, ug	4	35
Pantothenic acid, mg	1.8	3.5
Folic acid, ug	85	50
Vitamin B_{12}, ug	1	4
Ascorbic acid, mg	40	17

There are three main classes of proteins in milk: (i) casein, (ii) α-lactalbumin, and (iii) β-lacto globulin. Human milk contains about 0.4 percent casein. The remainder consists mainly of lactalbumin and lactoglobulin.

In addition to providing nourishment, the proteins of milk are also associated with certain specific functions. For example, the proteins of the casein group form micelles with calcium and phosphates and are important carriers of these minerals. The amount carried in this manner in milk greatly exceeds the quantities present in simple aqueous solutions.

In the first few weeks after birth, the total nitrogen content of milk from mothers who deliver premature infants *(preterm milk)* is greater than of milk obtained from women delivering full-term infants *(term milk)*). Usually, beyond the first few weeks of lactation, the total nitrogen content in both milks declines similarly to approach what we call *mature milk*. Despite the decline in nitrogen content, the protein status of breastfed infants is normal at 1 year of age. Approximately 20% of the total nitrogen is in the form of nonprotein nitrogen-containing compounds, such as free amino acids and urea, in contrast to bovine milk, which has 5% nonprotein nitrogen. There is debate as to how much these non-protein nitrogen-containing compounds contribute to nitrogen utilization. The rate of absorption of non-protein nitrogen, determined by stable isotope methods, has been estimated at 13 to 43%.

It is now increasingly realized that the amino-acid composition of the protein in breast milk is biologically the most suitable for the human infant. Several studies have been carried out to estimate the requirement for individual amino-acids in infancy. In one study infants were fed mixtures of amino-acids in various combinations, and the level of individual amino-acids in the mixture which supported adequate growth was taken as the optimum level. In another study infants were fed a variety of milk formulae in quantities that maintained adequate growth and the concentration of the individual amino-acids in the milks was then calculated. Using the data from these two studies, an Expert Committee of the World Health Organization (W.H.O.) made recommendations about the amino-acid requirements of infants. In Table 5.2 data from these two studies, as well as the quantities of individual amino-acids recommended by W.H.O. are compared with the concentration of the same amino acids in human and cow's milk protein.

Table 5.2 Estimated requirements of essential amino-acids and their concentration in human and cow's milk protein

Amino-acid	Amino-acid mixture which will maintain adequate growth (mg/kg/day)	Amino-acid content of various formulae which will maintain adequate growth (mg/kg/day)	The lower value (mg/kg/day)	Intake of 165 mllk g/day Breast milk (mg/kg/day)	Intake of 165 mllk g/day Cow's milk (mg/kg/day)	Suggested* pattern mg/g protein	Human milk mg/g protein	Cow's milk mg/g protein
Histidine	34	28	28	36..3	156.75	14	20	27
Isoleucine	119	70	70	112.2	376.2	35	61	65
Leucine	229	161	161	165	577..5	80	90	100
Lysine	103	161	103	120.45	457	52	66	79
Methionine and cysteine	45 + cys.	58	58	77	198	29	42	34
Phenylalanine and tyrosine	90 + tyr.	125	125	179.8	579	63	98	100
Threonine	87	116	87	82.5	270.6	44	45	46
Tryptophan	22	17	17	29.7	80.8	85	16	14
Valine	105	93	93	115.5	404.2	47	63	70

* Joint F.A.O./W.H.O. Expert Committee, 1973.

In adults, eight amino acids are essential. They cannot be synthesized in the body and must be supplied in food. These are isoleucine, leucine, lysine, methionine, phenylalanine, threonine, tryptophan and valine. Infants require these eight plus histidine. Precise information on the requirement of amino acids at different periods of growth in the infant is lacking. Based on studies of intake of breast milk in Swedish infants and the composition of human milk, information about average daily intake of various amino acids at different ages can be derived (table 5.3).

Table 5.3 Estimated daily intake of energy, protein and essential amino acids at different ages in breast-fed infants

	1 month	2 months	3 months	6 months
Mean intake of breast milk (ml)	600	727	765	780
Calories	420	509	535	546
Protein (g)	6.4	7.7	8.2	8.3
Amino acids (mg)				
Histidine	186	225	237	241
Isoleucine	402	487	512	522
Leucine	720	872	918	936
Lysine	540	654	688	702
Methionine	114	138	145	148
Phenylalanine	288	348	367	374
Threonine	348	421	443	452
Tryptophan	180	218	229	234
Valine	522	632	655	678

The protein quality (proportion of whey and casein proteins) of human milk (30% casein, 70% whey) differs from that in bovine milk (82% casein, 18% whey). The caseins are a group of proteins with low solubility in acid media. Whey proteins remain in solution after acid precipitation. Generally, the soluble proteins in the whey fraction are more easily digested and tend to facilitate more rapid gastric emptying. The whey protein fraction provides lower concentrations of phenylalanine, tyrosine, and methionine and higher concentrations of taurine than the casein fraction of milk. The pattern of amino acids in the plasma of breastfed infants is used as a reference in infant nutrition.

The types of proteins contained in the whey fraction differ between human and bovine milks. The major human whey protein is α-lactalbumin, a protein involved in the mammary gland synthesis of lactose and a nutritional protein for the infant. Lactoferrin, lysozyme, and secretory immunoglobulin A (sIg A) are specific human whey proteins involved in host defense. Because these host-defense proteins resist proteolytic digestion, they are capable of a first line of defense by lining the gastrointestinal tract. The three host defense proteins are essentially absent in cow’s milk. The major whey protein in cow’s milk is β-lactoglobulin.

Amino-acid pattern

Besides the total quantity of amino acids present, the proportion in which they occur is also important with regard to the utilization of a protein food. The relationship of each individual amino acid to other amino acids determines the efficiency of its utilization by the body. Hence the pattern of amino acids in food is one of the important factors influencing the total amount of protein required. Each individual protein has its own turnover rate, responding in a specific way to any change in metabolism. The turnover in the whole body is the result of these activities. Feeding studies in infants show that the pattern of amino acids found most suitable for supporting growth also resembles closely the pattern found in breast milk. Table 5.4 compares the patterns of requirement in infants with those of breast milk, cow's milk and egg proteins. It is obvious from the table that the protein of breast milk will be utilized with the greatest efficiency by the infant.

Table 5.4 Comparison of patterns of amino acid requirements with that of milk and egg proteins (mg per g of protein)

Amino acid	Suggested pattern of requirements	Composition of protein: Human milk[b]	Cow's milk	Egg
Histidine	14	29	27	22
Isoleucine	35	62	47	54
Leucine	80	112	95	86
Lysine	52	84	78	70
Methionine and Cystine	29	41	33	57
Phenylalanine and Tyrosine	63	80	102	93
Threonine	44	54	44	47
Tryptophan	8.5	28	14	17
Valine	47	81	64	66

a Joint FAO/WHO Expert Committee, 1973.

b DHSS Report on Health and Social Subjects, No. 12. HMSO, London, 1977.

Human milk has a high concentration of free amino acids equivalent to a fifth of total milk nitrogen compared with 5 per cent in cow's milk and most milk formulae. Moreover, amongst the amino acids of human milk, free taurine is prominent, in contrast to its low concentration in cow's milk and its virtual absence from formula feeds. Infants cannot synthesize taurine from cysteine, which should be a matter of concern in view of the high concentration of taurine found in the developing central nervous system of the newborn in many species including man.

Metabolism of milk protein

Do the quality and quantity of protein in the infant's diet affect his well-being in any way? Present evidence suggests that it is almost certainly so in the case of the low birth weight infant and very likely so in the case of the normal newborn. In the pre-term infant many of the enzyme systems in the liver are not fully developed. For example, the mechanism for synthesizing cystine from methionine is incomplete in the pre-term baby, so that unlike the adult, he must rely on an exogenous supply of cystine. Cow's milk is a poor source of cystine and infants fed on cow's milk-based formulae are likely to experience a deficiency of this amino acid. In the same way, the capacity for the breakdown of amino acids is impaired in pre-term infants, especially with regard to phenylalanine and tyrosine. When these babies are fed cow's milk based formulae, with high protein concentrations, the blood levels of these two amino acids rise, reaching in some cases levels as high as those in phenylketonuria. Furthermore, these high blood concentrations are known to persist for as long as 6 weeks. Hence, from this point of view alone, there are several risks in the artificial feeding of infants. These risks are greater in the pre-term infant or in the infant whose physiological reserves have been compromised by asphyxia, trauma, infection or congenital defects. The inability to handle protein in large amounts or of different composition may persist into the second half of infancy. In one study healthy infants exclusively breast fed until 3 months old were randomly assigned to formulas containing 1.3, 1.5 or 1.8 g/100 ml of cow's milk protein. They were compared with infants still being breast fed (BF group) and another group that was receiving breast milk and formula (Mixed Feeding group). At 6 months serum urea levels were lower in breast fed and mixed fed groups compared with urea levels in all three formula fed groups. Also plasma levels of phenylalanine, tyrosine, and methionine were higher in all formula fed groups. Plasma levels of valine, isoleucine, and threonine were higher in infants consuming formula with 1.5 and 1.8 g protein /100 ml. At 12 months plasma levels of tyrosine, methionine, valine, isoleucine and leucine were higher in those infants receiving formula containing 1.8 g protein /100 ml.

The type of protein also matters. In another study infants were fed formula containing 1.5 g protein/100 ml. but one group in which the protein was made up of 60% whey protein and 40% casein, and another group receiving protein of composition 18% whey protein to 82% casein. The two groups were compared with infants who were exclusively breast fed. The levels of citrulline, threonine, phenylalanine and tyrosine were higher in the plasma and urine of both formula fed groups compared to the breast fed infants. The levels of tyrosine and phenylalanine were higher in the plasma of infants fed the casein predominant formula than in those fed whey predominant milk. But the concentration of taurine was lower in the plasma of both formula fed groups compared to the breast fed infants. This study shows how difficult it is to get the amino acid composition of formulas right.

With regard to amino acid composition, the two main characteristics of human milk are the low ratio between methionine and cystine, and the relatively low content of the amino acids phenylalanine and tyrosine. In fact, the protein of human milk is the only known animal protein with a methionine/cystine ratio less than 1.0. Only vegetable proteins demonstrate this property.

Milk fat (Tables 5.5 and 5.6)

The fat in milk is the main source of energy since, per unit weight it has twice the energy that can be obtained from either protein or sugar. It provides 40-50 per cent of the total calories in breast milk. Fat is present as globules consisting largely of triglycerides surrounded by a hydrophilic surface layer composed of a mixture of phospholipids, cholesterol, vitamin A and carotenoids.
The lipid system in human milk is structured to facilitate superior fat digestion and absorption. The lipid system comprises an organized milk fat globule, a pattern of fatty acids (high in palmitic 16:0, oleic 18:1, and the essential fatty acids, linoleic 18:2ω6 and linolenic 18:3ω3) characteristically distributed on the triglyceride molecule (the major fatty acid, 16:0, esterified at the 2 position of the molecule), and bile salt-stimulated lipase. As the lipase is heat-labile, it is important to recognize that the superior fat absorption from human milk is reported only when unprocessed milk is fed. Most manufacturers of infant formulas have attempted to modify their fat blends to mimic the fat absorption in human milk. Thus, the mixture of fatty acids in commercial formulas differs from that in human milk. Generally, to mimic the fat absorption from human milk, commercial formulas have a greater quantity of medium-chain fatty acids than human milk.

Present evidence suggests that most of the long-chain fatty acids of the milk triglycerides are derived from mother's dietary fat and transported in blood to the breast as triglycerides in chylomicrons. Hydrolysis occurs under the influence of lipoprotein lipase present in the capillary walls of the mammary gland, releasing free fatty acids and partial glycerides which are taken up by the alveolar cells and re-esterified. In animal experiments it has been shown that prolactin administration can result in fatty-acids from body stores being released for utilization in milk secretion by the mammary gland.

The acinar cell can synthesize short and medium-chain fatty acids by a step-wise condensation of acetyl coenzyme-A units up to a length of C16. The esterification of fatty acids with glycerol takes place on the rough endoplasmic reticulum to produce fat droplets, which then coalesce to form globules within the cell cytoplasm. In the alveolar cell numerous fat globules can be seen scattered all over the cytoplasm. The smallest are present in the basal region of the cell and a progressive increase in size occurs the nearer the globules are to the apical membrane. The increase in size is due to the accumulation of freshly synthesized fat and finally the fat globule is released into the alveolar lumen by an apocrine process in which a portion of the cell membrane is 'pinched off together with the fat globule. Thus the fat in milk is carried as membrane enclosed fat globules. The core of the globule is triglycerides which comprise 98 to 99 per cent of milk fat. The enclosing membrane is made up of phospholipids, cholesterol and proteins.

Naturally occurring fatty acids contain 4 to 24 carbon atoms in a molecule. Recall that according to the number of carbon atoms present, fatty acids are divided into long (18 or more carbon atoms), medium (8 to 12 carbon atoms), and short (4 to 6 carbon atoms) chain fatty acids. Short chain fatty acids are not abundant in food fats. Medium chain acids are also not very common, but are of interest because they are absorbed through the portal circulation instead of the intestinal lymphatics. Long chain fatty acids constitute the major proportion of fat in both human and cow's milk. As a general rule, the absorption of fatty acids in the gut is inversely related to the number of carbon atoms. The longer the chain, the less efficient is the absorption. On the other hand, the more the number of double bonds, the better the absorption.

In all milks the fat is largely made up of fatty acids with 14 to 22 carbon atoms. Depending upon the species, fatty acids occur in varying amounts of saturated and unsaturated ones. In human milk they are 95 per cent long-chain and 5 per cent medium-chain as compared to cow's milk which has 83 per cent long-chain, 5 per cent medium-chain and the remaining 12 per cent as short-chain fatty acids. Small amounts of branched and cyclic fatty acids as well as fatty acids with odd numbers of carbon atoms are also found. These are thought to derive from maternal dietary intake of such fats and do not seem to be of nutritional importance to the infant.

An important consideration in the synthesis of milk fat in the cow is the rumen, which acts as a large fermentation tank with a capacity of several gallons, depending upon the size of the animal. Cellulose is broken down in the rumen by the action of bacteria and protozoa and the products of this fermentation, like acetate, butyrate, etc., are utilized in the synthesis of lipids. Hence cow's milk contains a large proportion of short chain fatty acids. Moreover, the lipids within the rumen, being plant lipids, are highly unsaturated when they are first released from their vegetable source. They then undergo rapid hydrogenation in the fermenting environment of the rumen and are converted into saturated fats. These are then absorbed and contribute to the saturated fatty acids of milk.

The pattern of fatty acids in human milk is also unique in its composition of very long chain fatty acids. Arachidonic acid (20:4ω6) and docosahexaenoic acid (22:6ω3), derivatives of linoleic and linolenic acids, respectively, are found in human but not bovine milk. Arachidonic and docosahexaenoic acids functionally have been associated with cognition, growth, and vision.

The fat content of human milk changes during early lactation. It increases from 2.0 g/100 ml in colostrum to 4.9 g/100 ml in mature milk which is in keeping with increasing energy requirement of the growing infant. The fat content also varies during feeds, from 3.0 g/100 ml in midday fore milk to 4.0 g/100 ml in midday hind milk, and during the day from 3.0 g/100 ml in early morning milk to 4.5 g/100 ml in evening milk. During the transition from colostrum to mature milk the proportions of cholesterol and phospholipids relative to total fat content fall. This is almost entirely due to increase in concentration of triglycerides rather than to a decrease in concentration of the other two lipids. Phospholipids actually increase in concentration from 22.4 to 29.2 mg/100 ml.

Milk fat is an important source of energy and fat-soluble vitamins. The breast-fed infant is able to absorb more than 90 per cent of the ingested fat at the age of 1 week, compared to 70 per cent of the fat in cow's milk or the fat from proprietary formulae containing a mixture of animal and vegetable fats. The absorption of fat becomes more efficient as the infant gets older, but even at the age of 1 month breastmilk fat is absorbed better than that in cow's milk. In the newborn, especially if pre-term, the levels of pancreatic lipase and bile salts are low. Efficient fat absorption depends on alternate mechanisms for digestion of dietary fat, for example gastric lipolysis due to lingual and gastric lipase compensating for low levels of pancreatic lipase. An additional compensatory enzyme is the bile salt stimulated lipase in human milk. This lipase releases products of fat digestion which have a role in destroying gut parasites, such as Giardia. In endemic areas, breast-feeding protects against Giardia infection. This is an example of protection mediated without the intervention of immunoglobulins.

Table 5.5 Fat content of human and cow's milk per 100 ml milk

	Fat (g)	Choles-terol (mg)	Energy (kcal)	Total saturated fatty acids (mg)	Total mono-unsaturated fatty acids (mg)	Total poly-unsaturated fatty acids (mg)
Human milk						
Mean	4.2	16	70	2001	1612	317
(Range)	(3.7-4.g)	(12-23)	(65-75)			
Cow's milk	3.9	14	67	2330	1244	107

Table 5.6 Concentration of different fatty acids in human and cow's milk (mg/100 ml milk)

Fatty acid		Human milk	Cow's milk
Butyric	4:0	0	118
Caporic	6:0	0	74
Caprylic	8: 0	Trace	44
Capric	10:0	54	103
Lauric	12: 0	213	129
Myristic	14:0	290	413
Palmitic	16:0	1051	959
Stearic	18:0	393	413
Others		Trace	77
Total saturated		2001	2330
Myristoleic	14: 1	Trace	52
Palmitoleic	16: 1	160	100
Oleic	18: 1	1408	1026
Others		44	66
Total mono-unsaturated		1612	1244
Linoleic	18: 2	285	52
Linolenic	18:3	32	55
Arachidonic	20: 4	Trace	Trace
Others		Trace	Trace
Total poly-unsaturated		317	107

Of the macronutrients in human milk, fat is the most variable in content. The fat content rises slightly throughout lactation, changes over the course of the day, increases within-feed, and varies from mother to mother. Some investigators comment that the variability in fat content is related to the degree of breast emptying. The variation between individual mothers tracks through lactation, and although it is not affected by diet, it may be affected by maternal body composition.

Fatty acid composition of breast milk is dependent upon the source of fat in the mother's diet, and the total quantity of fat varies according to the adequacy of calories and other nutrients. Lipid content is also dependent upon the presence or otherwise of depot fat and its availability for the synthesis of milk fat. Thus, fatty acids of human milk are unique to each individual mother. Nonetheless, one can recognize a constant pattern in the lipids of human milk. When breast milk from mothers in different countries was analyzed, it was found that the most important difference lay in short chain fatty acids with 10 to 14 carbon atoms. These acids were in higher concentration in East African and Asian mothers. The high proportion of C10 to C14 acids was associated with a relatively lower proportion of C16 to C18 acids in both the saturated and unsaturated groups. This is probably due to the fact that Europeans live on a high-fat diet rich in C16 to C18 acids and the mammary gland has little need to synthesize new fatty acids. The East African communities use foods which are low in fat, and the high proportion of C10 to C14 acids in their milk is due to net synthesis within the breast of fat from carbohydrate sources. Thus the types of fatty acids in human milk are influenced primarily by the type and proportion of fat in the mother's diet. The fraction of milk lipids derived from endogenous fat synthesis within the mammary gland is increased on low-fat diets. In one trial a shift in dietary fat from 40 to 10% of total calories caused an increase in the milk content of short-chain saturated fatty acids.

Evidence from diverse populations indicates that the capacity to produce milk of sufficient quantity and quality to support the growth of infants is satisfactory even when the mother's dietary supply of nutrients is limited. The additional nutritional needs imposed by lactation do not require drastic alterations in diet. Around the world, vastly diverse diets support adequate milk production. On the other hand, a chronically deficient diet resulting in depletion of maternal nutrient stores may adversely affect milk composition. With the exception of extreme dietary deprivation, maternal energy intake seems to have only a weak effect on milk volume. Experimentally, short-term diet restriction to 1500 kcal per day for 1 week did not compromise milk production rates; however, there was some suggestion that diets with less than 1500 kcal per day compromised subsequent milk production.

When specimens of tissue fat in infants are analyzed for their fatty acid composition, it is found that the nature of body fat is largely determined by that of the dietary fat. Infants fed on human milk have a different composition of tissue fat from those fed on cow's milk or on milk formulae containing vegetable oils. This observation is important for two reasons. The brain and the rest of the nervous system undergo rapid growth throughout early infancy. Though the brain cells are largely developed by the time of birth, myelin is still to be laid along the axons and the dendritic connections. Fat is an important constituent of myelin, as indeed of the rest of the nervous system. The accumulation of long chain polyunsaturated fatty acids (C20 and above) in the developing brain starts before birth. It continues after birth and myelination is not complete until about4 years of age. The tissues of the new born infant are capable of synthesizing these long chain fatty acids from their precursors, chiefly linoleic (C18:2) and linolenic acids (C18:3). The brain appears to have a priority for the precursors when supplies are short. Animal experiments indicate that the brain lipids are altered according to diets fed to the newborn. There is no proof as yet that this is also the case in the human, but the results of animal experiments suggest that this cannot be ruled out. Thus, intake of biologically inappropriate fatty acids could produce a long-lasting effect on the growth of the nervous system. Secondly, as far as the intake of nutrients is concerned, the infant is dependent upon just one food source, milk. Unlike the adult who eats a varied diet and has several food sources providing a rich variety of nutrients, the infant's choice is restricted to those nutrients which are present in the milk with which he is being fed. There is virtually no margin of safety and any inadequacy in the milk will be translated into altered composition of body tissues being formed at the time. Such a deficiency is then likely to be carried over to a future period when the required nutrients become available and the deficiency can be corrected. Whether such a restructuring of myelin can occur is not yet known, but present evidence suggests that it is unlikely because of the very slow turnover rate of myelin.

Sixty percent of the total energy intake of the infant during the first year is utilized by the brain, and much of the energy used to construct neuronal membrane and myelin sheath of axons comes from fat in the milk. Thus fat is not simply a source of energy but is comprised of a series of complex hydrocarbon structures necessary for the creation of membranes. In this context human milk provides a supply of ready synthesized docosahexaenoic acid (C22:6 n-3) and Arachidonic acid (C20: 4n-6).

Improved **long term cognitive and motor abilities** in full term infants have been correlated with the duration of breast feeding. After adjusting for parents' socio economic status and education, significant increments in cognitive test scores at ages of 3, 4 and 5 years could be shown to parallel the duration of breast feeding. Similar improvements have also been reported in the case of pre term infants who received breast milk during their stay in hospital. The current thinking is that these improvements are due to a naturally correct mix of fatty acids in breast milk which helps in the structure of myelin being laid down in new-borns' brains at this early age. (See Fig. 5.1). Long chain polyunsaturated fatty acids like arachidonic acid (20:4 n-6) and docosahexaenoic acid (22:6 n-3) are highly concentrated in the phospholipid bilayers of biologically active brain and retinal neural membranes, and are important in neuronal function. Human milk contains these fatty acids in large amounts. As expected breast fed infants have significantly greater concentrations of docosahexaenoic acid (C22:6n-3) in their cerebral cortex phospholipids compared to infants fed formula milk.

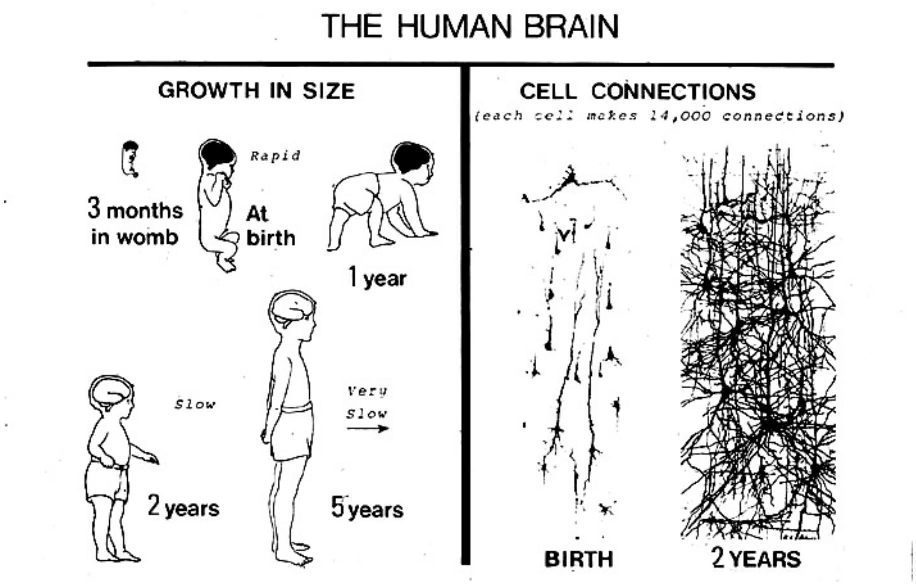


Figure 5.1 Brain growth. Even though an infant is born with a full complement of nerve cells rich connections between the neurons are established in early years, and myelin has an important role in the process.

The foetus and the newborn (especially if pre-term), the breast fed baby and the weanling all need fatty acids in the correct amounts and ratio to achieve full expression of their genetic growth potential, especially of nerve tissues. In an attempt to get the correct mix of fats, manufacturers of many brands of powdered milks modify the fat composition by removing butter fat from cow's milk and replacing it with vegetable oils (Table 5.7)

Table 5.7 Fatty acid composition of human and cow's milk, several proprietary infant feeding formulae and commonly used vegetable fats[b] in their manufacture

	Saturated					Unsaturated			
Fatty acids	C10:0	C12:0	C14:0	C16:O	C18:0	C16:1	C18:1	C18:2	C18:3
Human milk	1.3	5	7	25	9.3	3.8	33	6.7	<1
Cow's milk	2.7	3.3	10.8	25	10.8	2.6	27	1.3	1.4
SMA	1	10	6	16	11	1	29	24	2
Nativa	2	9	9	22	7	1	35	13	1
Almiron B	0	0	<1	11	2	<1	27	58	2
Farilacid	2	2	9	25	14	2	35	7	1
Frisolac	<1	6	3	32	4	0	38	16	0
Similac	2	19	7	9	3	0	19	40	<1
Milumil	1	4	7	35	8	1	32	10	0
Nan	2	4	11	31	9	2	24	16	1
Pelargon	2	2	8	24	11	1	30	16	1
Humana 1 and 2	1	7	4	23	8	<1	44	13	<1
Oleo oils	-	0.2	3.3	26	20	-	45.5	3.0	0.5
Corn oil	-	-	-	13	4	-	29.0	54.0	-
Coconut oil	6	49.5	19.5	8.5	2	-	6.0	1.5	-
Soya oil	-	-	Trace	11.0	4	-	25.0	51.0	9.0
Cottonseed oil	-	-	1.0	29.0	4	2	24.0	40.0	-

a Expressed as g/100 g total fat.

b Expressed as g/100 g of the oil.

This practice gives rise to even more difficulties. For example, when infants were offered feeds in which 60 per cent of the fatty acids were in the form of linoleic (C18:2) acid, a rapid increase in the amount of linoleic acid in the adipose tissue was noted. Such a change is accompanied by alteration in the phospholipid composition of cell membranes, especially of the erythrocytes. It was found that in pre-term babies fed infant formulae rich in poly-unsaturated fatty acids, the erythrocyte cell membrane becomes at risk of peroxidation. Iron added to the formulae generates free radicals which initiate the process of peroxide haemolysis of the erythrocyte. To avoid this, large amounts of vitamin E (an antioxidant) are needed.

Several reports on the **antiviral properties of human milk** have been published, and are discussed in the sections which follow. It has been shown that the lipid component of milk and colostrum has pronounced antiviral action against all dengue types of viruses as well as Japanese B encephalitis; St Louis encephalitis; West Nile, yellow fever, Herpes hominis and polio viruses. A strong relationship between lipase activity in milk and antimicrobial activity was demonstrated leading to the identification of monoglycerides and fatty acids as the active agents. Human milk has high lipase activity which helps fat digestion and the release of fatty acids and monoglycerides. The lipase is active even at low temperatures so that the digestion of milk fat begins long before the milk reaches the small intestine of the infant. Since free fatty acids are an important source of energy the lipase of breast milk ensures that free fatty acids are readily generated from the infant's food. The effect of lipase is also dependent upon the chemical configuration of the fat being hydrolyzed. For example, the most common of the saturated acids in both human and cow's milk is palmitic acid. In the case of human milk it is in the 2-position and is absorbed as 2-monoglyceride. In cow's milk it is in the 1- or 3-position from where it is liberated as free palmitic add in the lumen of the intestine, where it combines with calcium to form calcium palmitate soap and is excreted as such, resulting in loss of both fat and calcium.

Carbohydrate

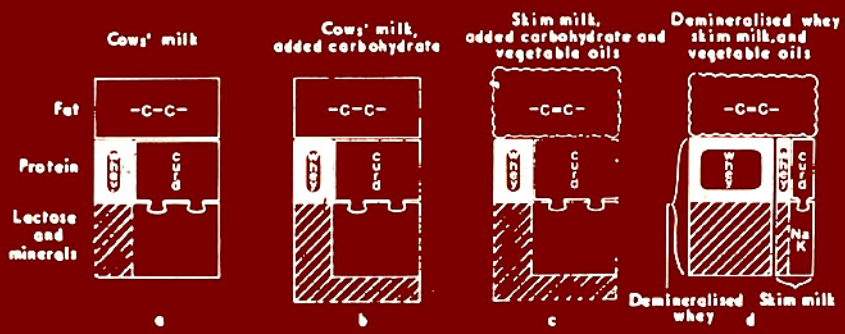
Lactose is the predominant sugar in the milk of most mammals, with very few exceptions. The extremes of variation in the lactose content of the milk of mammals are from 4 g per dl in the dog and the elephant to about 7 g per dl in man. By contrast, the fat composition can vary by almost 30-fold. This relative constancy of lactose secretion in milk is an indication of its important role in mammalian biology. The nature of this role needs to be determined, but for the present one can speculate along the following lines:

(1) Amongst the various sugars, per molecule (and hence per unit of osmotic pressure) lactose provides twice the calorific value of glucose. Since milk is secreted at the same osmotic pressure as plasma, there is less energy consumed in maintaining osmotic equilibrium when lactose is used as the main sugar. In human milk, lactose accounts for half the osmotic pressure, the remainder being due to monovalent ions like Na^+, K^+, Cl^-, etc. Because of the high concentration of lactose in breast milk, the solute content of breast milk is low, which makes it well suited for the immature kidneys of the infant.

(2) High concentration of lactose in human milk influences the pH of the gut in the newborn and its bacterial flora. Together with other immune factors to be described below, the high lactose content of breast milk prevents the growth of the potentially dangerous pathogen, Escherichia coli, and instead promotes colonization by Lactobacillus.

(3) It is likely that lactose is utilized for the synthesis of the galacto-lipids of the growing brain in the infant. In many mammalian species the quantity of galactose per unit weight of brain tissue of the off-spring is closely related to the lactose content of the mother's milk. However, children suffering from galactosaemia or lactose intolernce who receive diets free of galactose and lactose for many years since infancy have not shown any obvious ill effects. It has been pointed out that the glycolipids, glycoproteins and glycoamino-glycans of the central nervous system can be synthesized from glucose in the liver. Cow's milk is low in lactose; and so, in the manufacture of many infant feeding formulae, the first stage in the "humanizing' of cow's milk is to increase the sugar content. This is done either by adding more lactose or other sugars like sucrose, fructose, glucose and dextri-maltose. Except for the colonization of the gut by the potentially dangerous E. coli instead of the normal Lactobacillus, no immediate ill-effects have been reported as a result of feeding these abnormal sugars in early life. However, long-term ill-effects cannot be ruled out. For example, an association between inflammatory bowel disease and ingestion of refined sugars has been reported in adults. Also, endocrine responses in bottle-fed infants are significantly different from those who are breast-fed. The contrived and synthetic nature of many infant formulae together with the

presence of "unnatural' carbohydrates may play a role in setting the metabolism of formula-fed infants at a different level. (See Fig. 5.2)



Modifications of whole cows' milk (a) in manufacture of infant formulae; (b) added carbohydrate; (c) substituted fat; and (d) demineralised whey.

Figure 5.2 Structure of infant feeding formulae on the market

(a). unmodified cow's milk (b). cow's milk with added carbohydrate

(c).Skim milk with added carbohydrate and vegetable oils

(d). demineralized whey skim milk and added vegetable oils.

HUMAN MILK AS NUTRIENT

In each mammalian species, the milk has evolved together with the mammal to provide the offspring with nutrition best adapted to the environment. Thus, in the whale the milk contains large amounts of fat to help the infant lay down body fat for protection against cold and to aid buoyancy. In the kangaroo, the mother has two separate nipples, each producing milk of different compositions. The new-born kangaroo is first attached to one nipple, where he obtains milk of high protein concentration. When the offspring is grown and can leave the pouch for brief periods, he changes over to the other nipple and obtains from it milk of different composition.

The attempts of the food chemist to modify the milk of one mammal, the cow, for feeding another, the human infant, have been largely unsuccessful, notwithstanding the claims made in the promotional literature. The reasons are obvious. It is not just the question of adding a sugar to get the carbohydrate content right, or of diluting to get the protein content right, nor of replacing butter fat with a mixture of vegetable oils. The entire structure of the protein in human milk is so very different from that in cow's milk (figure 5.3).

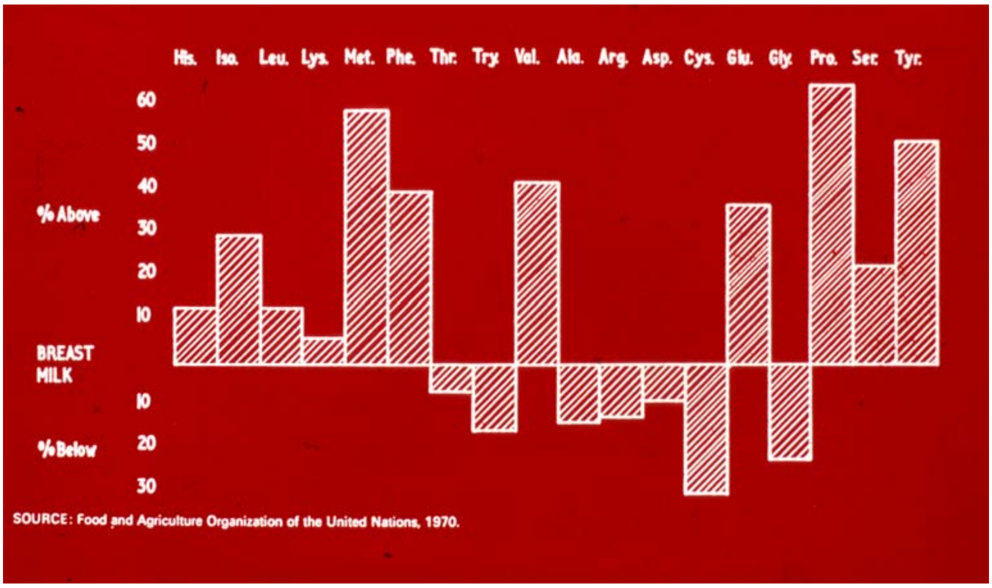


Figure 5.3 Comparison of the amino acid pattern of human and cow's milk protein using human milk protein as the standard. (The values, expressed as mg amino acid per g nitrogen in cow's milk, have been calculated as a percentage of those for breast milk expressed on the same basis.) (Source: Food and Agriculture Organization of the United Nations, 1970.)

The fatty acid composition is unique for each mother and so also are the electrolytes and trace elements. It is not surprising that the history of artificial feeding of infants is full of examples of one mishap after another - starting with rickets in the early part of the century, neonatal tetany in the early 1950s, pyridoxine deficiency in the late 1 50s and 1 60s and haemolysis due to vitamin E deficiency and risks of hypernatraemia (high blood sodium) in more recent years. Products promoted as "ideal foods' are withdrawn a few years later when their shortcomings are discovered, only to be replaced by another family of products which are again promoted with equal vigour.

The uniqueness of mother's milk in the nutrition of her infant is apparent when we consider the cellular mechanism of synthesis and secretion of its various constituents. Hormonal stimulation throughout pregnancy prepares the breasts for secretion of milk. Soon after the birth of the baby there is secretion of prolactin from the anterior pituitary. Together with other hormonal changes, it provides the stimulus for the activities of the several enzymes in the acinar cells of the mammary glands, leading to the synthesis and secretion of milk. Various cell organelles participate in the process. Synthesis occurs on the ribosomes in the rough endoplasmic reticulum in accordance with the genetic message carried within the cell nucleus. Thus, whereas the ribosomes and the rough endoplasmic reticulum provide the framework for the site of synthesis, the biological characteristics of the final product are determined by the DNA and the mRNA operating from the cell nucleus. The Golgi apparatus provides storage for the final product until it is emptied into the cell lumen (figure 5.4).

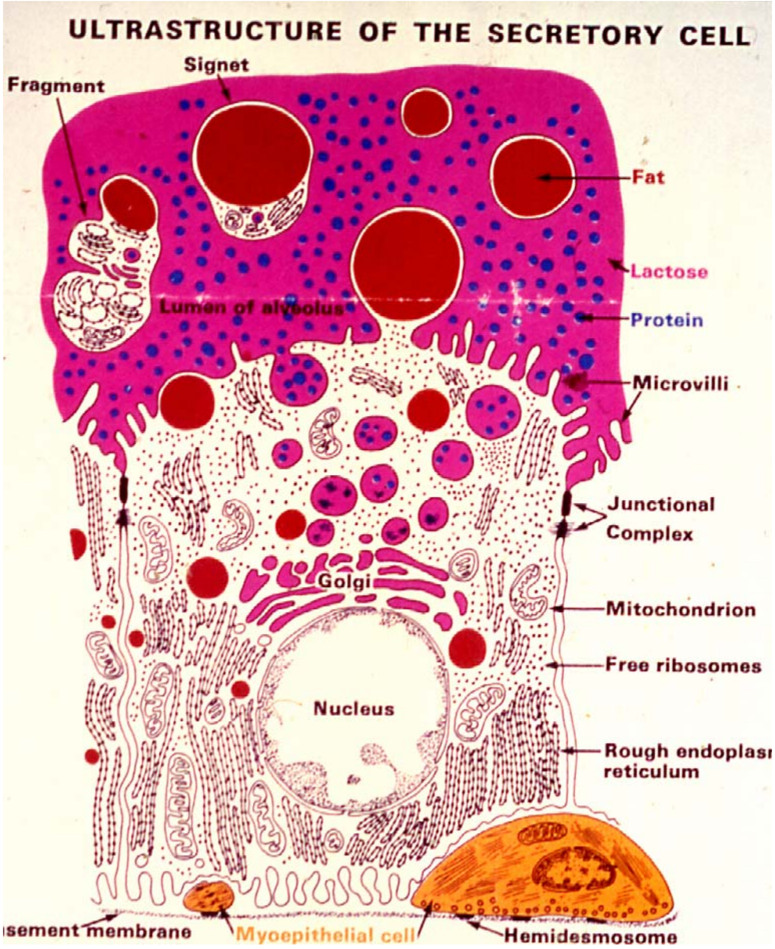


Figure 5.4 Ultra structure of the secretory cell

The raw materials for milk synthesis come from the mother's body either as substances circulating in the blood e.g. amino acids, or as products stored in her tissues, e.g. fats. Ultimately they are all derived from her diet. Thus, the interaction of the genetic constitution of the mother with her environment provides the raw material for the synthesis of milk in ways determined by the genetic code in the nucleus of the alveolar cell. The infant, on the other hand, is endowed by the mother with half of his genetic make-up. Hence from the biological point of view mother's milk is a better fit for the unique metabolic activity of the infant's tissues. No amount of dilution, addition, adjusting or so-called humanizing of the milk of another mammal will give the characteristic configuration of molecules and biological properties of a mother's milk for her offspring.

Minerals and Trace metals

Calcium and phosphorus are the two major mineral constituents of milk. They are present in milk in concentrations exceeding those in blood plasma so that active transport mechanisms for their secretion must exist. However, very little is known about the secretory mechanisms, except that the calcium and phosphorus ions bind with casein to form micelles and that such binding occurs in the Golgi vesicles.

The absorption of calcium and phosphorus in the gut of the new-born is dependent not only on the concentration of these ions in milk but also on other factors, especially fats and vitamin D. Unabsorbed fatty adds tend to form soap with calcium, which is then excreted as such. Several studies on the relation of fat absorption to that of calcium have shown that there is a positive relationship between the excretion of fat and that of calcium. Even with high levels of calcium in the feed, inadequate absorption of fat can lead to faecal excretion of calcium soap. Calcium absorption is also thought to be related to the proportion in which it is present with regard to phosphate. Human milk contains 33 mg of calcium and 15 mg of phosphorus per 100 ml as ompared with cow's milk, which has 125 mg of calcium and 96 mg of phosphorus. Balance studies have shown that when infants are fed breast milk, the retention of these minerals is in amounts equal to the estimated requirements for growth in spite of their comparatively low concentration in breast milk. This is partly because the two minerals occur in the correct proportion in breast milk and also because the fat in human milk is so well absorbed. Infants fed on unmodified cow's milk, either full strength or dilute, have low blood levels of calcium and in many of them the serum calcium is low enough to cause tetany. In several commercial preparations, the fat is now modified by replacing cow's milk fat with a mixture of vegetable and animal fats, and calcium as well as vitamin D are added so that tetany is rare; but in general, serum levels of calcium in breast fed infants are higher than those of infants fed on most formulae.

Breast milk was said to contain only small quantities of vitamin D and yet it is rare to see rickets in fully breast-fed infants even during winter months. The earlier assays of vitamin D were made on the lipid fraction of the milk, but recent work has demonstrated that, unlike cow's milk, most of the vitamin D in human milk is present in the aqueous phase as a sulphate. This water-soluble conjugate is present in concentrations of 0.91-1.78 μ/dl and is more than adequate for the infant's requirements of 10 μg/day.

The parts played by phosphorus and magnesium in neonatal physiology are not yet fully understood. In general, phosphate levels in serum tend to move in a direction opposite to that of calcium so that in tetany, where calcium levels are low, those of phosphate tend to be high. Some cases of tetany respond to the administration of magnesium and low levels of magnesium may have a causative role. With regard to electrolytes and minerals, establishment of homeostasis in the first few days of life is important, and colostrum is the main form of milk which helps to achieve it. The levels of the three minerals and the proportions in which they are present in human and cow's milk as well as some of the commercial preparations are given in Table 5.8.

Table 5.8 Concentrations of calcium, phosphorus and magnesium (mg/l) in human and cow's milks and in some commercial preparations

Milk type	Calcium	Phosphorus	Magnesium	Ca/P	Mg/P
Human colostrum	481	157	42	3.1	0.3
Human transitional	464	198	35	2.3	0.2
Human mature	344	141	35	2.4	0.2
Cow's milk	1370	910	130	1.5	0.1
Lactogen (1 to 9 dilution)	630	490	74	1.3	0.2
Ostermilk	560	460	49	1.2	0.1
Ostermilk 2	650	520	62	1.3	0.1
S.M.A.	560	440	53	1.3	0.1
Gold Cap—S.M.A.	440	330	53	1.3	0.2
Cow & Gate—Premium	550	400	45	1.4	0.1
Baby Milk Plus (1 to 8 dilution)	620	500	+ / -	1.2	

Trace Elements

The levels of trace elements such as iron, copper and zinc are generally higher in colostrum than in mature milk. Human milk is unique in the manner in which the trace elements are distributed among the various milk fractions. Relatively small proportions of these elements are associated with casein, relatively large proportions with whey, and significant amounts with fat. All trace elements in human milk occur as complexes bound to specific proteins called ligands. The ligands facilitate the transfer of their individual trace elements across the mucosal epithelium of the neonatal gut, thereby improving their bioavailability.

Very little is known about the mechanisms of secretion of trace metals such as copper, zinc and iron. In a study of 50 women between the 6th and 12th weeks of lactation it was found that the copper content of milk varied considerably among women and also within the same individual. The values ranged from 0.09-0.63 µg/ml. There is also variation in the amount of copper secreted at different times of the day, the morning milk having a slightly higher copper content than the evening secretion. As lactation proceeds the concentrations of iron and copper remain relatively constant. The secretion of zinc is high in early lactation and falls over the first month or so. In one study zinc concentration was reported to fall from 8µg/ml at day 1 post-partum to 3 (ug/ml at 28 days. Zinc concentration continues to fall after 1 month of lactation reaching 0.6µg/ml at 5 months.

The iron content of milk is also variable, the variations being present between women as well as in the same individual. The values range from less than 0.1 to 1.6 µg/ml. In the case of the healthy mother, the average healthy infant receives 0.35mg/kg/day of zinc and 0.05 mg/kg/day of both copper and iron.

DANGERS OF ARTIFICIAL FEEDING

We have already considered some of the dangers of feeding infants on formulae in which nutrients like proteins, fats, and carbohydrates are biologically unsuitable or present in unusual amounts. Long-term epidemiological observations, as well as carefully conducted metabolic studies, would be necessary to prove such dangers in a conclusive manner. The wide range of biological variability between individuals and the physiological margins of safety, added to the adaptability of each individual, make the interpretation of data difficult; there is therefore inevitable delay in obtaining conclusive evidence. For example, it has taken more than 25 years of painstaking research to prove the dangers of smoking; the relationship of saturated fats to coronary heart disease had to wait a similar long period before it could be conclusively established. The situation with regard to artificial feeding is identical in many ways. Thus the first reports of hypernatraemia in infants, associated with feeding of certain milk formulae, appeared in 1955, but it was not until the publication of a Working Party report in 1974 in the UK that several brands of powdered milk were withdrawn by the manufacturers. All these brands had enjoyed great popularity until then, and each one had been promoted by its manufacturer as desirable for infant feeding. Yet they all contained large amounts of electrolytes, enough to tax the infant kidneys' capacity, especially in warm weather or during an episode of fever or diarrhoea (figure 5.5). In many developing countries these brands of milk powders are still on sale. Due to the hot climate the dangers of hypernatraemia and electrolyte disturbances are even greater in the tropics.

Infants meeting their protein and calorie needs from breast milk obtain about 1 meq of sodium/kg per day, compared to 4.8 meq in the case of infants fed on full-cream cow's milk or unmodified dried milk powder. It is not widely appreciated that minerals are sometimes added to cow's milk during the manufacture of powdered milk in order to adjust the pH and make its composition stable. Sodium carbonate or bicarbonate are used in making some roller-dried and spray-dried milks, and sodium phosphate or citrate are added in the manufacture of evaporated milks. In some types of milks, whey protein neutralized with sodium bicarbonate is used. When such preparations are fed to an infant the immature kidneys are presented with a heavy solute load for excretion. In addition, the larger protein content of cow's milk also contributes to this excessive solute load. As a rough guide for calculating the renal solute load, each gramme of dietary protein is taken as providing 4 milli osmols, and each milli equivalent of sodium, potassium and chloride is taken as providing 1 milli osmol of such a load. The total available water for excretion by the kidneys (and carrying the solute load) is equal to the total amount ingested minus the insensible water loss and losses through faecal excretion. Figure 5.5 gives the renal solute loads in the case of some of the common milk preparations in a 5 kg infant who consumes 200 ml/kg/day at varying levels of insensible water loss. It is clear that in the case of unmodified cow's milk and some of the commercial preparations, the baby's renal concentrating capacity will be stretched, especially when the environmental temperature is high. For example, insensible water loss of 550ml is not unusual in environmental temperatures of 90°F which are not infrequent in many tropical countries. If, in addition, there is any intercurrent illness as well, such as fever or mild diarrhoea, such an infant will be

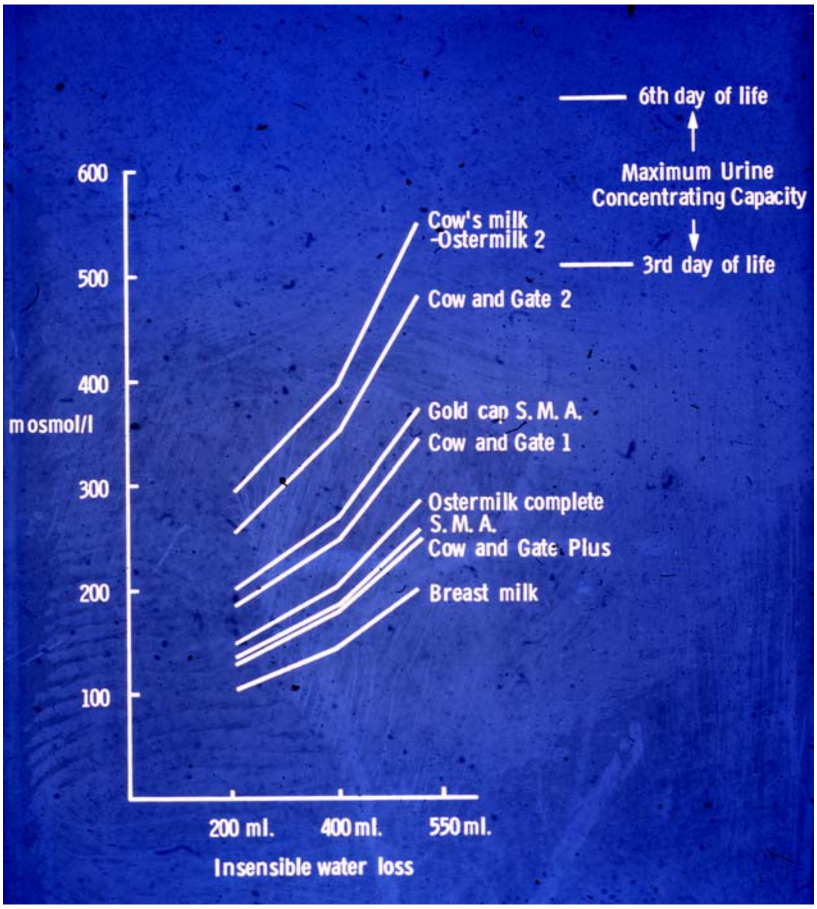


Figure 5.5 Urine osmolar load in a 5 kg infant fed on different milk formulae at 200 ml/kg/day with varying insensible loss.

The electrolyte content of breast milk is three to four times less than that of cow's milk (table 5.9). Because breast milk and cow's milk have the same calorie content per given volume, infants fed cow's milk will consume about 3-4 times as much sodium as an infant fed breast milk The fully breast-fed infant has a salt intake of 1 mmol/kg compared to the artificially fed infant who takes 5 mmol/kg. Mistakes in reconstitution are common, so that the actual sodium content of the feed tends to be higher and at times dangerously so. Solids tend to be introduced in the diet of the artificially fed baby at a much earlier age, so that the salt intake has been found to increase from 9 to 60 mmol/day in these infants. By comparison, in the fully breast-fed infant the salt intake increases from 2.6 mmol/day to 6.5 mmol/day. It is not surprising that babies fed cow's milk formulae have a tendency to develop hyper-natraemia. A relationship between hypertonic dehydration, over-concentration of feeds and cot deaths has been suggested as a result of post-mortem findings of high sodium concentration in the vitreous humor in a large number of cases of cot death.

Table 5.9 Electrolyte and mineral content of human and cow's milk

(m mol/litre)

	Na	K	Cl	Ca	Mg	P
Human milk						
mean	6.5	15.4	12.1	8.8	1.2	4.8
range)	(4.8-8.7)	(14.6-15.9)	(9.9-15.5)	(8.0-9.0)	(1.1 -1.3)	(4.5-4.8)
Cow's milk						
mean	21.7	38.5	26.8	30.0	5.0	30.6
range)	(15.2-39.1)	(28.2-43.6)	(25.4-31.0)	(27.5-32.5)	(3.8-5.8)	(29.0-32.3)

Source: DHSS (1977) and (1980).

Many of the dangers of artificial feeding arise from errors in reconstitution. In experiments in which mothers, trained midwives and health visitors took part, it was shown that there were wide individual variations in the quantity of milk powder measured for preparing a given volume of feed. The amount of milk powder measured could vary by as much as 20-30 per cent from that recommended by the manufacturers. In the case of babies from well-to-do homes, over concentration of feeds is the rule. Since this danger was recognized in 1972 and national campaigns started in many West European countries, the incidence of hypernatraemia has dropped markedly.

Another danger which is not fully recognized yet is that of metabolic acidosis. Most infant formulae which are based on cow's milk present a greater acid load to the infant compared to breast milk. There is a significantly higher likelihood of acidosis in bottle-fed infants. Diarrhoea and dehydration in bottle-fed infants carry the added risk of metabolic acidosis besides hypernatraemia. As with the solute load, the pH falls with concentration of feeds, each extra scoop lowering the pH by 0.05 in the case of some brands.

Optimal growth is only possible in a well balanced “inner milieu”. Pre-term infants are especially vulnerable to disturbances of acid-base metabolism because of low renal capacity for net acid excretion. When 452 low birth weight infants were screened for spontaneous development of incipient metabolic acidosis (urine pH < 4.5 on two consecutive days), 149 such episodes were noticed.

The dangers of artificial feeding are most obvious in Third World countries. Breast feeding has declined sharply in several countries in the face of intensive promotion by the manufacturers, and in the absence of a strong professional and governmental support for breast feeding. Many mothers take to artificial feeding only to find that the family income is inadequate to pay for the cost of powdered milk. In one survey of ten countries in the Third World it was revealed that the cost of artificial feeding a 6 month-old infant could be as much as a third to a half of the minimum wage. In fact, because of the high levels of unemployment, many wage-earners accept employment at wages far lower than the statutory minimum wage. Thus the true cost of artificial feeding could well be a sizeable proportion of the family income. The temptation to "stretch' one can of milk powder is only too great in such a situation with consequent underfeeding of the infant. In 1972, in Barbados, only 18 per cent of the poorer mothers were using a 11b (0.45 kg) can of powdered milk for 4 days or less, as indicated by the manufacturer. The majority extended the use of the milk from 5 days to as much as 3 weeks. It is not surprising, therefore, that the decline of breast feeding in the developing world is accompanied by a high incidence of undernutrition in children. (See Figs. 5.6, 5.7 5.8 and 5.9)

Figure 5.6 (left) In a village street in India an infant is left un attended with a bottle

Figure 5.7 (right) Close up showing marked under nutrition.

Figure 5.8 and Figure 5.9 Dangers of artificial feeding

An additional danger in the overcrowded homes of the poor is that of infected feeds due to lack of hygiene and the inability to care for the feeding bottles and mixing utensils properly. Diarrhoeal illness in early infancy and in the absence of adequate primary health care facilities can be life-threatening. (See Fig 5.10).

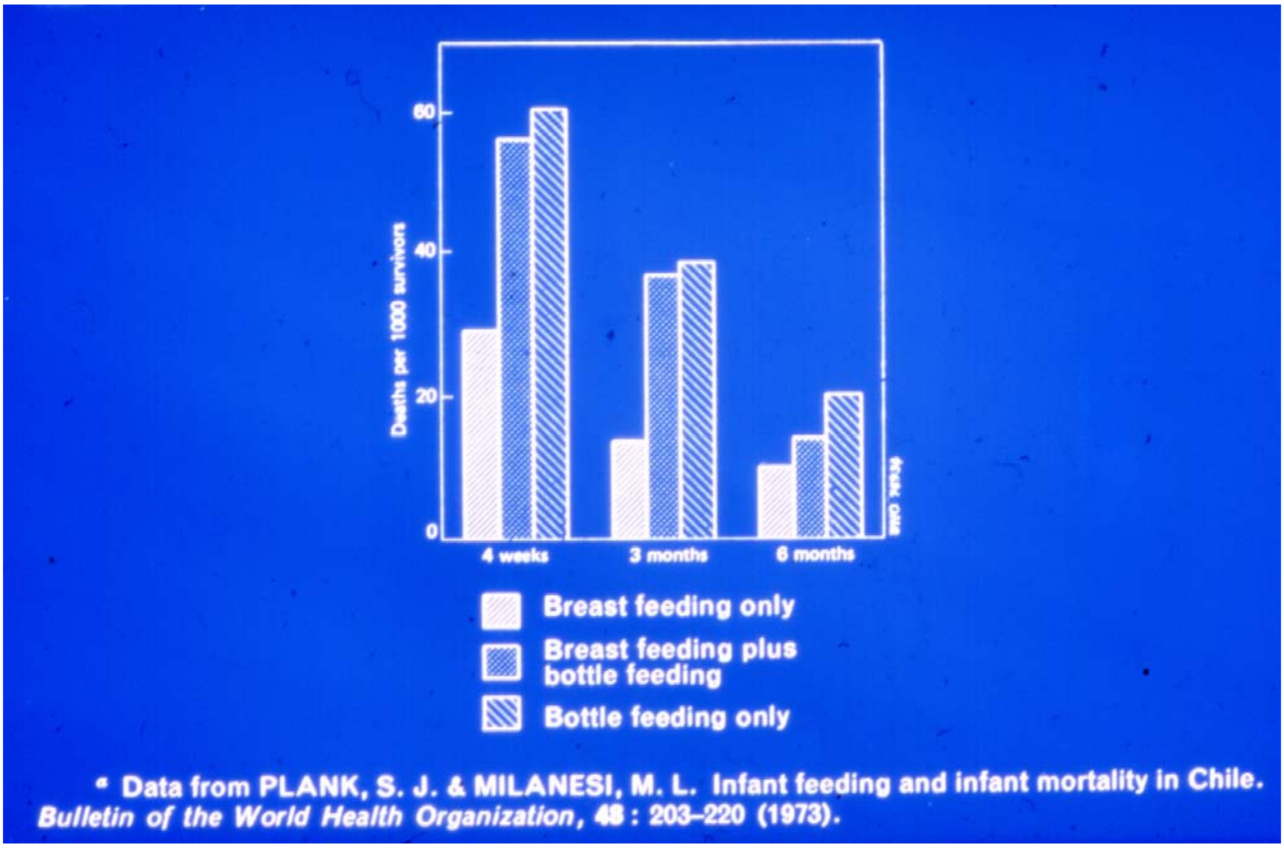


Figure 5.10 Survival rates of infants by method of feeding

It has been estimated by UNICEF that every year 1 million infant deaths occur in the world due to causes related to bottle-feeding, directly or indirectly. The survivors of the initial episode of diarrhoea often face a vicious cycle of malnutrition and recurrent diarrhoea, often terminating in death due to diarrhoea or malnutrition. The long-term effects of inflammatory bowel disease so early in life need further study. It has been postulated that chronic inflammatory bowel diseases like Crohn's disease and ulcerative colitis may have their beginnings in infective diarrhoea of early infancy.

HUMAN MILK AS A PROTECTIVE AGENT

Mother's milk is not only a source of nourishment for the baby, but also a powerful antimicrobial agent. Breast milk contains several factors which act in concert to form a biological system for protection against infection. For a long time epidemiological evidence has been indicating the benefits of breast feeding as regards protection from infection. When 1712 mothers in rural Chile were interviewed to assess the effect of feeding practices on the health of infants, it was found that if bottle feeding commenced before the age of 3 months, the mortality was three times that in breast-fed babies. Similarly, in the study of patterns of mortality in childhood conducted by the Pan American Health Organization in South America in 1973, it was found that breast feeding was a major factor in infant survival. More recently epidemiological studies have revealed the protective effect of breast feeding against a variety of viruses including the respiratory syncytial virus.

In the early days of milk secretion almost half the protein in breast milk is in an immunologically active form either as lactoferrin or as one of the immunoglobulins or as complement (table 5.10). Even though the concentration of IgA and lactoferrin declines as lactation proceeds, the immunologically active proteins still constitute a large proportion of the total protein content of breast milk.

Table 5.10 Immunologically active proteins of human milk (mg/100 ml)

	Day 5	Days 8-28	Days 50-200
Immunoglobulin A	490	151	148
Immunoglobulin M	12	4	1
Immunoglobulin G	32	32	1
Complement (C3 and C4)	7	2.5	1.5
Lysozyme	10	10	10
Lactoferrin	550	300	150
α-antitrypsin	10	5	-
Total (mg/100ml)	1111	504.5	311.5
Total protein (g/100 ml)	2	2	1.5
Total volume of milk (ml/24 hours)	500	750	900-1000

Source.- McClelland, D. B. L., McGrath, J. and Samson, R. R. Acta Paed. Scand. (1978,Suppl.271.)

The various protective factors in breast milk and their modes of action are described below.

Immunoglobulins (Figure 5.11).

Breast milk also contains IgA, IgM and IgD. Of these IgA is in the largest amounts (113-158 mg/100 ml) and has been shown to play an important biological function. A fully breast-fed infant receives about 0.5-1 g of IgA per day from the milk. IgA is not bactericidal and its primary function is to block the adhesion of pathogens to mucosal cells. Because of its stable structure, antibodies carried by IgA are specially adapted to function on mucosal surfaces.

The concentration of IgA in breast milk is higher than that in the mother's serum, indicating active secretion rather than passive transfer. Moreover, the configuration of the molecule in milk is different from that in serum. It is present as a dimer whereas in the serum it exists as a monomer. The two molecules of the dimer are joined together by a polypeptide chain, called the J chain. There is also a secretory piece attached to the molecule, which is a component of immunoglobulins found in secretions, and has the function of facilitating the passage of the molecule through the mucous lining. The composite molecule is more resistant than serum IgA to pH changes and enzymic attacks and is therefore active in the infant's gut. In several studies the antibodies carried in the IgA of the milk have been demonstrated in the stools of the breast-fed infant in amounts directly proportional to milk intake. In various studies some 20-80 per cent of secretory IgA in breast milk has been reported to pass through the gut undegraded.

Secretory immunoglobulin A is found in both the humoral fraction and the milk fat globule where it is strongly associated with the membrane of the fat globule. A quantity of undigested and functional milk fat globules is to be found in the stools of the newborn indicating the extension of the protective mechanisms of sIgA throughout the whole intestine.

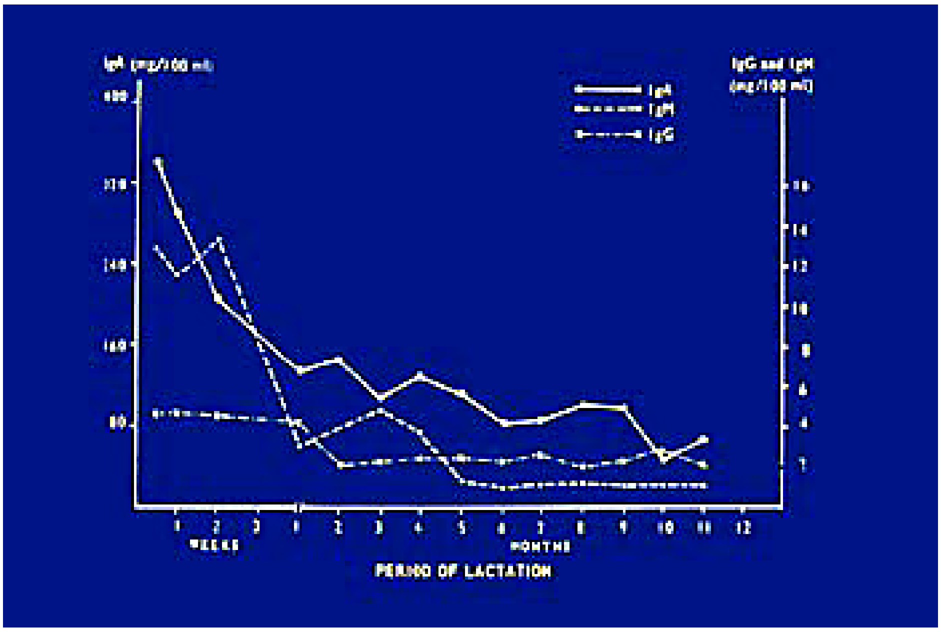


Figure 5.11 Immunoglobulins in breast milk

IgG in breast milk also serves an important anti-infection function. It is known that during pregnancy IgG passes from the mother's blood to the infant through the placenta. Early studies on human colostrum did not show the presence of large amounts of IgG and it was thought that in the case of the human the only mechanism of transfer was through the placenta. However, breast-fed babies have higher levels of serum IgG at 4-6 weeks compared to bottle-fed controls. Since the baby receives a considerable amount of IgG by way of the placenta, there is presumably no urgency for large quantities to be provided through the colostrum after birth, as is the case with the calf and the pig. Instead, the breast-fed human infant receives IgG in small doses over a prolonged period.

IgG antibodies derived from the mother are crucial for tissue defense. In contrast the secretory IgA antibodies in mother’s milk provide mucosal defense. They prevent micro organisms from entering tissues.

Antibodies

Breast milk contains antibodies against many organisms, both viral and bacterial. Most of these antibodies are of the IgA type and a large proportion of them are directed against E. coli, though antibodies against tetanus, Shigella, Haemophilus, Pertussis, Vibrio cholerae and V. pneumoniae have also been demonstrated.

There is experimental evidence to show that E. coli antibody in breast milk is specific against the E. coli in the mother's gut. In one experiment, pregnant women were administered E. coli of an unusual nature, and it was found that even though there was no serum antibody response, breast milk contained antibodies against the same E. coli. It would thus appear that plasma cells in the gut wall of the mother become sensitized to bacterial antigens in the gut lumen, and then move through the blood stream to "home in' on the mammary gland where they contribute the specific antibody to the milk. (See Fig. 5.12). Antigenic material contained in microbes and foods from the gut lumen is presented to the T and B lymphocytes via the specialized M cells that cover Peyer’s patches and other lymphoid tissue aggregates lining the gut mucosa. The responding B cells switch to production of IgA, leave the Peyer’s patches and migrate to various mucosal sites and to exocrine glands including the mammary glands. As a result the fully breast fed infant receives about 0.5 to 1 g of secretory IGA per day.

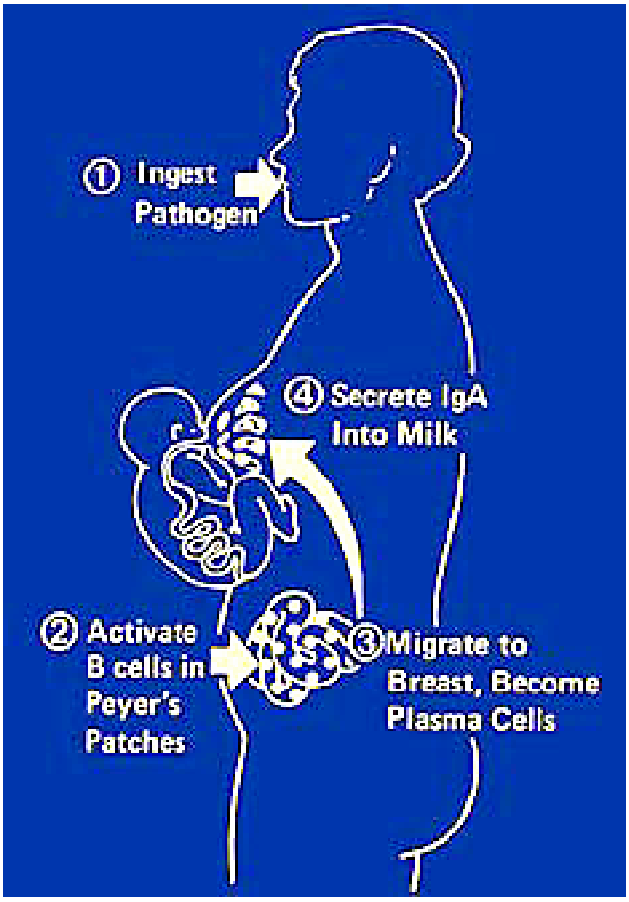


Figure 5.12 The entero-mammary axis

As Fig. 5.12 shows the lactating mammary gland is part of an integrated mucosal immune system with local production of antibodies mainly consisting of secretory immunoglobulin A (sIgA). These antibodies generally reflect antigenic stimulation of mucosa associated lymphoid tissue by common intestinal and respiratory pathogens. Antibodies in breast milk are thus highly targeted against infectious agents in the mother's environment. These microbes are the most likely to be encountered by the infant after birth.

Lactoferrin (Figure 5.13)

An iron-binding protein in breast milk, lactoferrin, plays a key role in the action of IgA on the bacterium E. coli by inhibiting the proliferation of this organism in the gut of the newborn. Breast milk contains large quantities of lactoferrin, 2-6 mg/ml. It has a high affinity for ferric iron which E. coli require for growth and multiplication. Lactoferrin thus deprives E. coli of iron and bacterial proliferation is slowed. In laboratory experiments it can be demonstrated that in the presence of lactoferrin only traces of antibody are required to produce bacteriostasis. When excess iron is added, the lactoferrin is saturated and its action against E. coli is lost.

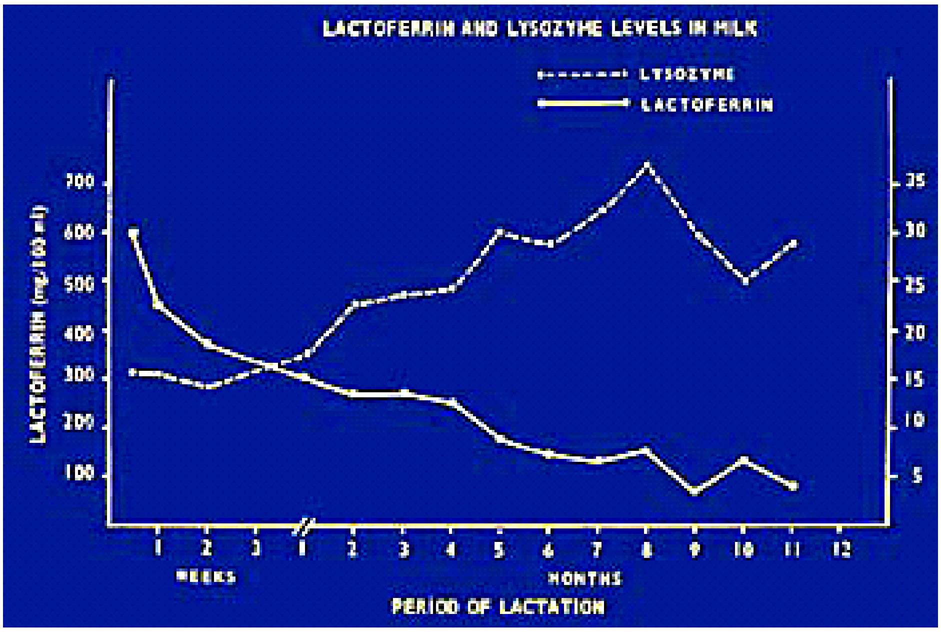


Figure 5.13 Lactoferrin and Lysozyme in breast milk.

Lysozyme

Human milk is rich in lysozyme – a basic protein that can help break up the cell wall of micro-organisms. Daily intake of lysozyme in the newborn infant is estimated to be 20 – 30 mg/day in the first month and rising to 50 – 60 mg daily up to 28 weeks. Lysozyme is specifically effective against Clostridia so that the stools of breast fed infants show a marked reduction and even absence of these organisms.

Lymphocytes and macrophages (See Fig.5.14)

Human milk contains a large number of cells varying from 20O0 to 4000 cells/mm3. These are of two main types: the lymphocyte and the macrophage.

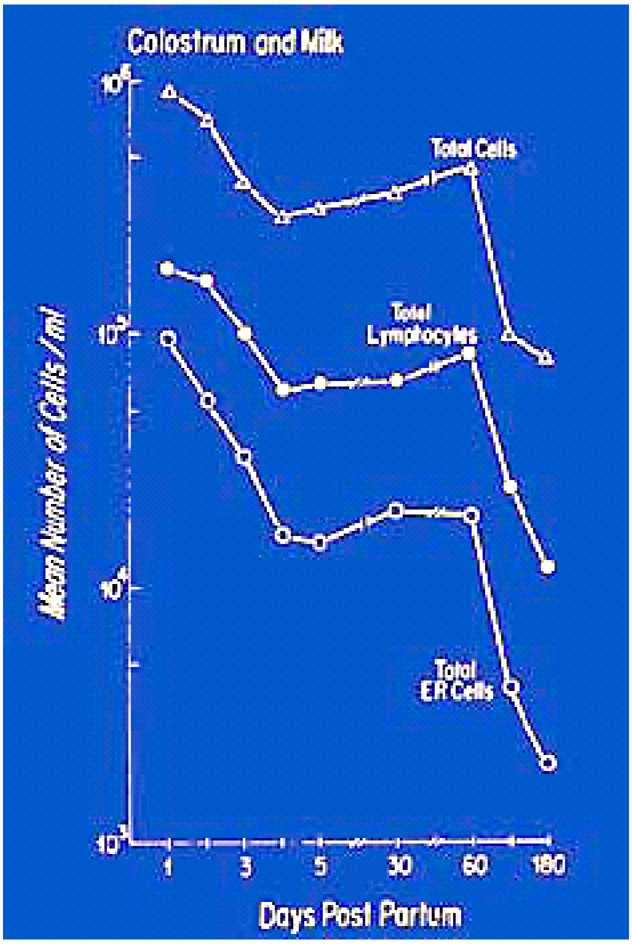


Figure 5.14 Cells in breast milk.

The lymphocytes are immunologically active and synthesize IgA as well as β1c complement. They are the type of cells which "home in' on the mammary gland after being sensitized to bacterial antigens in the mother's gut, and they secrete specific antibodies against these bacteria. The macrophages of breast milk are capable of destroying Klebsiella, Staphylococcus aureus and E. coli in vitro after opsonisation by the aqueous phase of milk. The efficiency with which these organisms are killed is as good as that in the case of blood leucocytes in serum. In addition, the macrophages and neutrophils from human milk can be shown to phagocytose Candida albicans. In animal models which were appropriately stressed by hypoxia they were also shown to protect against necrotizing enterocolitis.

Animal studies indicate that the cells in breast milk may have a role to play beyond the lumen of the gut. Transfer of tuberculin sensitivity demonstrated in the case of the human infant is an example of such a role. It would appear that besides being immunologically active in the gastrointestinal tract the “live” components of breast milk act as transmitters of immunologic information and help prepare the immune system of the newborn for meeting environmental challenges. For example, a substantial increase in the secretary IgA content of nasal and salivary mucus has been found in breast-fed infants as compared to those who are bottle-fed during the early neonatal period. It has been suggested that this may be due to a soluble cell factor in milk activating the developing immune mechanisms of the infant. The presence of such an immunoregulatory factor has been confirmed in laboratory experiments using colostral cells. Infants on exclusive breastfeeding show better seroconversion with the triple vaccine, oral polio and BCG. This has been attributed to the priming of the immune system by factors contained in breast milk. (See Fig. 5.15)

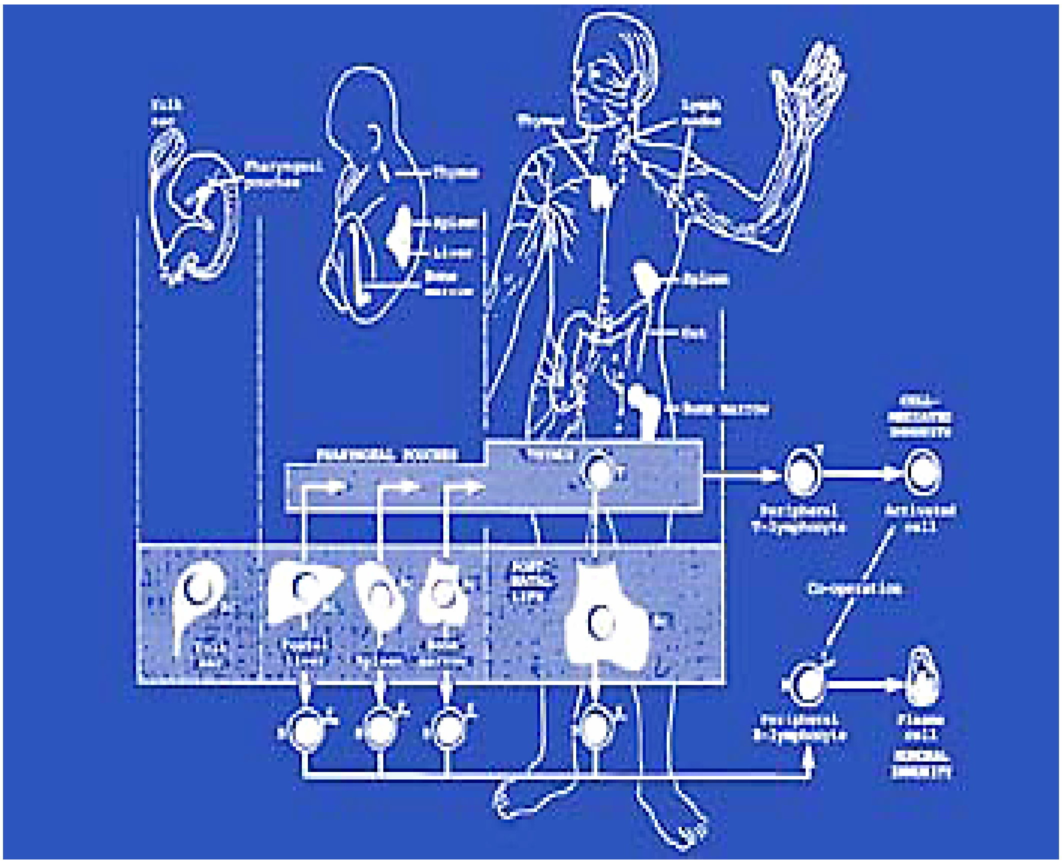


Figure 5.15 The Developing Immune System and role of Breast Milk

The immune system of the newborn is not yet fully primed, and therefore limited in scope. It expands rapidly especially due to exposure to gut micro flora of the mother during delivery. The many defense factors contained in breast milk modulate the early exposure of the newborn to microbes through the intestinal and respiratory mucosa. The role of individual immune factors of breast milk in the priming of newborn's immune system is summarized below:

Component	Action
B lymphocytes	Produce antibodies targeted against specific microbes
Macrophages	Kill microbes inside the newborn’s gut, produce lysozyme and activate other components of the immune system
Neutrophils	May act as phagocytes
T lymphocytes	Kill infected cells directly or send out chemical messages to mobilize other defenses. They can proliferate in the presence of organisms that cause serious illness in infants. They also manufacture compounds that can strengthen the newborn’s own immune response
Secretory IgA antibodies	Bind to microbes in the infant’s digestive tract and thereby prevent them from passing through walls of the gut into body tissues.
Bifidus factor	Promotes growth of Lactobacillus bifidus which prevents colonization by pathogenic microbes.
Fatty acids	Disrupt outer membrane coats of certain viruses and destroy them
Lactoferrin	Binds to iron thereby denying it to bacteria, and thereby disrupt their growth.
Lysozyme	Kills bacteria by disrupting their cell walls.
Oligosaccharides	Bind to microorganisms and prevent them from attaching to mucosal surfaces.

Other protective factors

Breast milk contains large amounts of the C3 and C4 components of complement, which can be activated in experimental conditions by the antibody contained in the IgA of the milk. The exact mechanism of action of these substances has not yet been fully determined. It has been postulated that they interact together as a biological system in mounting immunological attacks on bacteria in the baby's gut.

In addition there is the bifidus factor which promotes the growth of the Lactobacillus organism under the specific pH and chemical environment of the neonatal gut generated by breast milk. The gut flora of the artificially fed infant is made up largely of E. coli, with some Streptococcus faecalis, in contrast to the breast-fed infant in whom the lactobacillus predominates. The E. coli harboured by the gut of the artificially fed infant constitute a reservoir of potential pathogens. The exact conditions under which they can cause disease are not yet understood. The immune factors in breast milk will keep the number of E. coli in the gut low until such time as the baby has developed his own immunity.

The composition of breast milk with its high lactose content, low phosphate and low protein provides the correct substrate for the growth of lactobacilli. In laboratory experiments human milk has been found to be 40-100 times as effective as cow's milk in supporting the growth of these organisms. The bacterial colonization pattern of breast-fed and bottle-fed infants is similar on day 7 after birth. By day 30 a distinct pattern may be identified in each group. By this age bifidobacteria are the predominant flora in the colon of breast-fed infants and outnumber enterobacteria. Enterococci are reduced and Clostridia and Bacteroides are rarely isolated. In this way breast milk is unique. It is an agent which protects at the same time as it nourishes and the mammary gland performs a function not very different from that of the placenta in intrauterine life.

Breast milk also contains oligosaccharides which bear a surface resemblance to receptors for pneumococci on oropharyngeal epithelial cells. They can thus divert pneumococci and prevent their adherence to target cells. Similarly, other receptor analogues are present which can block the attachment of H. influenzae, E. coli and several toxins.

This description of the protective constituents of breast milk identifies the mammary gland as part of the general system of mucosa associated lymph tissue. Antigen contact at one site gives rise to immunity in other distant sites. The 'homing-in' of sensitized lymphocytes explains why in breast-fed infants the levels of IgA are significantly higher in the saliva and in the urine than in infants fed on formulae. Breast feeding helps promote the production of IgA at mucosal surfaces in the infant.

Closely related to protection from infection is the role of human milk in preventing hypersensitivity. Secretary IgA in the gut lumen is known to prevent the adsorption of antigen onto the gut mucosa. When there is a deficiency of IgA, macromolecules of antigen in the gut lumen are able to pass through the mucosal cells and enter the blood stream or lymphatics and trigger an immune response. Breast milk, with its high content of IgA, prevents the escape of antigen into the blood stream and thus protects against atopic disease. On the other hand, cow's milk or preparations based on it provide the body with a foreign protein in high concentration. In some studies a seven-fold greater incidence of atopic eczema has been reported in infants fed wholly on cow's milk formulae compared with those exclusively breast-fed, and a two-fold greater incidence in those partially breast-fed. Analysis of samples of ileo-caecal fluid in breast-fed infants shows that up to the age of 10 days, 1.3 per cent protein is the maximum concentration at which the protein is completely digested and assimilated. Tolerance of higher concentration rises gradually, so that at 3-5 months the infant can handle a feed containing protein at 2.5 per cent concentration. Many commercial preparations contain protein at a much higher concentration than this.

Recently it has been shown that breast milk contains a rich variety of substances, the significance of which has not yet been fully understood. It contains small amounts of several hormones like corticosteroids, prolactin, thyrotrophin and thyroxin. It also contains biological mediators of hormone function in the form of cyclic nucleotides, viz. cyclic AMP and cyclic GMP. Both the latter substances are known to participate in the regulation of proliferation and differentiation processes associated with the growth and maturation of the newborn. Studies in rats have shown that the stomach content of both these cyclic nucleotides remained high for at least 1 hour after a feed, indicating their availability for absorption in the gut. They are the building blocks of nucleic acid needed for DNA and RNA synthesis. Approximately 15 – 30 per cent of the total nitrogen in human milk is non-protein nitrogen and 20 per cent of this consists of nucleotides. Nucleotides, serve as immediate precursors in the synthesis of RNA and DNA. They represent 2 to 5% of the non-protein nitrogen in human milk. Numerous functions have been attributed to dietary nucleotide, including effects on lymphoid, intestinal, and hepatic tissues

BIOLOGICAL MEDIATOR: A NEW ROLE FOR BREAST MILK

Growth factors in breast milk

Recent studies concerning the properties of human milk make it abundantly clear that besides being a source of nourishment and a protective substance, human milk serves as a mediator of biological functions. Among the latter is the modulation of the growth and development of a number of organ systems, especially the gastro-intestinal and respiratory systems. This is achieved through the presence of growth factors, defined as low molecular weight proteins which initiate growth responses in target cells by binding to specific receptors on the surface of cells. After binding to the specific receptor the entire complex is internalized into the cell leading to an increase in both cell size and number. In the process a variety of cellular pathways are stimulated, including nutrient uptake and the synthesis of protein, DNA and RNA with concomitant inhibition of catabolic pathways.

In early studies of experimental animals (piglets and beagle puppies) it was shown that feeding on mother's milk stimulated the growth of the gastro-intestinal tract with increases in mucosal mass DNA and enzyme activity. The development of techniques of cell culture has since provided opportunities for biological assay and identification of the growth factors present in milk. Employing in vitro techniques it has been shown that at a concentration of 1 per cent (vol/vol), human milk is as active as 5 per cent human serum (vol/vol) in supporting cell growth in cultures, suggesting that milk could substitute for serum which is the usual source of growth factors for cultured cells. In the cultured cells, increased synthesis of DNA, stimulation of protein synthesis and cell division can be seen together with inhibition of protein degradation. The activity is greatest in colostrum obtained within 24 hours of birth. Subsequently it has been shown that 93 per cent of mitogenic activity of human milk for fibroblast culture can be accounted for by the Epidermal Growth Factor (EGF) which occurs in a concentration of 30-111 (μg/1). EGF accounts for more than 70 per cent of the total mitogenic activity. It increases DNA and protein synthesis in the gut and serves to accelerate maturation of brush border enzymes in the perinatal period. In animal studies the intestine appears to be more responsive to EGF following starvation, intestinal resection, and total parenteral nutrition induced villus atrophy. In these situations EGF acts to increase the absorptive surface area.

Animal work in three different species has shown the effect of intrauterine growth retardation (IUGR) on small intestine structure and function. Experimentally induced IUGR in rat pups produced a decreased intestinal weight and reduction in DNA content as well as in cell number. Total lactase, maltase and alkaline phosphatase activities were decreased. In piglets with IUGR small intestinal surface area is reduced, and the average number of villi per unit area of small intestine and the height of the villi are significantly reduced. In such cases EGF offers potential as growth promoting agent for the atrophic gastro-intestinal mucosa associated with intra uterine growth retardation and may aid mucosal repair and recovery.

The gastro-intestinal tract and its associated organs, in particular the pancreas, have a high rate of protein synthesis and turnover. Malnutrition in fetal life causes abnormalities in the structure and function of the small intestine and exocrine pancreas. Suboptimal function of digestive and absorptive processes may limit the ability of the growth retarded infant to achieve satisfactory growth.

Another substance with similar properties as EGF is the nerve growth factor (NGF). EGF is a potent stimulator of growth and differentiation in epithelial tissues whereas NGF is essential for the survival and development of sympathetic neurons. It is postulated that EGF stimulates the maturation of the gastro-intestinal epithelium, or rapid growth and differentiation of epithelial cells in other tissues, for example the liver, and that NGF helps with the arborisation of the sympathetic neurons of the gut. Other growth factors identified in human milk are insulin (I), insulin-like growth factor I (IGF-I), mammary derived growth factor and α-transforming growth factor (Table 511.).

Table 5.11 Growth factors in human milk

Growth factor	Concentration	Purification
Colony stimulating	n.d.	partial
Epidermal growth factor	25 – 40 ng/ml	complete
Erythropoietin	11 mµ./ml	n.d.
Insulin	0.5 - 2.8 µg /ml	n.d.
Insulin-like growth factor I	2 – 19 ng/ml	n.d.
Mammary-derived growth factor	n.d.	partial
Nerve growth factor	n. d.	n.d.
α-transforming growth factor	n.d.	partial

n.d.= not determined.

Growth factors ingested in milk are not degraded in the neonatal intestine. It has been suggested that orally ingested EGF can act directly on the gastro-intestinal tract and also exert an effect on other tissues after absorption.

Growth factors act through their relevant receptors, and it is postulated that these receptors are upregulated during this period of growth. This means that upregulation is intrinsically programmed at this age, which means that they are also upregulated in formula fed infants. As intestinal permeability is increased in formula feeding one can speculate as to the physiological effects in these infants. Secondly, within the gut receptors of many growth factors are expressed by non-epithelial cells such as fibroblasts and lymphocytes that reside in lamina propria in close proximity of the epithelial cell layer. As a result many of these growth factors have local stimulatory effect.

Studies on the physiological effects of various growth factors are continuing, and many of them have found a use in clinical medicine. Epidermal Growth factor (EGF) family of peptides are all trophic to the gut stimulating cell proliferation and modulate a number of physiological functions. In clinical medicine, the beneficial effects of EGF in stimulating mucosal growth and functional adaptation have been shown following intestinal resection, total parenteral nutrition, persistent diarrhoea and ulcerative conditions. Available evidence shows that EGF and Transforming Growth

Factor – α (TGF- α) are two important growth factors in breastmilk for the postnatal small intestine. Insulin-like-Growth-Factor-1 (IGF-1) helps with the intestinal muscle growth especially of the distal small intestine and the large intestine.

Growth factors have been identified in the milks of other mammals also. There is a great deal of variation according to species. In human milk EGF is the most active factor, with insulin and IGF-I playing smaller roles. Cow's milk has no EGF. IGF-I in bovine colostrum exceeds 1000 µg/l compared with 17 µg/l and 6.8 µ/l in human colostrum and mature milk respectively. Bovine milk lacks colony stimulating factor. Similar differences occur in marsupial milk, indicating that the concentration of various growth factors also varies considerably in milks of different species.

Newborns fed exclusively on formulae may receive considerably lower amounts of growth factors, particularly EGF. Women who deliver pre-term produce milk containing a higher concentration of EGF and growth promoting activity in fibroblast culture. Paradoxically the insulin concentration is depressed, indicating that the extra growth promoting activity of pre-term milk reflects an increase in concentration of specific growth factors rather than a generalized response.

A number of questions arise with regard to the biological role of the growth factors. Infants fed exclusively on formulae based on cow's milk in more developed countries do not seem to suffer growth failure. In less developed countries, where nutritional deficiencies are common, the situation is different. The presence of growth modulators would improve the efficiency of utilization of available nutrients. This is particularly so after an illness. In experimental ratsthe intestine is normally non-responsive to EGF after the first few weeks of life, but there is a significant response following fasting, gut resection, or intestinal atrophy following undernutrition. There may be important clinical applications for growth factors (and breast milk) in intestinal disease, a subject which requires further study.

Hormonal responses to feeding are different between breast-fed and bottle-fed infants. Blood levels of insulin and of gut hormones like motilin, enteroglucagon, neurotensin and pancreatic polypeptide show significant changes following a feed in bottle-fed infants. (See Figs. 5.16 and 5.17)

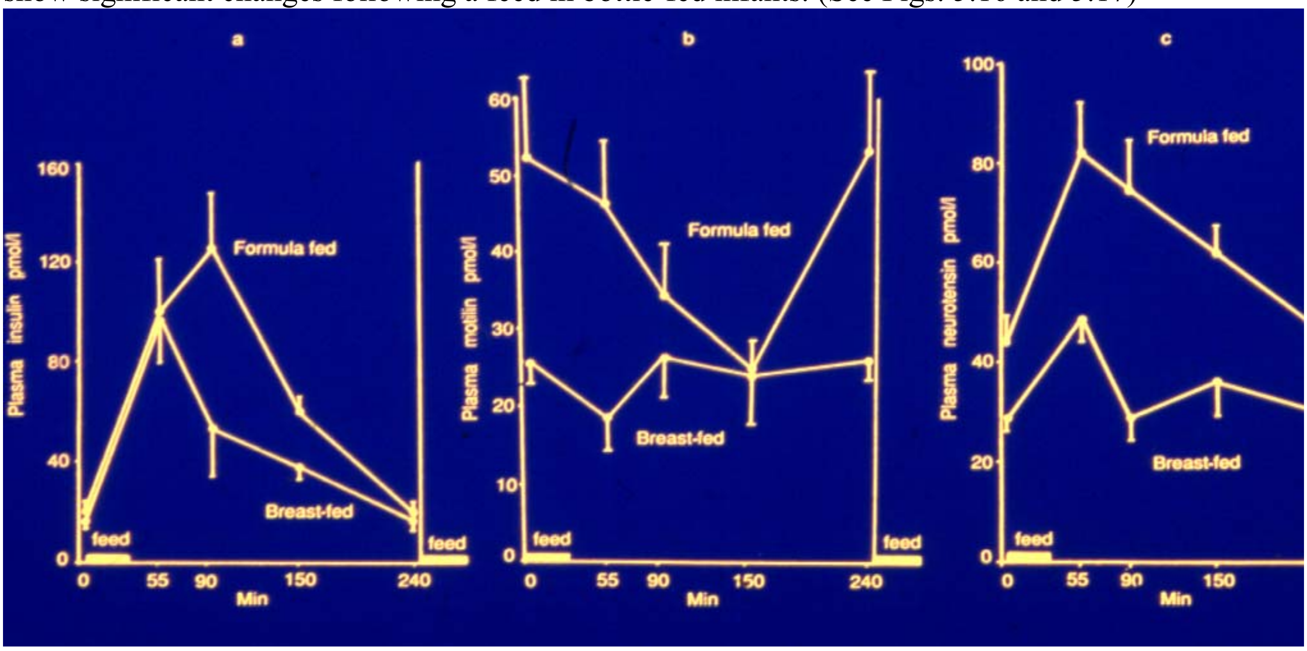


Figure 5.16 Endocrinological response to feeding.

Different responses in breast fed and formula fed infants

Plasma levels of a). insulin b). motilin c) neurotensin

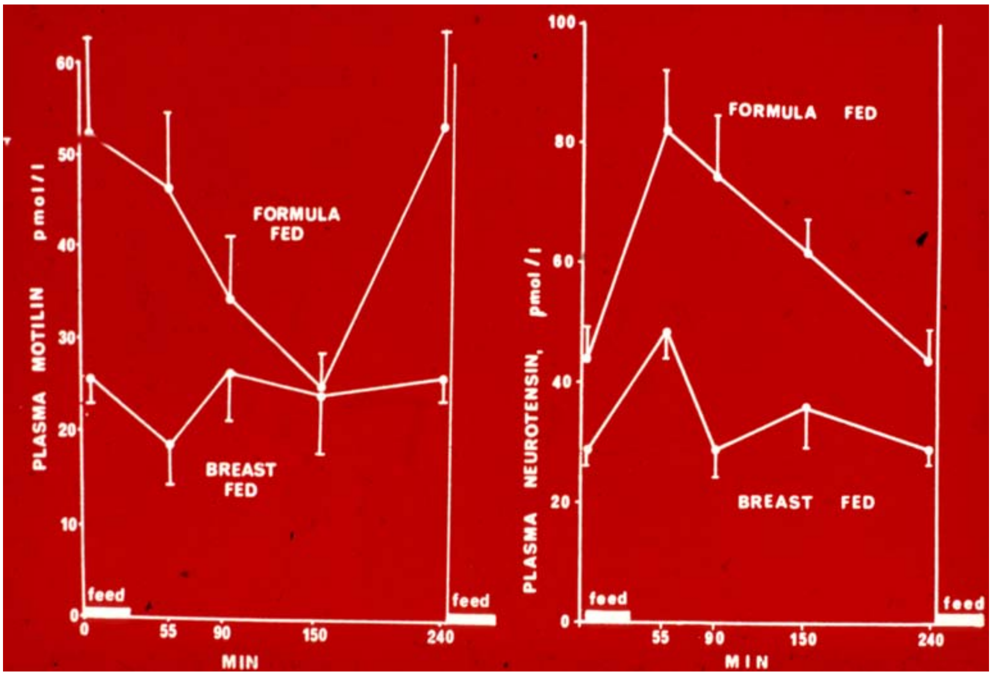


Figure 5.17 Gut hormone response during feeding. Plasma motilin and neurotensin.

In the case of breast-fed infants these changes are much reduced or absent. Basal levels of the hormones also tend to be higher in bottle-fed infants. Since some of these hormones are likely to play a key role in neonatal adaptation, only future research can demonstrate the long-term benefits of breast-feeding. However, when one considers the properties of human breast milk in the fields of nutrition, immunology, endocrinology and developmental biology, a new biological role of breast milk becomes obvious. It is not merely a nutritious broth to be compared with processed products marketed in cans or ready-to-feed bottles. It is a biological mediator carrying a rich variety of substances which can trigger and control extra-uterine adaptation of the infant for intact and healthy survival.

Transmission of viruses through breast milk

Human Immunodeficiency Virus (HIV).

Mothers infected with the HIV virus transmit the disease to their newborns both through the placenta (estimated risk 30%), and through breast feeding (estimated risk 15 %).This raises important clinical dilemmas for the clinician. In the more developed countries the current medical opinion is to avoid breast feeding and opt for formula feeding instead. In developing countries the hazards of artificial feeding are just too great. In 1987 the World Health Organization recommended that “breastfeeding should continue to be promoted, supported and protected in both developing and developed countries. In individual situations where the mother is considered to be HIV infected, the known and potential benefits of breast-feeding should be compared to the theoretical but apparently small risk to the infant of becoming infected through breast-feeding. Consideration should be given to the socioeconomic and ecological environment of the mother-child pair and the extent to which alternatives can safely and effectively be used.”

Several studies indicate that the risk of transmission of infection is about 15 per cent (range 7 to 22 per cent). The risk is present throughout the period of breast feeding, and may be slightly higher in the early stages of lactation. Transmission rates are dependent on maternal viral load, lower $CD4^+$ lymphocyte counts in the mother, raised maternal ESR, and presence of cracked nipples and mastitis.

Several strategies have been evolved to protect the newborn. In industrialized countries known HIV infected mothers are counseled to feed their infants on formula. This approach may partly be due to the health workers’ need to protect against future litigations. In developing countries where breast feeding is the preferred option, mothers need to be counseled to breast feed exclusively. Mixed feeding exposes the neonate’s gut to foreign antigens including cow’s milk proteins which have the potential for microscopic damage and bleeding. This breach in the gut’s defenses facilitates access by the HIV contained in the mother’s milk.

A second approach is to treat the mother with anti retroviral drugs. Because of the expense several modified treatment regimens have been tried. It has been found that when treatment is started at or before 36 weeks of pregnancy and continued during labour there is sufficient time for reduction of maternal viral load. Mother-to-child transmission has been shown to decline from 24.9% to 15.7% in such instances. In the case of mothers who have not attended for prenatal care and arrive in labour intrapartum zidovudine and lamivudine plus post partum administration of the same drugs to both mother and baby has been found to reduce mother-to-child transmission to 8.9% compared with 15.3% in those given placebo. This trial demonstrated that post exposure administration of anti retroviral treatment can protect the newborn. In a comparison trial between zidovudine and nevirapine, one dose of nevirapine administered to the mother during labour, and one dose of the same drug to the baby within 72 hours of birth decreased HIV infection at the age of 6-8 weeks from 20% in the zidovudine comparison group to 11.8% in the nevirapine group. Thus, short courses started during labour, although not as effective as long courses, do offer some protection. Lowering maternal viral load coupled with prophylaxis to the infant can substantially reduce mother-to-child transmission to possibly 3 to 4 per cent, and this is currently the preferred option in resource poor countries. Unfortunately in many countries mothers present to the labour ward only hours before delivery unaware of their HIV status, and with little time to do an HIV test. Since protective concentrations of several retroviral drugs in cord blood are achieved only when given 2 hours or more before delivery, the only option in such a situation is to treat the infant prophylactically. A single dose of nevirapine (a non nucleoside reverse transcriptase inhibitor) can reduce by 40% the untreated transmission rate of 15 per cent. More potent short course combined regimens, such as zidovudine (a nucleoside reverse transcriptase inhibitor) plus lamivudine (also a nucleoside reverse transcriptase inhibitor) boosted by nevirapine achieve residual peripartum transmission rates around 5 per cent. Clearly, as more potent and less toxic drugs come on the market different regimens would be tried and come to be recommended.

An innovative approach has been proposed by workers in South Africa in the form of simple home pasteurization of expressed breast milk. HIV is heat sensitive and Holder pasteurization is commonly used in milk banks in many hospitals. Typical pasteurization involves heating the milk to 63^0 Centigrade and maintaining to that temperature for 30 minutes. An alternative method is to heat to 71.5^0 Centigrade and maintaining the temperature for 15 seconds. Pretoria pasteurization which is intended for homes with poor resources uses a one litre capacity aluminium pot containing 450 ml of water which is heated to boiling, then taken off the fire and a glass jar containing 100 ml xpressed breast milk is stood in the water. Researchers found that the milk reaches a temperature of 60^0 Centigrade in about 7 minutes. The milk temperature remains between 56^0 and 62.5^0 Centigrade for between 12 and 15 minutes. Under experimental conditions samples of milk from HIV infected mothers (mean serum viral load 50 728 copies/ml and mean milk viral load 422 000 copies/ml) showed no evidence of viral replication when treated in this manner. Obviously these findings need to be validated in other settings with different ambient temperatures and glass jars of different makes and thicknesses.

Human T-cell leukaemia virus (HTLV-I)

This virus is endemic in parts of Japan and the West Indies. It can be transmitted by blood and sexual contact, but transmission from mother to child accounts for many of the infections. An estimated 25 per cent of the children of seropositive mothers are infected. In some studies up to 10 per cent of the T-cells in breast milk of carrier mothers had HTLV-I antigen. Since over 10 per cent of the cells in breast milk are T-cells this would amount to about 1000 infected cells/ml of milk.

A number of prospective studies suggest breast-feeding as a major mode of transmission. With the available data it would be reasonable to follow the same guide lines as for HIV, that is recommending breast-feeding in developing countries where the advantages outweigh the risks, and discouraging the known HTLV-I infected mother from breast-feeding in developed countries.

HTLV-I appears to be more readily transmitted through breast milk than HP/ but its effects on the infant are less pronounced. Only 5 per cent of carriers become affected after a latent period of several decades.

Cytomegalovirus (CMV)

In common with other members of the herpes virus family and the retroviruses, CMV persists in host cells indefinitely. In different studies, CMV has been isolated from breast milk in 14-44 per cent of seropositive mothers. The presence of specific antibodies in the milk does not prevent transmission. What is more important is the fact that neither symptomatic infection nor late sequelae have been documented in the infants.

Rubella

Both the wild and the vaccine strains have been isolated from breast milk. In women immunized soon after delivery 69 per cent pass the virus in milk. Either the virus or virus antigen is detectable in more than half of their infants and about a quarter may show a transient antibody to rubella virus. No symptoms or adverse effects are recorded in infants.

Hepatitis B virus

Most vertical transmission of hepatitis B occurs at birth as a result of exposure to maternal blood and secretions during labour. In endemic areas like Taiwan studies do not show any difference in infection rates between breast fed and bottle fed infants. With the advent of an effective and safe vaccine the theoretical risks of transmission of hepatitis B is of little concern.

Breast milk banking

Breast milk should be kept at room temperature for as short a time as possible and refrigerated immediately after expression. If a mother is expressing at *home and has no access to a fridge*, the milk can be kept at room temperature for up to 6 hours. If milk is to be used within 48 hours it should be stored in a refrigerator at a temperature of 2-4^0 C. Milk which has not been used after 48 hours should be stored frozen (-20^{0}C) for a maximum of 3 months if it is to be fed to an infant.

For banking of breast milk if the milk is to be fed within 48 hours simple refrigeration at 4^0 Centigrade is in most cases adequate. For anything longer than that freezing at -20^0 Centigrade or pasteurization at 62.5^0 Centigrade for 30 minutes is necessary. Pasteurization destroys cells, complement and bile-salt stimulated lipase but preserves immunoglobulins and nutrients including vitamins and most of the enzymes. Pasteurization will also destroy most viruses excreted in breast milk. (See Table 5.12)

Table 5.12 Effects of pasteurization on breast milk

Milk factor	Percentage activity retained
Immunoglobulins	
Secretory IgA	65—90
IgM	<25
IgG	65—85
Cells	None
Complement	None
Bifidus growth factor	Most
Enzymes	
Lysozyme	61—100
Lactoferrin	27—44
Lactoperoxidase	53
Bile-salt-stimulated lipase	None
Nutrients	
Proteins	Most
Carbohydrates	Most
Lipids	Most
Minerals	Most
Vitamins	60—100
Pathogens	
Viruses	None
Bacteria	<1

Physiology of Breastfeeding

Breastfeeding and the mother

All women are not alike regarding their capacity for lactation. Some possess a much higher potential than others. In common with all other physiological functions, the actual performance is not as great as the genetic potential, leaving room for 'physiological reserve'. In the same woman, second and later lactations tend to be more successful than the first, indicating that, as in all reproductive functions, 'trial runs' are necessary before optimal performance is achieved. In general, younger women tend to perform better than older ones. To some extent this may be due to a kind of 'disuse atrophy' as measured 'by the time-lag between the mature development of the gland at puberty and its functioning after the birth of the baby.

The Mammary Gland

The fully formed breast is made up of 15 to 20 lactiferous ducts which branch repeatedly and drain secretary alveoli. Each duct is dilated to form an ampulla or sinus just before it opens at the nipple. The alveoli and their draining system of ducts related to each lactiferous duct constitute a lobe of the mammary gland. The ducts together with their secretory units are surrounded by connective tissue which acts as supportive framework. In the non lactating breast the secretory units are not seen, and the breast mainly consists of clusters of ducts set in connective tissue which is divided into lobules by means of dense septa. (See Fig.5.18)

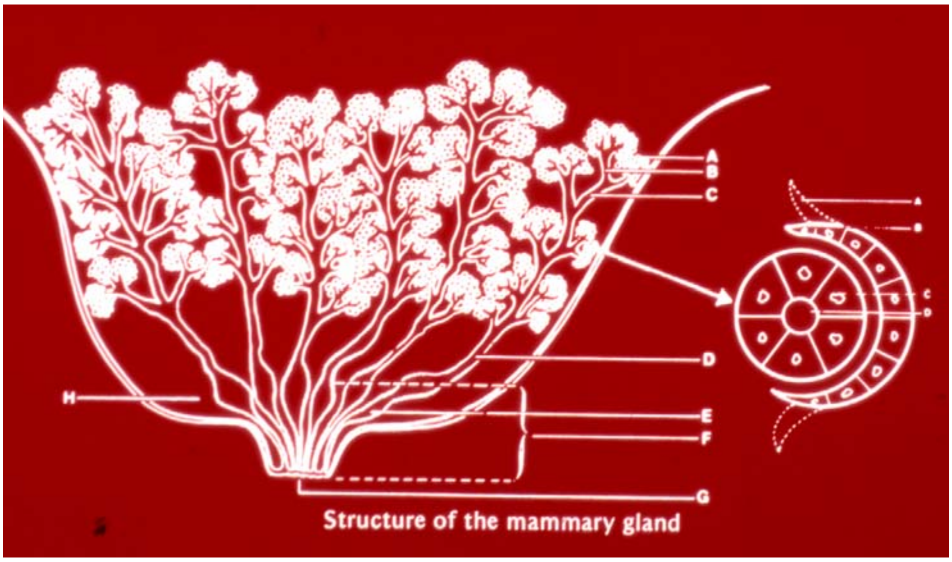


Figure 5.18 Structure of mammary gland.

A. Alveolus. On the right, myoepithelial cell
B. Ductule.
C. Duct
D. Lactiferous duct
E. lactiferous sinus
F. Ampulla
G. Nipple opening
H. Alveolar margin

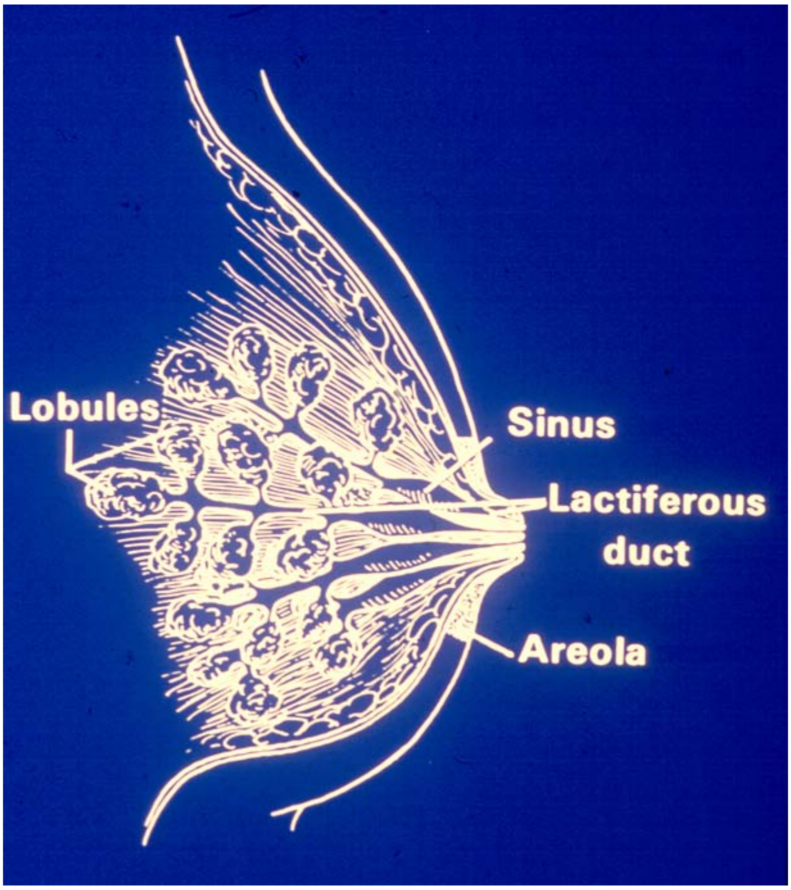


Figure 5.19 Mammary gland longitudinal section

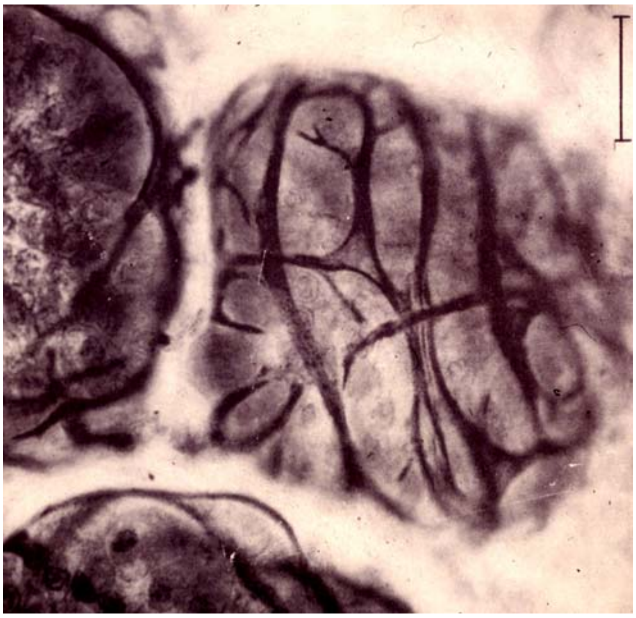


Figure 5.20 Electron microscope view of mammary gland lobules surrounded by myo-epithelial cells

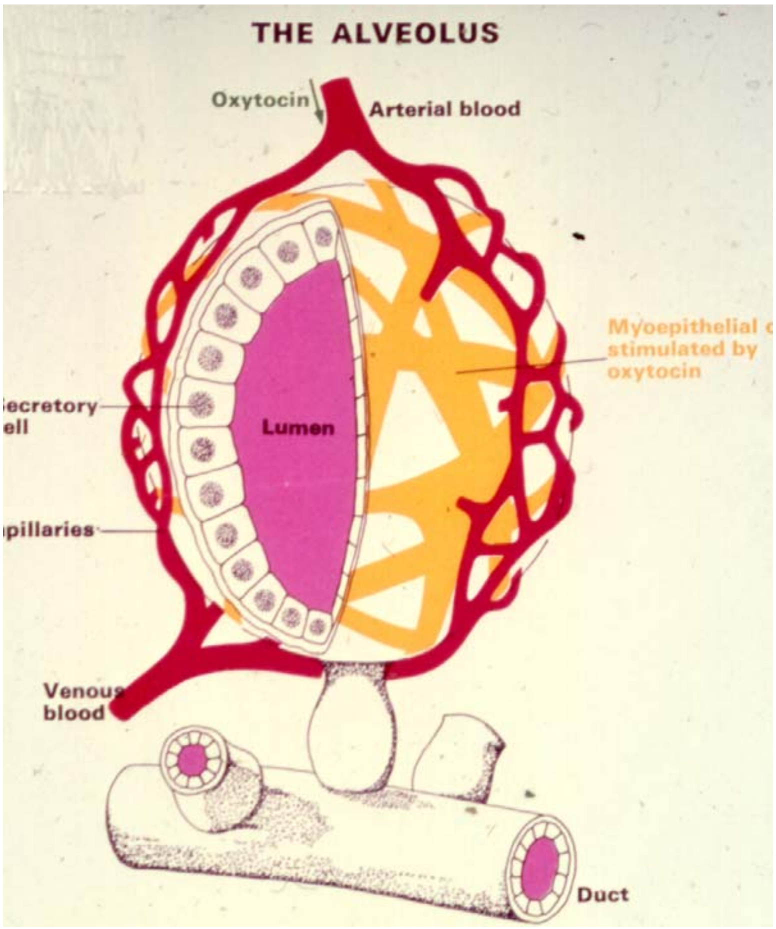


Figure 5.21 Schematic view of alveolus with myo-epithelial cell

During pregnancy the breasts enlarge progressively under the influence of high levels of maternal hormones viz. oestrogen and progesterone. It is believed that oestrogen promotes growth of ducts and the collecting system, and the progesterone stimulates the growth of alveolar buds. Other hormones such as prolactin, growth hormone, adrenocorticosteroids and the thyroid hormone are also necessary for the optimal development of the secretory apparatus of the mammary gland.

There is a wide variation in the extent of growth of the breasts during pregnancy. It is greater, as a rule, in younger women and during the first pregnancy. Lactational performance is also generally related to the growth of the breasts during pregnancy.

From the physiological point of view the lactational performance of the individual mother is related to her nutritional status, endocrine and psychological factors, as discussed below.

Nutrition

During pregnancy maternal metabolism changes so that a woman lays down body stores of energy in the form of fat, which is deposited in the subcutaneous tissue of the trunk and on the legs. In a well nourished woman the increase in body fat amounts to about 4 kg, which is equivalent to a store of 35 000 kcal - enough to provide for lactation for 4 months at the rate of nearly 300 kcal/day. Thus the average woman enters the final weeks of pregnancy with a considerable store of food energy to act as a buffer against sudden deprivation of food (Figure 5.22). The stimulus to accumulate this fat store is through a change in the control of the energy balance caused by progesterone and other hormones, as well as through a slowing down of energy expenditure as pregnancy advances.

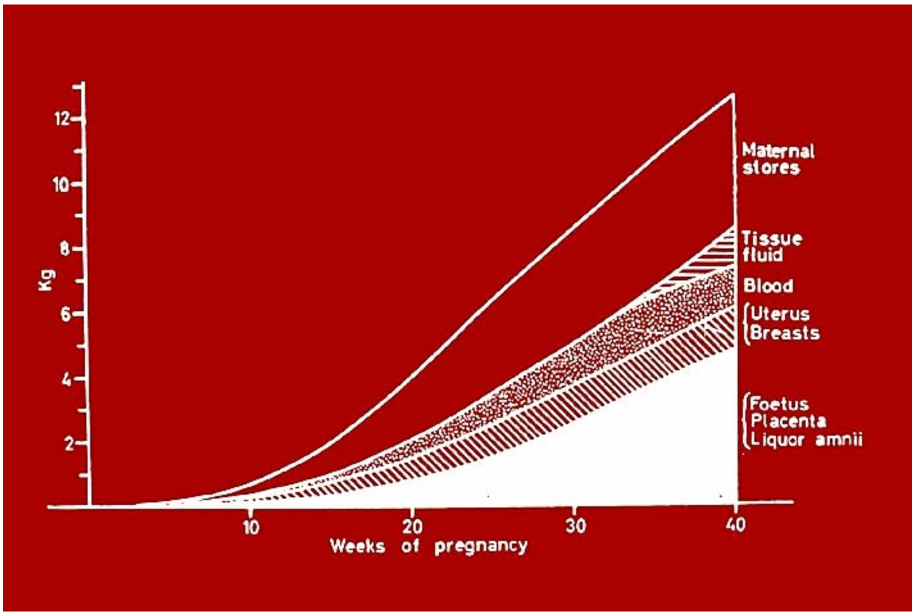


Figure 5.22 Weight gain during pregnancy in healthy women

Mothers who do not breast-feed their babies will carry these extra stores of fat on their bodies unless they resort to dieting. In general, in a well- nourished community, mothers who breast-feed are able to regain their figures more easily than those who do not. In the latter, as pregnancy follows pregnancy, there is a tendency to become obese.

As lactation proceeds, the accumulated body fat is converted into energy in the milk. In a study of healthy women in Aberdeen it was found that during the period of lactation weight was lost at an average of 0.28 kg/week, even though the women were eating an average of 590 cal more than women in a control group who were not lactating. Assuming a milk output of 850 ml daily, the amount most healthy mothers are capable of, an equivalent energy loss of 600 cal has to be provided. Dietary energy is converted into milk with an efficiency of about 90 per cent. Based on these assumptions, and also on the fact that the body lays down stores during pregnancy, it-is recommended that an additional 500 cal a day is an adequate supplement for a nursing mother.

The nutritional needs of lactation are chiefly for calories and not so much for proteins. Human milk is thought to have a protein content of 1.1 g/100 ml. This is calculated by estimating the nitrogen content of the milk, which is then multiplied by a factor of 6.25 to obtain the protein content. It is thought that this process overestimates the protein level by more than 20 per cent because of the contribution from the non-protein nitrogen-containing constituents of the milk, and the true protein content of human milk could well be less than 1 g/100 ml. This small protein requirement of human milk can be easily supplied from a predominantly cereal-based diet, so long as it provides adequate calories.

The high efficiency rate of conversion of food energy into breast milk in the mother, and the very low requirement of protein, added to the biological ability to store energy during pregnancy, enables mothers who are subsisting on marginal nutrition to breast-feed their infants for prolonged periods. Mothers in prisoner-of-war camps have been reported to be able to breast-feed their infants successfully. Similar descriptions about mothers in refugee camps also abound in the medical literature. Enhancement of metabolic efficiency during lactation has been reported by several authors. This partly explains why, in many disadvantaged communities, women on low energy intakes of 1600—1800 kcal/day are able to nourish their infants up to the age of 6 months or more on breast milk alone.

Individual mothers differ in their capacity for milk production. This capacity is established early in lactation, and more or less remains as lactation proceeds. Thus in studies where women are ranked by milk output at the beginning of lactation the order remains essentially the same later on. A factor which contributes to larger milk outputs initially is the size of the baby. There is good correlation between the weights of babies at birth and the amount of milk produced at 3 months. Another factor is high frequency of feeding as happens with true demand feeding in all traditional societies. In industrialized countries also, mothers who wish to breast-feed exclusively for prolonged periods of time have been shown to succeed in doing so by demand feeding both during the day and night.

In many peasant societies, and also in urban disadvantaged communities, there are marked variations in the availability of food by season or otherwise. Regular hungry seasons, when food stores from the previous harvest are running low, occur in many peasant societies. The hungry season usually coincides with the rains when a great deal of physical labour is required on the land for clearing, ploughing or digging and planting. Thus demands for energy expenditure coincide with low energy intake during the hungry months. Studies in the Gambia have shown that energy consumption in pregnant women falls to 1350-1450 kcal/day, and among lactating women to 1200-1300 kcal/day during the wet season as compared to 1600-1750 kcal/day in the most favorable months. Depletion of body fat stores to make up for decrease in energy intake occurs in both pregnant and lactating women. Breast milk output may decrease during the stressful wet season, but not in all. Decrease in milk output is often associated with infective illness in the infant, indicating that a combination of illness induced anorexia in the infant and altered breast-feeding pattern in the mother because of workload are at the root of the observed seasonal decrease in milk output, and not decreased food intake by the mother as previously thought.

The concentration of various constituents of breast milk, such as protein, fat, carbohydrate, calcium and iron, are little influenced by the nature and amount of the maternal diet within a wide range of intake values and over a prolonged period of lactation (Table 5.13). Thus in New Guinea it was found that the composition of milk was much the same after 18—24 months of lactation as it was at 6—12 months. It is known that if the mother's diet is inadequate the output of milk will be reduced. Even then many studies have shown that mothers of lower socio-economic groups are able to secrete 400-800 ml of milk/per day in the first year of lactation, the output falling to 200 to 450 ml/day in the second year.

Table 5.13 Composition of breast milk (g/100 ml)

	Protein	Fat	Lactose
Indonesia	1.67	3.3	7.14
New Guinea	1.01	2.36	7.34
India	1.06	3.34	7.47
Egypt	0.93	4.01	6.48
Pakistan	0.9	2.73	6.20
South Africa	1.35	3.90	7.1
England	1.07	4.2	7.4
United States	1.27	4.54	7.1
Australia	1.41	4.95	6.46

When the diet during pregnancy is poor the mother will gain little weight. Thus the total average weight gain in pregnancy in South India is 6.0 kg, compared with 11.7 kg in the United Kingdom and 17.0 kg in the United States. (Figure 5.23).

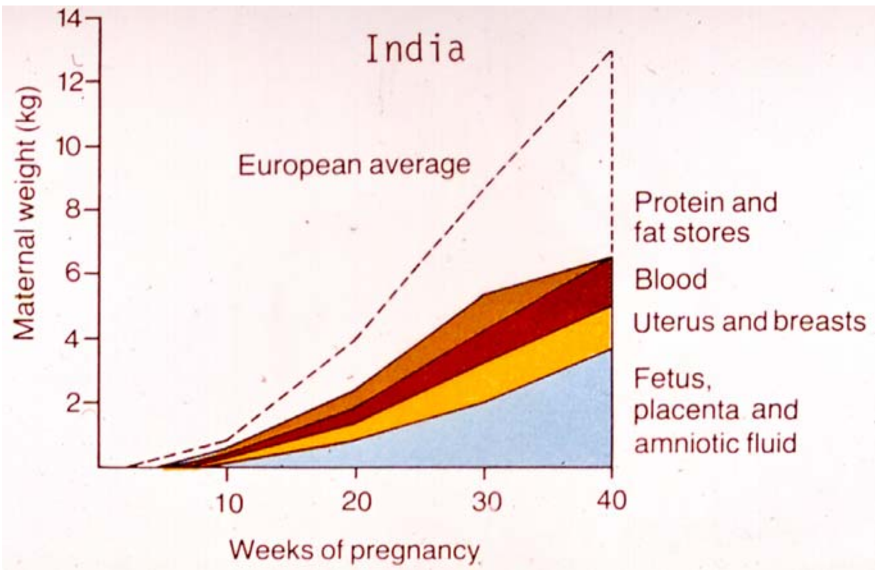


Figure 5.23 Weight gain in pregnancy in women from low socio-economic groups

In Tanzania the average weight gain in pregnancy is 9.1 kg, and in Uganda it is 8.39 kg. Most of this weight consists of the weight of the baby and other products of conception, so that the true weight gained by the mother is very little. Such a mother will commence lactation with inadequate body stores to fall back upon. In spite of this the milk output can be considerable. For example, in one study of South Indian women of a lower socio-economic group it was found that the average daily output of milk was 400 ml at the end of 18 months of lactation. Thus the child in his second year can be assured of almost one pint of milk daily in the poor circumstances of the rural household. It is likely that in such conditions the nutritional and energy cost of lactation is subsidized by maternal tissues. In one study, 82 women of the lower socio-economic group in South India were followed from the 16th week of pregnancy up to one year after the birth of the baby. The average daily intake of food provided 1400 cal and less than 40 g of protein. The average weight gain in pregnancy was 6.5 kg, most of it (6.0 kg) consisting of the weight of the conceptus, so that immediately after the delivery the net increase in weight was found to be 0.68 kg. As lactation proceeded the women tended to lose weight for the first 6 months, after which their weight became stable. The average weight loss in one year, as compared with the initial weight of the mother, was 1.5 kg, most of which (1.2 kg) occurred in the first 6 months after delivery. In spite of the loss of weight the secretion of milk was adequate to support the growth of the infants, who grew from an average weight of 2.90 kg at birth to 7.39 kg at the age of one year (Table 5.14).

Table 5.14 Changes in body weight during pregnancy and lactation in women from lower socio-economic group in south India

	Initial Wt	Wt before delivery	Wt immediately after delivery	Months after delivery			
				3 mths	6 mths	9 mths	12 mths
Number studied	82	82	82	72	59	60	56
Weight (kg)	41.91	48.53	42.59	41.27	40.55	40.41	40.36
Change from initial wt (kg)	—	+6.62	+0.68	—0.18	—1.33	—1.39	—1.61
Child’s wt (kg)	—	—	2.90	5.02	6.60	7.05	7.39

It would appear that bodies of lactating mothers juggle between daily nutrient intake and body reserves laid down during pregnancy with the result that the infant is protected from short term fluctuations in dietary intake to ensure a relatively constant supply of energy and other macro nutrients. Milk yield of 750 g/ 24 hours is commonly recorded in studies in many different populations regardless of the mothers’ racial background or nutritional status. In one study of 34 lactating women samples of breast milk were analyzed at weekly intervals for 1 month following onset of lactation, whilst monitoring maternal dietary intake. Maternal dietary saturated and mono-unsaturated fatty acids were found significantly related to corresponding milk pattern in the phase of transitional milk. The total poly unsaturated content was significantly related only to the mature milk. In this phase 42 per cent of the variation occurring in PUFAs could be related to variation in maternal PUFA dietary intake. With advancing lactation milk PUFA provision sources gradually shift from adipose tissue catabolism to maternal diet.

Endocrine factors

The development, growth and secretary functions of the mammary gland are dependent upon stimulation by appropriate hormones. In adolescent girls the breasts develop and grow to adult size under the influence of the sex hormones. In pregnancy there is further development of the secretary apparatus of the gland under the influence of high levels of circulating estrogens and progesterone. Parturition triggers the secretion of prolactin from the anterior lobe of the pituitary, and under its influence the canard cells of the mammary gland synthesize and secrete the various components of milk.

In all experimental animals, hypophysectomy during lactation inhibits milk secretion. Lactation can be restored by supplying the necessary hormones, and in four species studied the hormones shown in Table 5.15 were found to be necessary.

In the human, endocrinological control of lactation is through a complex combination of hormones. However, for all practical purposes prolactin and oxytocin can be considered the key lactogenic hormones in both initiating and maintaining milk secretion. Prolactin release from the anterior pituitary stimulates the synthesis of milk. Oxytocin secretion from the posterior pituitary causes the milk to flow into the 10 to15 lactiferous ducts which lie behind the nipple, from where it can be obtained by the infant during suckling.

Table 5.15 Hormones necessary for lactation

Species	Hormones required
Rat	prolactin and ACTH
Goat and sheep	prolactin, growth hormone, adrenal steroids and thyroxine
Rabbit	prolactin alone

During pregnancy the level of prolactin in the maternal bloodstream rises steadily but milk production cannot begin until the inhibitory effect of placental estrogen and progesterone is removed. After the delivery of the placenta this inhibition declines, and milk flow commences usually within 48—96 hours. In rare instances retained fragments of the placenta can continue to exercise inhibition of milk secretion. Putting the baby to the breast soon after the delivery has many advantages, one of them being the evacuation of the uterus which contracts (causing 'after pains') in response to oxytocin release from the pituitary.

Laboratory techniques of measuring prolactin and oxytocin have been developed comparatively recently. Several studies have since demonstrated the importance of prolactin in mammalian lactation. It has many similarities in structure and function to the growth hormone and to the lactogenic hormone derived from the placenta. Together with other hormones, such as the adrenal steroids and thyroxine, it forms the lactogenic hormone complex necessary for successful lactation.

In the non-lactating individual the secretion of prolactin is inhibited by a hypothalamic factor termed the 'prolactin-release inhibiting hormone. This substance is synthesized in the hypothalamus and transported to the anterior pituitary in the portal system along the stalk of the pituitary. At delivery the inhibition of prolactin release is removed, resulting in the secretion of the hormone from the anterior pituitary. (See Fig. 5.24)

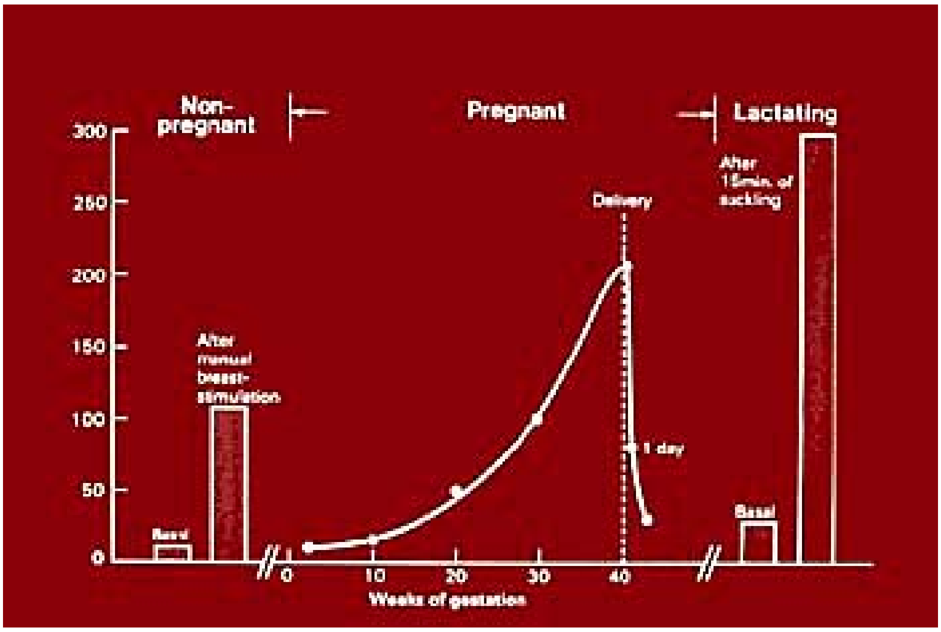


Figure 5.24 Prolactin levels in blood

Recently it has been demonstrated that administration of the thyrotrophin-releasing hormone (TRH) results in elevation of blood levels of prolactin as well as thyrotrophin, suggesting that TRH could be a physiological prolactin-releasing hormone. It has also been shown that TRH improves milk output in women with declining lactation. Thus there are important possibilities for the clinical use of TRH.

The event that triggers lactation is the delivery of the placenta with the associated loss of placentally derived hormones. The high levels of prolactin achieved during pregnancy are then able to exert an influence on the mammary glands and milk production begins by removal of inhibition. In the early days milk production is highly variable varying between 200 – 900 mg/24 hours. Over the next 3 to 5 weeks milk output gets progressively adjusted to the baby's needs.

Galactorrhoea is known to occur as a side effect of some drugs, such as reserpine and chlorpromazine. These pharmacological agents act on the hypothalamus, removing the inhibition exerted by the hypothalamus on the secretion of prolactin. These drugs have been used to induce lactation in women.

The let-down reflex

Once the acinar cells of the breasts begin to secrete milk, its continuing secretion and flow along the lactiferous ducts is maintained by a neuro-endocrinologic mechanism commonly known as the 'let-down reflex'. The nipple and areola are richly supplied with nerves. When the baby is put to the breast the tactile stimulation at the nipple during suckling results in afferent nerve impulses which travel to the hypothalamus. In turn the hypothalamus activates the anterior and the posterior lobes of the pituitary gland. Prolactin is secreted from the anterior lobe and under its effect the secretary activity of the acinar cells of the mammary gland is stimulated and maintained. At the same time oxytocin is secreted from the posterior lobe of the pituitary. It causes the contraction of the myoepithelial cells in the mammary gland, thereby propelling the milk along the duct. It is a common experience of many mothers that when the baby is put to the breast on one side, some milk may drip from the breast on the other side, and hence the term ‘let-down’ or milk-ejection reflex. (See Figure 5.25). Later, when lactation has been well established and the reflex mechanism has been reinforced several times over, many mothers experience a tingling sensation or heaviness in the breast as feeding time approaches, or even on hearing the cry of the baby in the next room

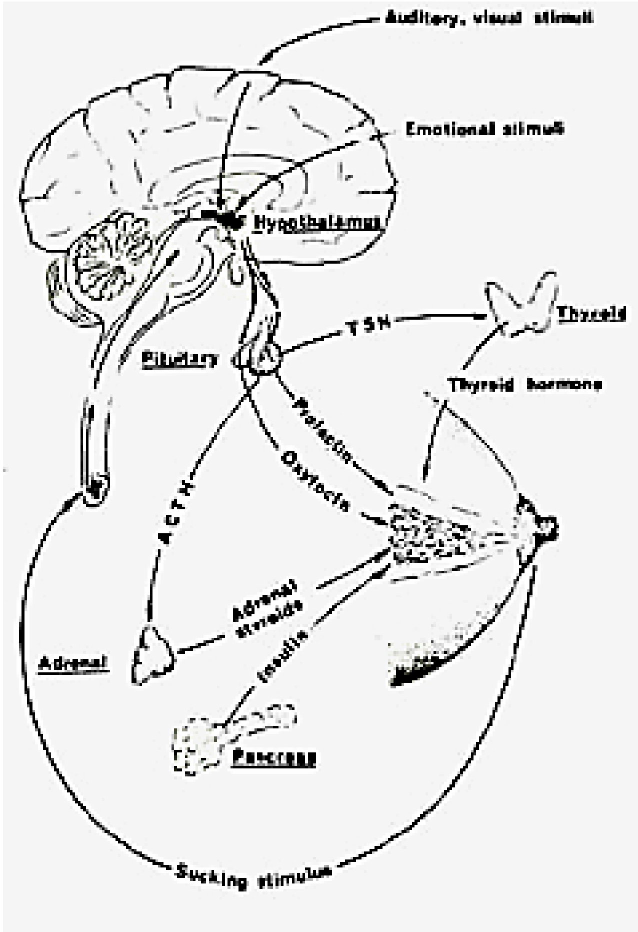


Figure 5.25 The let-down reflex

The let-down reflex is the most crucial physiological mechanism in successful lactation. Any factor interfering with suckling at the breast by the infant will interfere with this mechanism and affect milk secretion, eventually causing the breasts to dry up. On the other hand, regular and repeated emptying of the breast by suckling will stimulate milk secretion and flow. In order to help establish lactation the baby should be put to the breast as soon after delivery as possible, allowing time for the baby and the mother to recover from the rigours of labour. In most studies of normal full-term deliveries the infants have been shown to be able to suckle within 5 to 10 minutes of birth. After this the breast should be offered ‘on demand’ in order to establish a flexible regime of feeding. Any ‘top feeds’ or feeds of glucose water will only serve to interfere with and weaken the letdown reflex by removing the stimulus of suckling, and should be avoided. The regular offering of the breast ‘on demand’ requires close mother-infant interaction which occurs best when the infant is nursed in the same bed in close contact with the mother or in a cot nearby, instead of in a distant nursery where easy access is not possible. When lactation fails, in most cases it is due to lack of adequate suckling stimulation through inadequate mother-infant interaction, or compliance by the mother with pressures to reduce the frequency or duration of suckling (for example the rigid routine of a maternity ward, or family pressures), or due to anxiety and uncertainty in the mother. The secretion of prolactin is proportional to the stimulation of the nipple and the areola. A confident approach in which the mother is encouraged to offer the breast readily without any reservation helps to overcome her anxiety and shyness, and also provides for proper development of the let-down reflex.

Changes in prolactin concentration during single suckling episodes were studied in 20 breast-feeding women who were 4 to 40 weeks postpartum. Basal levels of prolactin were dependent upon the interval between suckling episodes. The magnitude of the prolactin response to suckling varied with the time of day when suckling occurred, being more marked with feeds after mid-day than in the morning. Such a diurnal variation indicates variation in the sensitivity of the hypothalamus to the suckling stimulus, and stresses the importance of night feeds. The basal prolactin concentration, the rise in prolactin levels on suckling and the amount of milk taken by the infant were all independent of the time since delivery until the introduction of supplementary feeds. Once weaning began there was a significant decrease in prolactin secretion with time. The usual practice of offering solids before breast-feeding means that hunger is largely satisfied, and the baby has less need or desire for breast milk. Hence suckling is less frequent and also less vigorous. As the amount of solid food taken increases with age so the duration of suckling episodes and the volume of milk consumed at each feed decreases.

During lactation oxytocin release takes place in a pulsatile manner. It usually commences a few minutes before lactation in response to preparation for or expectation of a feed. On the other hand prolactin is not released until after suckling has started, and is always in response to the tactile stimulation of the nipple during suckling.

The principle of the let-down reflex has been increasingly used in clinical practice to help mothers relactate when the flow of breast milk has dwindled or dried up after premature weaning or following a period of separation, for example hospitalization, or pre-term infants requiring prolonged intensive care. It has also been used to induce lactation in adoptive mothers. In one study of 606 mothers in whom lactation was successfully stimulated there were 240 adoptive mothers. Of these 83 had never been pregnant, 55 had been pregnant but had never breast-fed and 102 had previously breast-fed an infant. Increasing numbers of such reports in the medical literature give credence to the accounts in the anthropological literature of stimulation of milk supply by using galactagogues (for example fenugreek in Egypt), or high energy foods for parturient women (for example ‘palm nut soup’ in Ghana and Nigeria), as well as of inducing lactation in the grandmother or a female relative in the tragic event of a maternal death.

The ‘let down’ reflex is highly variable. In some mothers it can be vigorous, causing a sharp pain in the breast, and milk may spurt out in small jets. Other mothers may only experience a tingling sensation and milk may drip from the breast. This variability reflects differences in maternal physiology. As long as there is a flow of milk into the lactiferous ducts from where it can be obtained by the infant during suckling, it represents a normal response.

MOTHER- INFANT RELATIONSHIP

The act of suckling is a form of intimate communication between the mother and her infant, and it contributes to the creation of the love bond between the two. The skin contact, the eye-to-eye or "en face' position adopted during or soon after feeding, the satisfaction of hunger in the infant and the pleasurable tactile stimulation in the mother during suckling all promote, as well as add to, the process of bonding between the two. In many mammals, the time of birth is a critical period during which imprinting occurs, so that the mother recognizes her off-spring and vice-versa. Similar imprinting during a critical post-partum period also occurs in the human, and breast feeding plays an important role in this process. Mothers who are separated from their infants, for medical or other reasons, at this critical period, have a higher incidence of rejection of their babies and of child abuse. (See Figs. 5.26 and 5.27)

Figure 5.26 Mother-infant interaction during breastfeeding. Note body contact eye contact and body warmth

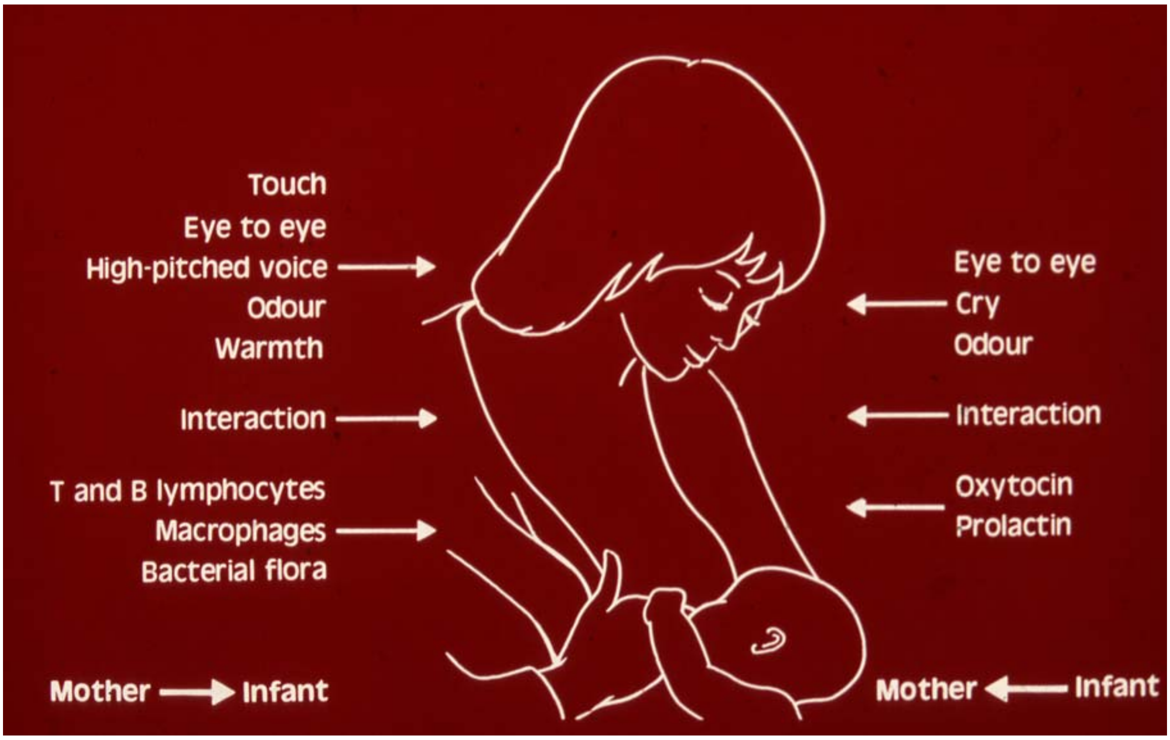


Figure 5.27 Mother-infant interaction during breastfeeding. A schematic view.

In many peasant communities prolonged breast-feeding for periods of up to 1.5—2 years is the rule. If lactation lasts for such a long period it is more likely to do so because it is a process which gives satisfaction and pleasure to the mother and not because of the dictates of duty. The psychological responses of lactation, such as nipple erection and uterine contraction, are similar to those of coitus. Some women are known to experience orgasm from breast-feeding. The studies of Master and Johnson have pointed out that nursing women have a higher level of interest in sex than non-nursing post-partum women. Nursing women not only reported sexual stimulation from suckling but were also interested in rapid return to active intercourse with their husbands.

The mother's attitude is very much dependent upon the social and cultural milieu in which she has been brought up. If there is undue modesty and embarrassment at the thought of breast-feeding, the 'let-down' reflex is likely to be inhibited. Similarly, in cultures which do not attach any stigma to breast-feeding, the amount of suckling allowed is unrestricted and on demand, which is known to help milk production. Thus infants on an unrestricted feeding schedule are known to gain weight and grow faster than those on a rigid schedule. Similarly, those fed at short intervals grow better than those fed at longer intervals, demonstrating thereby that the frequency and duration of suckling are important in determining milk yield.

The mother's desire to feed her infant is aroused if there is close physical contact. Infants who are nursed alongside the mother are fed more frequently than if they are kept in a separate nursery. The response of the baby is equally important. A lethargic baby sucks very little and thus does not stimulate milk production. In this respect the amount of medication given to the mother is important. In the case of mothers who are heavily sedated with barbiturates during labour the infants may be drowsy for as long as 5-6 days after birth and are not capable of effective suckling.

The mother's own personality and life experiences are also important. Mothers with positive attitudes who react to their babies with joy and delight are on the whole more successful at breast-feeding. Figure 5.28 indicates the contributions of various psychological factors to the success or failure of lactation.

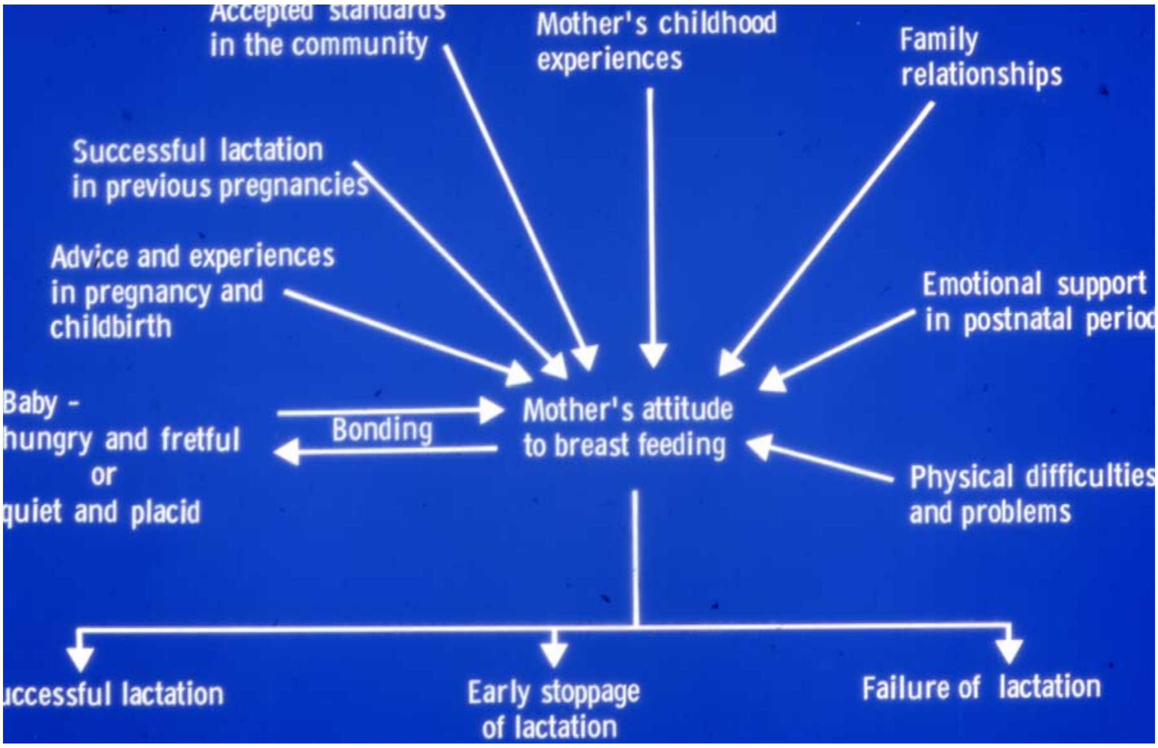


Figure 5.28 Emotional and social Factors influencing lactation

It is clear that a confident and cheerful approach from those who attend the mother in a friendly and sympathetic environment will go a long way in creating the emotional environment in which the physiological process of lactation can be initiated and developed.

Mother-Infant Bonding

The act of breast-feeding is an act of tenderness and love. After the initial period of anxiety in the mother about her competence to breastfeed and the initial learning attempts by the infant to fixate and suckle, the pair settle down to a routine of regular feeding. At each episode of feeding the close body contact, the eye-to-eye contact, and the pleasurable feeling of satiety in the infant reinforce the growing bond between the pair. Several authors have commented on the early post-partum period as a sensitive period for both the mother and the infant. In many mammals attachment for the offspring is dependent upon close proximity and contact between the mother and the newborn in the immediate post-partum period. Similarly there is evidence of imprinting in the offspring from early perceptions and experiences. The process of bonding in the human can be helped through early mother—infant contact, by rooming-in and by putting the infant to the breast soon after the delivery. There is now increasing evidence for recommending such practice. Mothers who have experienced early contact generally develop a strong and warm relationship with their infant, and breast-feed for a longer period. The infants also show more rapid development. Many traditional societies enforce a period of isolation for the mother and her baby during which the mother is spared all household chores, can receive only a limited number of visitors and must rest in bed in close proximity with her baby. This period of sole contact with the baby can be as long as 40 days in some cultures. Besides reducing energy expenditure, such a practice enables the mother—infant dyad to concentrate on one another, and encourages bonding.

Critical periods

Several crisis periods can occur with regard to breast-feeding during which the risks of premature weaning are high. These periods may be listed as follows:

1 First hours after birth. Separation of the mother from the baby and early discharge from the maternity unit to the demands of the home and the family can be extremely disruptive. Adequate time with the newborn with the exclusion of outside interference is essential for bonding, and for the establishment of lactation.

2. The period of adaptation during which the mother resumes her duties and functions in the home whilst the family adapts to the newcomer. Intense tensions can arise during the period of establishing relationships between wife and husband, husband and newborn, newborn and other family members and mother and other children.

3. Return to work for a working mother. There is a need for wise counseling for the mother to continue with breast-feeding under new conditions.

4. Around the age of 4 to 6 months when there are changes in the emotional make up of the infant.

5. First menstruation by which time or earlier there is return of sexual drive and resumption of sexual activity. Counseling for contraception is essential to avoid an unplanned pregnancy.

6. Weaning. This period is beset with hazards for the infant unless it is well-planned and gradual. Abrupt or ‘crisis’ weaning is often at the root of undernutrition besides causing emotional damage to the child due to the sudden rupture of a close and trusted relationship.

THE SPACING OF PREGNANCIES

It is estimated that more conceptions are prevented through lactational amenorrhoea than all the contraceptive methods put together. Certainly in the rural areas of the developing world breast feeding and abstinence are the only two practical methods of contraception which are universally available. Studies in Nigeria, Senegal, Rwanda, Bangladesh and Java of mothers in rural areas showed a postponement of menstruation by more than a year in breast feeding women compared with those who did not breast feed. In Korea, Taiwan and India, a postponement of between 8 and 12 months has been found. By comparison, women who do not breast feed return to regular menstruation in about 3 months after the birth of the baby.

It has been estimated that the contraceptive effect of prolonged lactation, which is ‘on demand’ and unsupplemented, can amount to a reduction of as much as 20 per cent of expected births in areas of high fertility. A review of 11 prospective studies showed that when breast-feeding is exclusive and ‘on demand’ it provides more than 98 per cent protection from pregnancy in the first 6 months after delivery. Lactational infertility generally decreases with time. The length of time depends on the pattern of feeding and supplementation.

In Chile the day of first ovulation after childbirth was investigated in 281 white women by using vaginal cytology, endometrial biopsy 7 and basal temperature. It was found that when the women were nursing the infant on the breast exclusively, there was an average of 112 to 190 days to first ovulation, compared with 50-60 days in women who did not breast-feed.

Measurements of blood hormone levels in women after childbirth have demonstrated that in the case of women who do not breast-feed the levels of prolactin decrease rapidly and from the third day after delivery they are significantly lower than in lactating women. In the latter, high levels of prolactin continue beyond 90 days postpartum. On the other hand, women who are breast-feeding show low levels of estrogen in spite of normal or high levels of gonadotrophic hormones. This would indicate that prolactin has an inhibiting influence on the synthesis of ovarian steroids. Since the secretion of prolactin is proportional to the duration and intensity of nipple stimulation, on-demand feeding and unsupplemented lactation is vital to cause delay in ovulation. These investigations demonstrate that lactation is not only an integral part of reproduction, in which parturition is but a milestone, but that it exercises a central control on reproduction. (See Fig. 5.29)

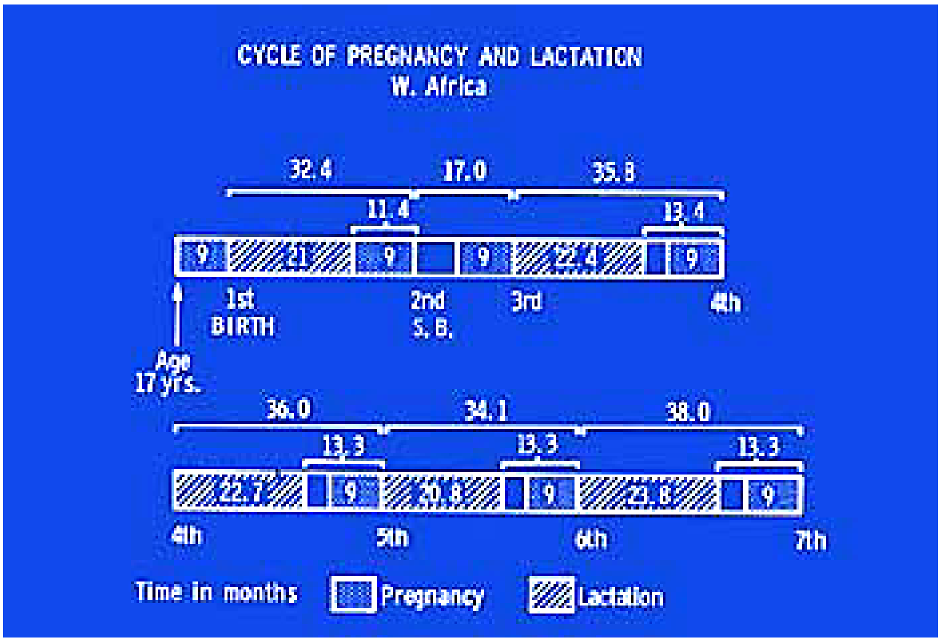


Figure 5.29 Lactation, the central control of reproduction.

In this community where prolonged breastfeeding is universal, the average birth interval was more than 31 months. But when still birth occurred, the birth interval was reduced to 17 months because of absence of lactation.

The contraceptive effect of breast feeding is due to the surges of prolactin in the mother's blood which occur as reflex responses to the tactile stimulation of the nipple during suckling. Prolactin in turn has an inhibitory effect on ovarian activity. The contraceptive effect is therefore maximum when breast feeding is on demand, complete and unrestricted both during the day as well as the night. The contraceptive effect is greatly reduced if breast feeding is partial and supplemented early with solids or cow's milk formulae. By prolonging the birth interval on-demand breast feeding ensures adequate mothering of the infant, which is yet another way in which it contributes to the protection of the infant.

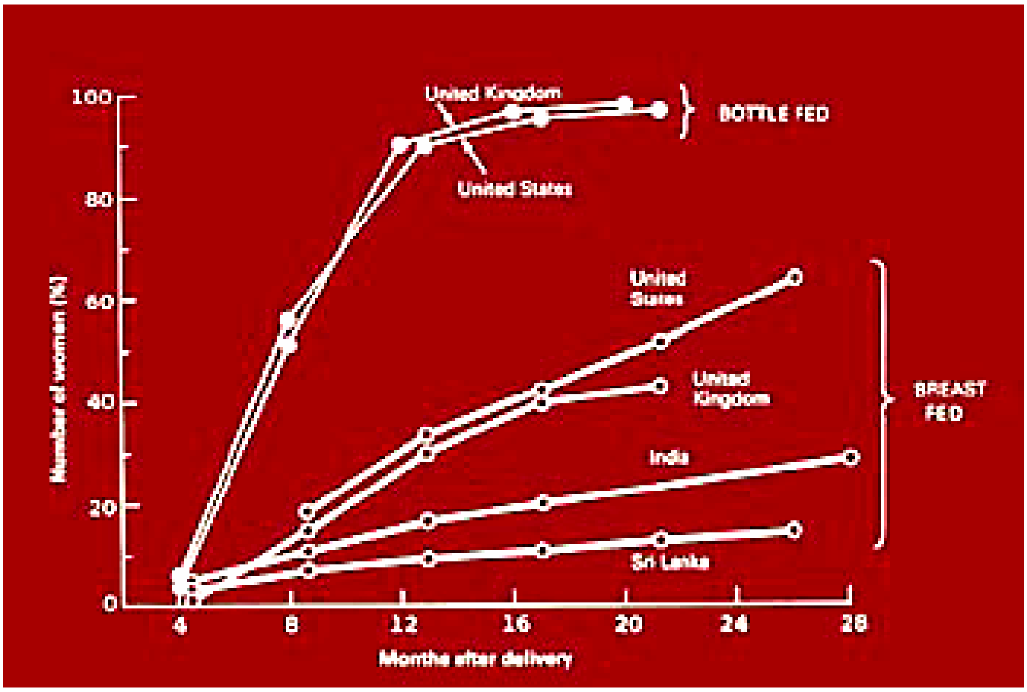


Figure 5.30 Return to regular menstruation, amongst women who fed their infants on breast or on bottle.

In breast-feeding women a quantitative relationship between the strength of the suckling stimulus and the contraceptive effect is demonstrable. Exclusively breast-feeding women experience a longer period of lactational amenorrhoea compared to those who introduce supplementary food at an early age. In one study 27 breast-feeding and 10 bottle-feeding mothers were followed up from the time of delivery until the normal ovulatory menstrual cycle at the Medical Research Council's Reproductive Biology Unit in Edinburgh (U.K.). Those women who bottle fed began to menstruate on average 8 weeks after delivery, and to ovulate after 11 weeks. By contrast the breast-feeding women began to menstruate 33 weeks after delivery, and to ovulate after 36 weeks. No woman ovulated while she was breast-feeding six or more times a day and for more than sixty minutes a day. Also no woman ovulated during unsupplemented breast-feeding in this study. When the breast-feeding women were grouped according to whether they ovulated late (more than 40 weeks after delivery) or early (less than 30 weeks after delivery) it was found that the late ovulators breast-fed for longer, suckled more often, kept up night feeding longer and introduced supplementary foods for the baby more gradually. When supplements were introduced at about 16 weeks after delivery there was a sharp decline in the duration of suckling and in the number of times the infant was put to the breast. This was associated with a fall in blood prolactin levels in the mother. Within 16 weeks of introducing supplements, ovarian follicles had begun to develop in 20 of the 27 women, and 14 of them had ovulated. This and other similar studies demonstrate the importance of the ‘natural’ form of breast-feeding - frequent, on demand, both day and night-time feeding — for child spacing. Secondly, advice for supplementary feeding in an exclusively breast-fed infant should never be given lightly. The risk of another pregnancy must always be borne in mind. Supplementary feeding must always be accompanied by counseling about contraceptives.

Lactational amenorrhoea (See Fig. 5.30), however, does not correspond exactly to period of absent fertility, since between 2 and 10 per cent of mothers conceive while still amenorrhoeic. This is because ovulation and conception can precede the first menstruation, and the return of menstruation cannot be used as an infallible guide. The longer lactational amenorrhoea lasts the less reliable it becomes as a means of contraception. Even then it has been estimated that in traditional societies, such as Bangladesh, the conception rate during breast-feeding is less than 5 per 100 women-years which compares well with many modern contraceptives. In the developing world as a whole breast-feeding provides an estimated 35 million couple years of protection as compared with 24 million couple years from all other forms of contraception put together. Analysis of data from several countries shows that a 25 per cent decline in breast-feeding would result in a 2 to 16 per cent increase in fertility. The increase in the use of contraceptives needed to offset this could be as great as 700 times the current rate of contraceptive use.

Breastfeeding and the infant

Suckling is the process by which the infant obtains milk from the mother's breast. It is not the same as sucking, even though some -negative pressure is generated within the infant's mouth. During suckling the nipple is actually 'milked' between the infant's palate and the tongue by rhythmic movements of the tongue and the lower jaw (Figures 5.31A and B).

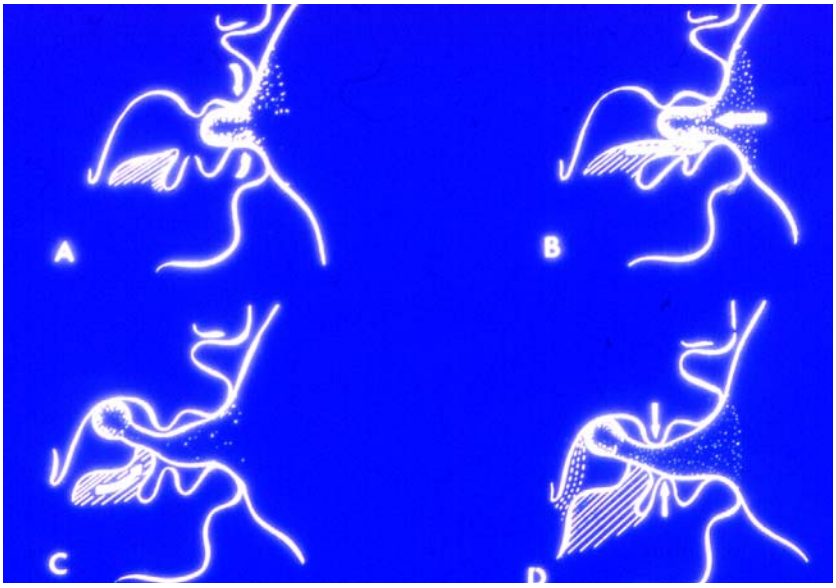


Figure 5.31 The suckling response.

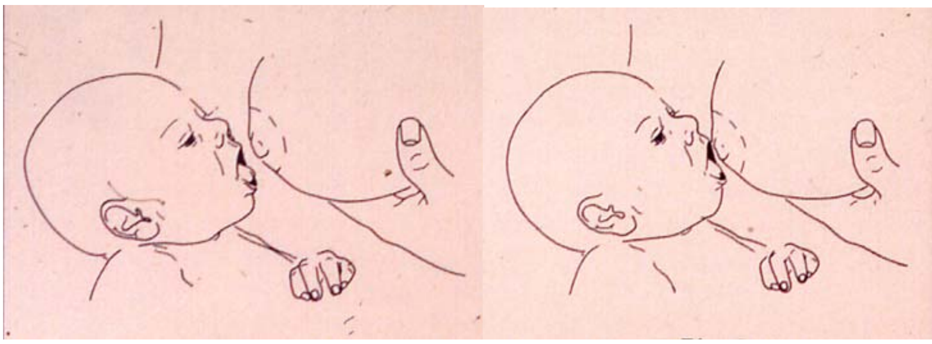
A. The lips of the baby close around the nipple and the areola.
B. The tongue protrudes to grasp the nipple.
C. The tongue pulls back bringing the nipple against
the hard palate and the areola into the mouth.
D. Negative pressure is created by the action of the cheeks,
The gums compress the areola and with an active 'let-down' reflex milk flows from the high pressure system in the breast to the area of negative pressure in the baby's mouth.

In order to obtain nutrition from the mother the baby should not only be able to find the nipple and suckle it, but he should also be capable of swallowing the milk as well as digesting and assimilating it. Physiological maturity is necessary for the successful accomplishment of these different parts of feeding. In the animal kingdom the initiative for suckling is always taken by the newborn. In the human, however, the mother must take the first step by putting her baby to the breast.

The transfer of milk from the mother's breast to the baby takes place by a combination of two processes: (i) the ejection of milk from the breast by the 'let-down' reflex, and (ii) the active removal of milk by the baby during suckling. Both these mechanisms help to ensure that the infant obtains the full volume and nutrient content at each feed.

At times some babies ingest only the milk ejected by the mother and very little is consumed through the infant's own efforts. In such instances the baby's feeding technique is at fault, which must be helped by proper positioning. Similarly in some women the ejection of milk is poor and the baby's milk intake must largely come through active suckling and full emptying of the breast. For such cases also, correct attachment and positioning at the breast are important.

Several reflexes enable the newborn to obtain milk from the breast. These are the rooting reflex, the suckling reflex and the swallowing reflex. The full-term baby, when lightly touched on the cheek near the corner of the mouth, will turn his head so as to bring his mouth to the object touching his cheek. This is the **rooting reflex**, which enables the baby to find the nipple when he is put to the breast. After the first few such experiences the baby begins to recognize the feeding situation, and will search for the nipple when he is picked up to be fed. Stroking the baby's lips gently with the nipple will usually trigger the rooting reflex and he will respond by opening his mouth wide to take in the nipple. (See Fig. 5.32)



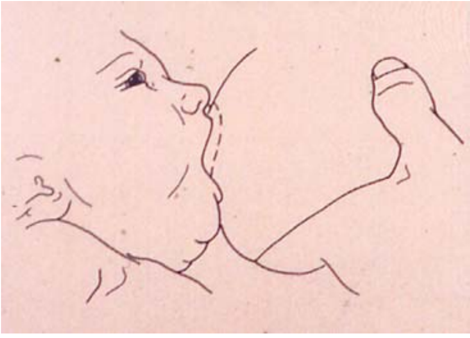


Figure 5.32 The rooting reflex

The wider the opening of the mouth the easier it is for the mother to help the baby attach to the breast. Hence the importance of establishing a strong rooting reflex at the beginning. In addition to the reflex mechanism itself other sensory stimuli such as warmth and smell must also play a part in enabling the infant to locate the source of milk. The sense of smell is important in the case of many lower mammals. For example, if smell is blocked in baby rats (by instilling zinc sulphate into the nostrils) at the age of 2 to10 days, they are unable to make successful contact with the teat and do not survive. Once the nipple is put into the mouth of such anosmic rats they can suck well and thrive, demonstrating that the only defect is their inability to find the teat.

Recent studies in human infants indicate that the sense of smell may have a similar important role to play in enabling the infant to locate the nipple. When the breast pads of a mother are held near her infant the baby will turn his head towards them in preference to a clean pad held in a similar manner. This ability to distinguish the smell of milk can be demonstrated in a significant number of infants at the age of 5 days; by the 6th day many babies have a differential response between their own mother’s breast pads and those of another.

After the first few attempts at breast-feeding the infant learns quickly and the mother will notice that she can generate a strong rooting reflex by touching or stroking the infant’s mouth with the nipple.

The **suckling reflex** is aroused when the baby experiences the filling of his mouth, right up to the hard palate and the dorsum of the tongue, with the nipple or a nipple substitute. The full action in the reflex involves the jaws, tongue and cheeks (Figure 5.33). The movements of the jaw enable the gums to press on the areola, the suction generated draws the nipple and the areola well into the mouth forming a ‘teat’, and rhythmic compression with the tongue squeezes the milk into the mouth. The tongue is at first thrust forward and then backward, compressing the nipple against the hard palate and creating a true ‘milking’ action. The muscles of the cheek create suction and maintain a negative pressure in the mouth.

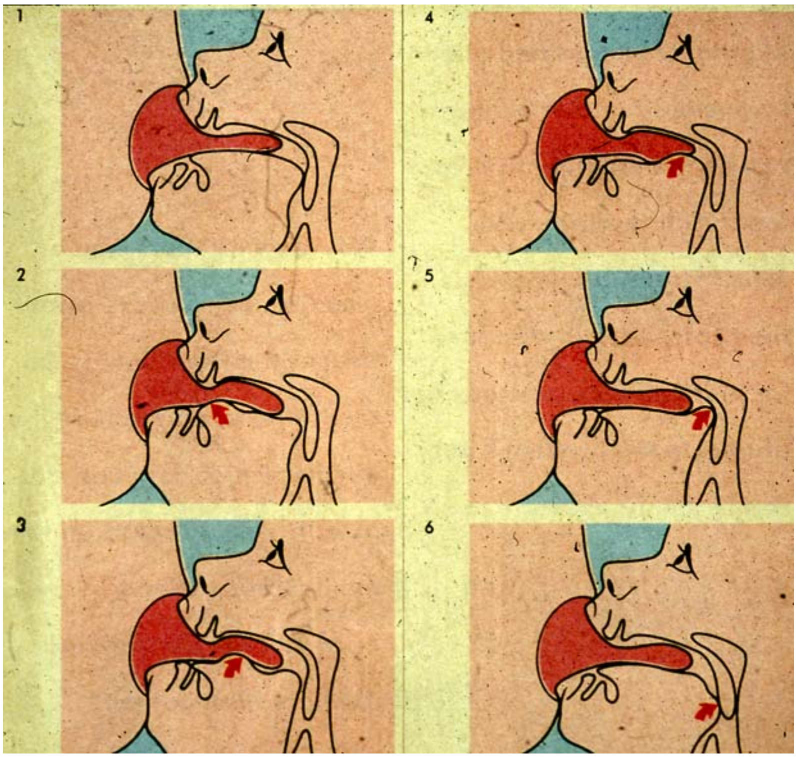


Figure 5.33 Suckling. Notice the wave of contraction along the tongue as each mouthful of milk is obtained and swallowed.

Again, the infant learns from experience, and after a few days he becomes skilled at obtaining the milk from the nipple. The lips will now close firmly at the junction of the nipple and the areola, and the tongue will be thrust forward to grasp the nipple and bring it against, the hard palate where the ‘milking’ can be done efficiently. With proper positioning there is no friction of the tongue or the gum on the nipple, and no movement of the breast tissue in and out of the mouth. If the positioning is faulty and the baby has to struggle at the breast, trauma and soreness can result. Any pain during feeding is a signal that the technique is faulty.

For a successful suckling reflex to be established the infant should be able to stretch the mother’s nipple against his hard palate. A protractile nipple is vital for success in breast-feeding, because only then is the infant able to take a good grasp with his mouth and carry out milking. In a large proportion of mothers who experience difficulties in establishing a good feeding response from their infants the nipples are not protractile, and on manual stimulation they project forward by less than 2.5 cm or not at all. In order to elicit a good suckling reflex, the back of the infant’s mouth needs to be filled with the nipple, hence the importance of adequately protractile nipples. During suckling it is the infant's tongue which milks the lactiferous ducts of the breast. To allow full movement of the lower jaw it should not be impeded by tight clothing or bonnets and should be well away from the base of the nipple. Since it is the feel of the nipple against the palate which evokes the suckling response, the correct positioning of the baby against the breast is important.

The baby's chin should drive into the breast to enable the nipple to reach the palate. If the baby's head becomes flexed the chin moves away from the breast and the nipple touches the lower jaw. At the same time the nose may be too close to the breast and the baby may have difficulty in breathing. Such a posture will lead to struggling at the breast and eventually nipple damage.

Helping the chin to thrust forward is best achieved by firm support to the baby's back at the level of the shoulders with the baby facing the mother.

A rubber teat placed inside the infant's mouth can also evoke a suckling reflex similar to the one with the nipple. However, when the infant is fed with a bottle, the movements of the tongue and the cheek muscles are different (Figure 5.34). There is relaxation of cheek muscles, as opposed to contraction when suckling on the breast. The rubber nipple strikes the soft palate where the flow of milk by gravity causes the infant to gag. The tongue then moves forward and presses the teat against the gums to control the flow of milk and to prevent flooding at the back of the mouth. Since the cheek muscles are in a relaxed position, the lips also are relaxed, making an 0 instead of compressing the teat as in the case of breast-feeding. Thus less work is required to suck at the bottle.

Figure 5.34 The suckling response to feeding from a bottle. The lips open out to receive the nipple, and the cheek muscles relax. The rubber teat rests on the tongue, striking against the soft palate. The Tongue moves forward to compress the teat against the gums and the palate so as to control the flow of milk.

Introduction of the bottle at an early stage will create a learning response to it and weaken the baby’s response to suckling at the breast. In some cases the desire to feed at the breast is also weakened. Normally, however, the breast has the advantage over the bottle in being able to elicit a strong suckling reflex as well as ejection of milk by the let-down reflex except in the case of those mothers whose nipples are poorly shaped or retracted. Between feeds, milk secretion in the alveoli takes place at a constant rate. The passage of fat globules and protein granules from the cytoplasm of the alveolar cells into the duct lumen is passive by the process of dialysis. This form of secretion produces a watery milk of comparatively lower fat (2 per cent) and protein content. It travels down the ducts to the lactiferous sinuses and awaits ingestion by the infant at the next feeding. It is called the ‘foremilk’ and it constitutes about a third of the total milk volume available to the infant.

When the infant suckles at the breast the secretion of oxytocin because of the let-down reflex in the mother causes the contraction of myoepithelial cells in her breast tissue. (See Fig. 5.35) The alveolar cells are squeezed hard and the larger fat globules and protein particles are forced out into the duct system. The 'hind milk' so produced has a high fat content (4-7 per cent) and constitutes the remaining two-thirds of the milk volume. It mixes with the previously formed foremilk and increases its caloric content. Thus a strong suckling stimulus is necessary for a vigorous let-down reflex and milk flow. If the let-down is not strong enough the infant will consume only the foremilk which is insufficient to sustain him both in quantity and quality.

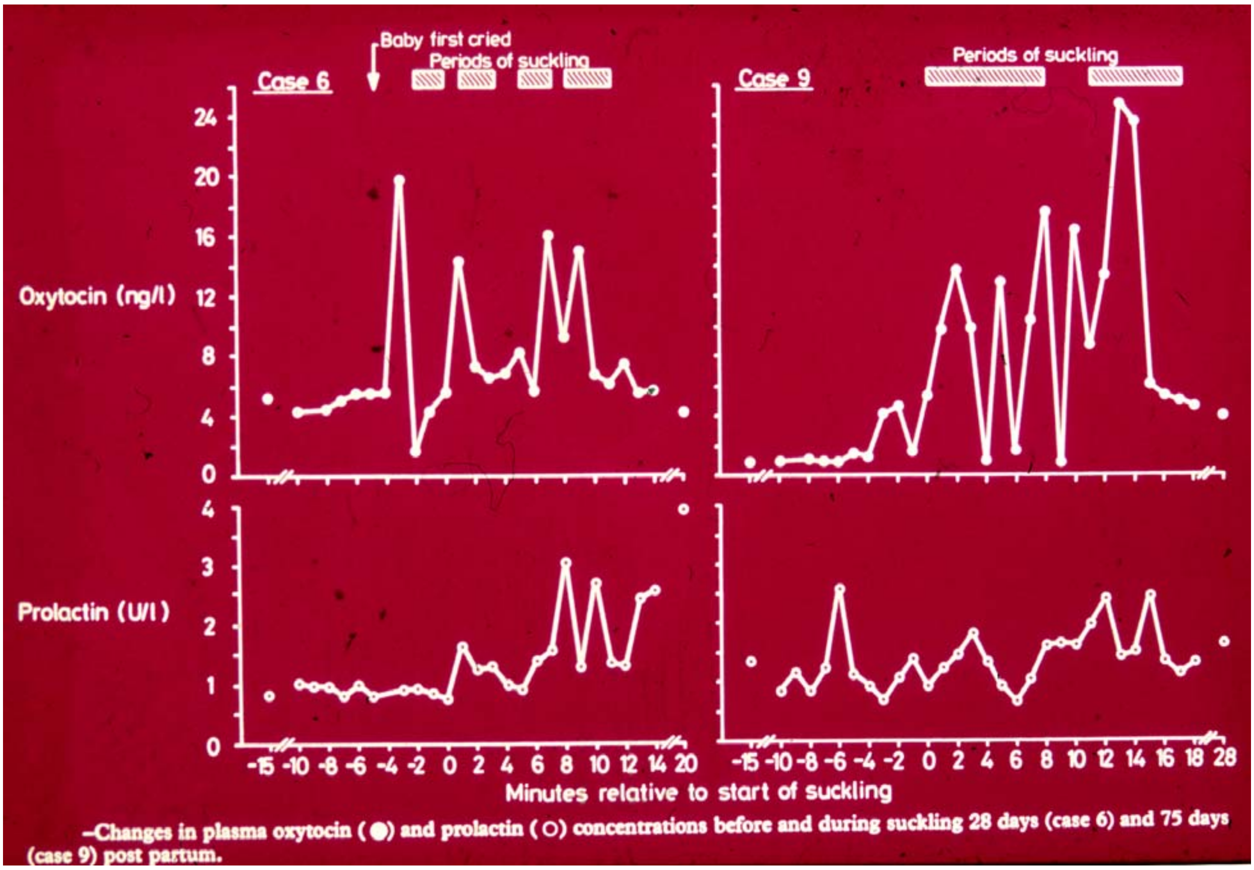


Figure 5.35 Secretion of Prolactin and Oxytocin during breast feeding

The composition of milk changes during feeding as described above. At the end of a feed breast milk contains 4-5 times as much lipid and 1.5 times as much protein as at the beginning. The concentration of lactose remains unchanged. These changes in the composition of milk during feeding occur regardless of the stage of lactation, and control the satisfying of hunger on the one hand and the slaking of thirst on the other. Infant appetite control is triggered by the fat (i.e. energy) intake. Inadequate triggering of the infant's satiety mechanism will result in the infant crying and being unsettled after feeds. Variation in the fat content of milk is almost entirely a function of the efficiency of milk removal and emptying of the breast with the fat content being improved by maximizing the emptying of the breast.

At each mouthful the baby swallows about 0.6 ml of milk. Coordinated action of the muscles of deglutition is necessary to convey the bolus of milk from the posterior pharynx into the oesophagus without aspiration into the respiratory passages. In the healthy full term infant the swallowing reflex is well developed, and suckling as well as swallowing pose no problems. Oesophageal function, however, is not efficient in the first few days after birth, so that there may be an extremely rapid peristaltic rate, biphasic waves or even non-peristaltic simultaneous contractions along the entire length of the oesophagus. As the infant grows older oesophageal activity shows better co-ordination during swallowing.

Recent studies indicate the presence of an upper airways reflex mechanism which helps to prevent aspiration. In experimental animals the introduction of water or milk of another species into the upper airway causes a period of apnea and a swallowing action is evoked. Introduction of normal saline or milk of the same species does not produce such an apneic effect. Cow's-milk feeding in the newborn activates this reflex. For example, it has been observed that when an infant is fed cow's milk he sucks continuously and breathes intermittently. When the same infant is fed expressed breast milk from the same bottle he sucks intermittently but breathes continuously. The breathing of the infant is thus more regular when he is fed breast milk, and such regularity of breathing cannot be demonstrated with cow's milk.

The neonate is a compulsive nose breather. Any obstruction in the nasal air passages causes respiratory difficulty and restlessness. In the case of a mother with retracted nipples the soft breast tissue will press against the infant's nose during feeding and cause obstruction to breathing. Thus small retracted nipples are a common cause of difficulties with breast-feeding.

The reflex mechanisms mentioned above require a healthy and vigorous infant with a well-functioning neuromotor system to bring them into play. Sedatives and anaesthetics given to the mother before or during labour can reach the infant, causing a lack of response to environmental stimuli and an inability to learn from the feeding situation for several days. Moreover, if the vigour of his suckling is also diminished, the let-down reflex will be weaker and the milk flow will be diminished. Barbiturates, phenothiazines and benzodiazepines all have such an effect. It is not yet widely recognized that local anaesthetics given to the mother are rapidly absorbed and cross the placenta, so that peak levels are reached in the foetus 9—10 minutes after a local anaesthetic block is given to the mother. Moreover, the effects of such local anaesthetics persist for a longer time in the baby, causing serious problems with feeding.

Successful lactation depends largely upon the physiological mechanisms of the mother working in synchrony with those of suckling in the infant. It would not be correct to think of the process a merely a mechanical one of secreting milk in the one and obtaining it in the other partner. The mother and her infant work together as a 'dyad'. One is able to stimulate a response or mould it in the other. Thus not only does the suckling stimulus from the baby result in the formation of milk and its ejection, but there is also evidence to show that the influence of hormones circulating in the maternal blood stream moulds the nipple to the suckling efforts of the baby. Moreover, the personalities of the mother and the infant come together in a mutually satisfying and pleasure-giving process.

Studies of breast-feeding mothers and their infants show that a few days after the establishment of lactation each child tends to have a characteristic level of milk intake throughout lactation, and each mother a characteristic level of milk output in successive lactations. Differences in intake between different children is related to the number of feeds and the intake per feed which remains roughly the same for a given child. The weight of the infant (at birth and later) correlates well with the milk intake until late in lactation. Once weaning has commenced, the intake of the weaning diet and the frequency of feeding determine the milk intake. Maternal weight, body mass index (weight/height^2), parity, energy intake and social class correlate well with the output of milk. Besides such factors, all studies on lactation normally conclude that the mother's self confidence and psychological attitude are amongst the strongest predictors of the success and duration of breast-feeding. Whenever there is an inadequacy of breast milk, either true or perceived, it leads to anxiety resulting in diminished frequency of feeding and low prolactin levels. This begins a vicious cycle ending in low milk output. Perceived inadequacy will often lead to premature weaning and supplementation with similar results. Hence the need for a confident approach and good counseling to maintain lactation.

THE NEONATAL GUT

In the full-term newborn the gastro-intestinal tract is well developed for the digestion and absorption of human milk. Several of the enzyme systems in the developing gut reach mature levels at or soon after term. Thus free acid can be detected in the stomach of the newborn within several hours of birth, and increases in amount in the first 24 hours. Pepsin secretion parallels the secretion of the acid and though less than the adult levels it is adequate for the pepsin digestion of milk. Tryptic activity is present in the pancreatic juice in a third of infants at 28 weeks' gestation. A tenfold increase in activity occurs between 28 and 36 weeks of gestation, after which the activity remains constant until term, followed by another tenfold increase between birth and the age of 9 months. Similarly, lipase activity is present at 34—36 weeks' gestation. It doubles by the time the infant is full-term and then a further tenfold increase in activity takes place between birth and the age of 9 months. In the mucosa of the small intestine a-glucosidases (maltase, sucrase, iso-maltase, amylase) are detectable in a 3 month-old foetus, reaching maximal values by the 6th to 8th month of gestation. 13-glucosidases (lactase) reach a maximal value only at the end of normal gestation, though in the prematurely born infant development of lactase activity occurs rapidly. Thus in the healthy full-term infant all the digestive enzymes are present in amounts adequate for the digestion of human milk (Table 5.16).

Table 5.16 Development of digestive enzymes in the gut

	Foetus					Infant
	Before 28 weeks	28 weeks	28—36 weeks	36—40 weeks	Birth	Birth—9 months
Trypsin	—	First detected in 1/3 of fetuses	Tenfold increase	→	→	Tenfold increase
Lipase	—	—	First → detected	Doubles	→	Tenfold increase
α - glucosidases	First detected at 12 weeks	→	Maximal			
β-glucosidase	—	—	—	Maximal value		

The development of the gut, like any other system in the body, is controlled and modulated by four interacting mechanisms: the genetic endowment, an intrinsic biological clock, regulatory mechanisms and environmental influences. *Genetic endowment* controls the overall process of development in the individual and to a lesser extent the development of specific tissues and organs. The term *biological clock* is applied to the predetermined sequence of events by which the development of an organ or a system occurs, for example differentiation of the primordial cells into specific cell lines out of which anatomical structures emerge and unique functions become manifest. Table 5.17. gives the biological time sequence of gut functions in foetal life.

Table 5.17 Biological clock in the development of the gut in foetal life

Foetal development	Weeks
Anatomical development	
Oesophagus	
Formation of superficial glands	20
Stomach	
Gastric glands develop	14
Pylorus and fundus defined	14
Pancreas	
Differentiation of endocrine/exocrine tissue	14
Small intestine	
Crypt villi develop	14
Functional development	
Suckling and swallowing	
Only mouthing	28
Immature reflex	33 to 36
Stomach	
Secretions	20
Small intestine	
Amino-acid transport	14
Glucose transport	18
Fatty acid absorption	24

The regulatory mechanisms triggering both genetic expression and the sequences of the biological clock are largely chemical signals from the hypothalamic—pituitary—thyroid—adrenal axis, local hormones of the gut, such as motilin and glucagon, as well as a number of physiologically active peptides secreted by a more diffuse neuroendocrine system. For these chemical signals to be effective, target tissue must possess receptors. Such receptors begin to appear at defined times on the cells of the different organs of the gut. Environmental influences play an important role in bringing out the full potential of the genetic endowment. In the case of the newborn, breast milk provides a major environmental influence on the further development of gut function in all mammals including man. Research into the properties of human breast milk has been overshadowed by its nutritional properties. Recent studies have shown that besides its nutrient content, breast milk has immunological properties; it also contains hormones and growth factors, which have a marked effect on the growth and development of gut function. It is now increasingly realized that the process of development in the gut as determined by the genetic endowment and progressing by sequence according to the biological clock with its regulatory mechanisms is ‘fine tuned’ by trophic agents present in breast milk. In this way breast milk comprises a series of biological systems. It has utrients to nurture and support growth; immunological agents for protection and for modulating the development of the immune system; trophic agents which. stimulate gut development, as well as a variety of factors that influence the metabolic—endocrine response in the infant. Thus it is a mediator of biological functions in the newborn. Some of these properties of breast milk are described in detail in Chapter 4. At this stage it is important to stress that in foetal life many of the above functions are served by the placenta. After birth these functions are taken over by the mammary gland.

ASSIMILATION OF MILK

In the infant during the first few weeks of life there is hardly any urinary excretion of nitrogen, suggesting that almost all the nitrogen consumed as protein in breast milk is utilized for building body tissues. Thus the infant does not burn protein for producing energy but utilizes it solely for building body tissues. In this respect breast milk has a distinct advantage because of its unique amino-acid composition. For example, several amino-acids in cow's milk occur in amounts 3—4 times greater than in human milk. Also there is a difference in the proportions in which the individual amino-acids are present (Table 2.2).

Many of the enzyme systems required for the degradation of various amino-acids are not fully developed in the newborn so that infants, especially premature babies, fed on cow's milk may show prolonged elevation of amino-acid levels in the blood lasting several weeks. Tyrosine, phenylalanine, branched chain amino-acids and methionine are the amino-acids which may be found in raised levels in such situations.

If a healthy breast-fed infant is taken as the biological norm then the metabolic differences found in formula fed infants are certainly abnormal. Even when the content of protein in the formula is much reduced in the so-called process of 'humanization' of cow's milk, significant metabolic differences between full term breast-fed and formula fed infants are found. These differences are more pronounced in pre-term infants, as well as in the case of those formulae in which casein is the predominant protein. In full-term infants, even as late as age 12 weeks after birth, the blood levels of all amino-acids except taurine and cysteine remain elevated. The possible effects of abnormally high levels of phenylalanine and tyrosine on the developing brain must cause anxiety. Persistently high levels of these amino-acids are considered responsible for the intellectual deficits seen in phenylketonuria and tyrosinaemia. Similarly elevated levels of the branched chain amino-acids, such as leucine, cause stimulation of insulin secretion. The levels of insulin are significantly higher in formula fed than in breast-fed infants. An amino-acid which is significantly different is taurine. Human milk has a high concentration of taurine which is thought to be needed by the developing brain. Thus it is now being increasingly realized that the metabolic and endocrine responses of formula fed infants are significantly different from their breast-fed counterparts.

Not only is the absolute amount of each individual amino-acid important but also the proportion in which various amino-acids occur. Their relationship to the carbohydrate and other constituents of milk also has a bearing on their utilisation. For example, the proportion of methionine to cysteine in human milk is well adapted to the metabolic situation in the baby. On the other hand, cow's milk with its high methionine and low cysteine content tends to cause methionine accumulation when given in full strength and relative cysteine deficiency when diluted. Because of these and several other aspects of the biochemistry of the newborn, breast milk remains the ideal food for the baby.

Table 5.18 Amino-acid composition of human and cow's milk (g/l)

	Mature human milk		**Cow's milk**	
	Mean	**range**	**mean**	**range**
Arginine	0.49	0.28—0.64	1.4	1.2—1.6
Histidine	0.31	0.12—0.30	1.2	1.1—1.3
Isoleucine	0.67	0.62—0.72	2.5	2.1—2.9
Leucine	1.2	1.1—1.3	3.6	3.2—3.9
Lysine	0.90	0.81—1.0	2.6	2.3—3.1
Methionine	0.19	0.17—0.21	0.8	0.6—0.9
Cysteine	0.25	0.22—0.28	0.29	
Phenylalanine	0.48	0.42—0.58	1.8	1.5—2.2
Tyrosine	0.38	0.34—0.42	1.9	
Threonine	0.58	0.50—0.63	1.7	1.3-2.2
Tryptophan	0.30	0.27—0.33	0.6	0.4—0.8
Valine	0.87	0.77—0.96	2.6	2.4-2.8

INTERVENTION PROGRAMMES

The data presented in the foregoing pages help to establish breast milk as an important biological agent for the survival and extrauterine adaptation of the newborn. In all societies morbidity and mortality rates are higher in artificially fed infants compared to those who are fully breastfed. Studies in Europe and the United States at the beginning of the century showed that mortality rates were 3 to 6 times higher in artificially fed infants. Even as recently as the 1940s the mortality risk for artificially fed infants was 2 to 3 times that for breast-fed infants in all social groups in Sweden. It was only from the 1940s onwards that reports from industrialized countries began to suggest equal mortality rates for both groups of infants. This is not so much due to the availability of improved products as to improved environmental hygiene. In the developing world, where more than three-quarters of the world's babies are born, the mortality risks continue to be high. It can be stated without reservation that if in the rural area of a developing country an infant has no access to the mother's milk, then the chances of survival will be very slim indeed. The greatest danger is from progressive undernutrition resulting in marasmus, and from diarrhoeal disease. The decline in breast feeding in the developing world has been associated with a rise in the incidence of marasmus and diarrhoea, especially amongst the urban poor.

Alarmed at the hazards of bottle feeding, the international agencies have been voicing concern since 1970 at the high-pressure advertising of baby foods in the developing world. Finally in 1981 the 34th World Health Assembly voted (with one dissenting vote) in favour of an international code of ethics for member states to adopt in their countries.

From the outset three major factors have been identified as contributing to the marked and rapid decline in breast feeding. These are the promotional practices of baby-food manufacturers and the absence of a unified and strong stand by the health profession against such promotion and in favour of breast feeding. Thirdly, and most surprisingly, governments of the Third World have hitherto failed to look upon breast milk as an important national resource, despite the large expenditure in foreign exchange on the importation of various brands of powdered milk.

Even though the health profession has an important and active role to play for the protection of breast feeding, there is need for support at the community and national level. The specific interventions should therefore be considered at the level of the health profession, the community and the nation.

Health profession-related interventions

(1) In all training institutions there should be adequate time allowed to teaching about breast feeding, including its practical management. The clinical, nutritional, public health and social benefits of breast feeding need to be emphasized together with the harmful effects of bottle feeding.

(2). Present-day medical practices, proven to be obstacles to successful breast feeding, need to be modified (table 5.19).

Table 5.19 Practices interfering with successful lactation

Practices	Effect on lactation	Modifications
Delaying first breastfeed.	Inadequate stimulation of let-down reflex.	Putting infant to the breast immediately after birth.
Excess maternal anaesthesia resulting in sedated newborn.	Weak, unco-ordinated suckling.	Avoidance of excessive sedation of the mother.
Supplying prelacteal glucose feeds.	Weakening of the stimulus.	Avoidance.
The rigid 4-hourly routine of feeding with no night feeds.	Confused mother resulting in anxiety, and a hungry fretful baby.	Frequent on-demand feeding during the day as well as the night.
Separation of the infant from mother.	Suppression of lactation.	Rooming-in.

Uninformed, unsupported mother.	Interference with the let-down reflex.	Preparation of the mother for lactation during pregnancy and counseling from lactation 'advisers' with emotional support in puerperium.
Excessive use Of instrumental Delivery (pain + anesthesia)	Suppression of lactation.	Avoidance
Unsympathetic, inexperienced staff.	Anxiety and frustration in mother	Adequately trained staff skilled in the management of breastfeeding
Provision of'gift packs, visits by "milk nurses' and use of posters and brochures advertising baby foods.	Suppression of let-down reflex and drying-up of milk, e.g. by the trial of the gift pack.	Hospital policies prohibiting all such practices.

(3) A generally positive attitude towards breast feeding in hospital wards and clinics will encourage mothers to breast feed. For example, mothers who have successfully breast fed their infants may be utilized as "counselors' and "demonstrators' in the antenatal and under-5s clinics. Small discussion groups of first-time lactating mothers may be set up in under-5s clinics utilizing such counselors to discuss problems and their management. A rational policy for hospital admission of children so that breast feeding mothers are admitted with their sick children, and "lodger babies' are admitted with their sick mothers will also help create a generally positive attitude towards breast feeding. Most important, of course, are the policies and routines of the maternity wards.
Simple modifications of hospital routines such as, for example, more relaxed attitude towards visiting by fathers and family members in the maternity wards, rooming-in, permissive feeding schedules for babies and so on have been known to raise the incidence of breast feeding. There are also other benefits like reduced incidence of neonatal sepsis and improved survival rates of low birth weight babies.

4) Besides a generally supportive attitude towards breast feeding in everyday medical practice, professional bodies also need to be active in the community and nationally to advocate breast feeding. In countries where medical and nursing associations have repeatedly advocated breast feeding, national policies and supportive legislation have eventually emerged. In this respect it is necessary to join hands with community and national groups like the local branches of La Leche League and the Consumers' Association.

Helping mothers breast feed

Preparation for breast-feeding should ideally commence in the prenatal period when in individual talks and group discussions the mother is helped to develop a positive attitude towards breast-feeding. In many cases it will be necessary to involve the husband or other members of the household as well, because very often the views and opinions held by the mother are a reflection of those of the immediate family. When the mother has a positive attitude and is favourably inclined towards breast-feeding the chances of success are better. The mother's attitude, as expressed verbally shortly after delivery, is also related to success in breast-feeding. In one study, 74 per cent of mothers with a positive attitude had adequate milk by the 5th day as compared to 35 per cent with doubtful and 26 per cent with negative attitudes. It is likely that the mother who is not favourably inclined towards breast-feeding will not allow the infant adequate suckling at the breast. Also psychological factors will interfere with the success of the 'let-down' reflex in her. Unless breastfeeding is common in a particular community many girls will grow up without ever seeing a baby being breast-fed. Hence it will be useful if some of the educational talks in the antenatal clinic are given by mothers who have successfully breast-fed their own children, and who can meaningfully discuss the details of the process with other women. The experience of the mother in the antenatal clinic and during childbirth is also important in developing a positive attitude. The woman who maintains good health in pregnancy and has an uneventful delivery, and with whom the health personnel are able to establish a good relationship, is more likely to develop a positive attitude towards breast-feeding. Generally, mothers come to a decision about the feeding of their infants fairly early in the pregnancy. Hence counseling for breast-feeding should commence early in the prenatal period and should be continued throughout.

Early days of lactation

The early days establish the trend for lactation. With a good start, breast-feeding is likely to remain trouble-free and mutually satisfying to both mother and infant. On the other hand, even small disturbances and difficulties at this stage can have major consequences.

The onset of milk secretion after the birth of the baby is a physiological event which seldom fails to occur. In contrast the establishment of successful lactation is a process which is dependent upon the constitutional, psychological and personality characteristics of the mother and the baby. Several post-partum events and routines of the maternity ward can either encourage smooth functioning or interfere with this process. Thus putting the baby to the breast soon after the delivery, and possibly even on the delivery table, is desirable, but a rigid ward routine may not allow it. Prelacteal feeds using a bottle are not necessary. In fact, as we have seen, they generate the wrong kind of suckling response in the baby, and are harmful. Yet prelacteal feeding is practiced in many maternity units. Even in very hot and dry climates prelacteal feeds of water are not indicated. Glucose feeds for 'strength' are complete nonsense. The energy consumed in a 2 oz (60 ml) feed is 12 kcal which is equivalent to 15 ml of breast milk. Close and continued contact between the mother and the infant creates the desire for breast-feeding, but strict adherence to asepsis in the maternity unit may demand separation of the baby from the mother. Every baby has his own unique pattern of feeding, but rigid feeding schedules do not take such individual differences into account, so that there is often interference with the smooth establishment of a feeding pattern.

Some Useful Hints

The first feed

The presence of the baby's father, a close family member or a friend at delivery can be very comforting, and is known to reduce the need for analgesics and anaesthetics. After all full-term normal births the modern practice is to offer the baby to the mother as soon as possible, ensuring skin-to-skin and eye-to-eye contact. Putting the baby to the breast at this time helps to establish lactation, by initiating the letdown reflex, and promotes bonding. Most normal newborns are able to suckle within 5-10 minutes of birth. The release of oxytocin as a result of the let-down reflex helps in the expulsion of the placenta. Mothers in whom contact with the baby and breast-feeding are established soon after the delivery tend to *have* fewer difficulties *with* lactation, and breast-feed for longer periods. The presence of the father at this time tends to make him more supportive of breastfeeding later.

The frequency of feeding

In practice it has been observed that if a baby has fed at delivery another feed may not be needed for up to 6 hours. For the first few days thereafter most babies feed at intervals of *2-4* hours. This is when a great deal of learning takes place for both the mother and the infant. By the 3rd or 4th day the frequency of feeds may reach 10-12 in 24 hours. As the milk comes in and the baby begins to regain his birth weight the feeds space out to intervals of 3-4 hours. The period of frequent feeding is a physiological response of the baby to the initial weight loss, which is on average 5 per cent of body weight. The weight loss is chiefly due to loss of water. With adequate feeding the baby re-establishes the water balance. At the same time the suckling stimulus ensures that the mother makes enough milk for the baby's needs. It is necessary for these responses to be more widely known so that formula feeds are not offered whilst waiting for 'the milk to come in'.

The duration of feeds

The earlier suckling begins and the more complete the emptying of the breasts the more successful is the establishment of lactation. In the early days, therefore, the baby should be put to the breast for at least 10 minutes on either side, increasing the time to 20 minutes by the third day. Such a defined *minimum* period is to ensure complete emptying of the breasts. The prolactin reflex operates several minutes later than the let-down reflex. If the baby is removed from the breast too soon the reflex will be that much weaker. Every infant sets his own pace and will feed on the breast for as long as milk transfer is taking place. This is important to bear in mind in the management of breast-feeding. However, if a baby continues to feed at one breast for prolonged periods (for example half an hour) regularly then there is likely to be some fault in the technique, and this should be looked into. Just as suckling in the baby is affected by drugs so also can the secretion of prolactin in the mother be influenced by drugs such as ergot given during the third stage of labour. In the same way the let-down reflex can be inhibited by psychological stimuli, such as embarrassment at nursing, fear of discomfort, uterine contractions during breast-feeding, or by actual pain following instrumental delivery. Careful attention to these details will enable a smooth suckling -milk-flow interaction between the infant and the mother.

There is no hard and fast rule about the frequency of feeding. Some babies require feeding more often than others. However, after the early days, feeds which are too frequent (less than 1 hour apart) indicate that the feeding technique is faulty. It is likely that the hind milk is not getting to the baby in sufficient amounts. The emptying time of the infant stomach is much longer with the hind milk than with the watery fore milk. In general, 'on demand' feeding is a more physiological approach since it enables milk supply to fit in with the demand. At each feed the mother should be encouraged to let the baby completely empty one breast before transferring to the other side. If the baby is satisfied with one breast only then the other one should be offered first at the next feed. Breast emptying regulates supply and maximizes milk quality in particular the fat concentration of the milk which in turn triggers satiety in the infant. Efficiency of milk removal is a function of successful attachment of the baby’s mouth to the breast by means of the rooting reflex.

In the initial stages many mothers need to be shown how to hold the baby during a feed. As we have seen, for the baby it is not merely a question of calling up reflexes but actual learning is involved. Such learning is facilitated by correct positioning. The baby should be held in the crook of the arm so that the head is free to move about and the back is supported. During feeding the baby turns his head slightly upwards as if he were looking up, and so the position should be such that the nipple is pointing at the baby's nose at the time of commencing a feed. During suckling, the baby should be held close enough for his chin to touch the breast. In such a position the nipple is more likely to reach the top of his mouth, which is ideal for establishing feeding behaviour. If the nipple is not well into his mouth, and the infant has to crane his neck forward, the nipple will come to lie on the tongue and lower jaw instead. In this latter situation the baby can obtain very little milk from the nipple, which only teases and frustrates him. Once the baby and the mother have experienced one satisfactory feed all subsequent feeds will usually go well.

Breast engorgement

For many mothers, once lactation is established and a pattern of feeding is set, there are no problems. In some, however, as milk secretion increases, certain difficulties arise. When secretion is in excess of the infant's requirements, breast engorgement occurs. As milk accumulates in the duct system it causes back pressure so that circulation in the veins and the lymphatics becomes sluggish and there is oedema. The mother will then feel a sense of discomfort in the breasts. The best way of handling such a situation is to empty the breasts of milk by suggesting more frequent feeds, or by means of a breast pump or by manual expression. Within a few days, as the baby's milk intake increases, the rhythm between milk secretion and milk flow is established and the engorgement is relieved. Sore nipples, due to cracks and fissures, may be the first sign of breast engorgement. As the breasts become very full the natural concavity at the junction of the nipple and the areola is lost. When feeding, the infant finds a small nipple on which he cannot take a firm grip and has to struggle to keep it in his mouth. The 'chewing' action which ensues traumatises the nipple and causes cracks and fissures. Management consists of manually expressing a small amount of milk at the commencement of a feed. This will reduce the tension in the milk ducts and restore the concavity between the nipple and the areola. A very full breast may also press against the nose of the infant during feeding, causing 'air hunger', and the infant appears to 'fight at the breast', which is again a common cause of sore nipples. Infection may enter through fissures and cracks in the nipple and cause mastitis. All these conditions are preventable by a little care and alertness in the early days of lactation. If the baby is put to the breast more often and if the breasts are emptied by manual expression, drainage of milk is established and engorgement is forestalled. In summary, if the breasts are engorged the mother should not stop nursing, but on the contrary she should feed the baby more frequently. If at this stage the baby is not suckling well, breast massage and manual expression should be carried out to release the tension in the breasts.

In some instances the infant is not able to develop a proper feeding technique quickly enough. The mother complains that on being put to the breast the baby will commence feeding but will not continue. There are three possible causes of such apathy towards feeding: (i) the nipple may not be well into the mouth, (ii) the baby is satisfied too soon, or (iii) the milk may have stopped flowing, which is usually due to maternal anxiety interfering with the let-down reflex. Apathy can also occur when there is bad positioning during feeding or an insufficient hold on the nipple. Apart from apathy, another cause of feeding problems in the infant is fighting at the breast. This is almost always due to difficulties in breathing due to an overfull breast impinging on the infant's nostrils, some form of nasal obstruction, or rarely due to the baby's upper lip riding up and blocking the nostrils during a feed (See Figure 5.36). The cause of apathy or breathing difficulty should be identified and corrected soon, because both can readily become habitual behaviour. Feeding by bottle as an interim measure is not the solution to these difficulties.

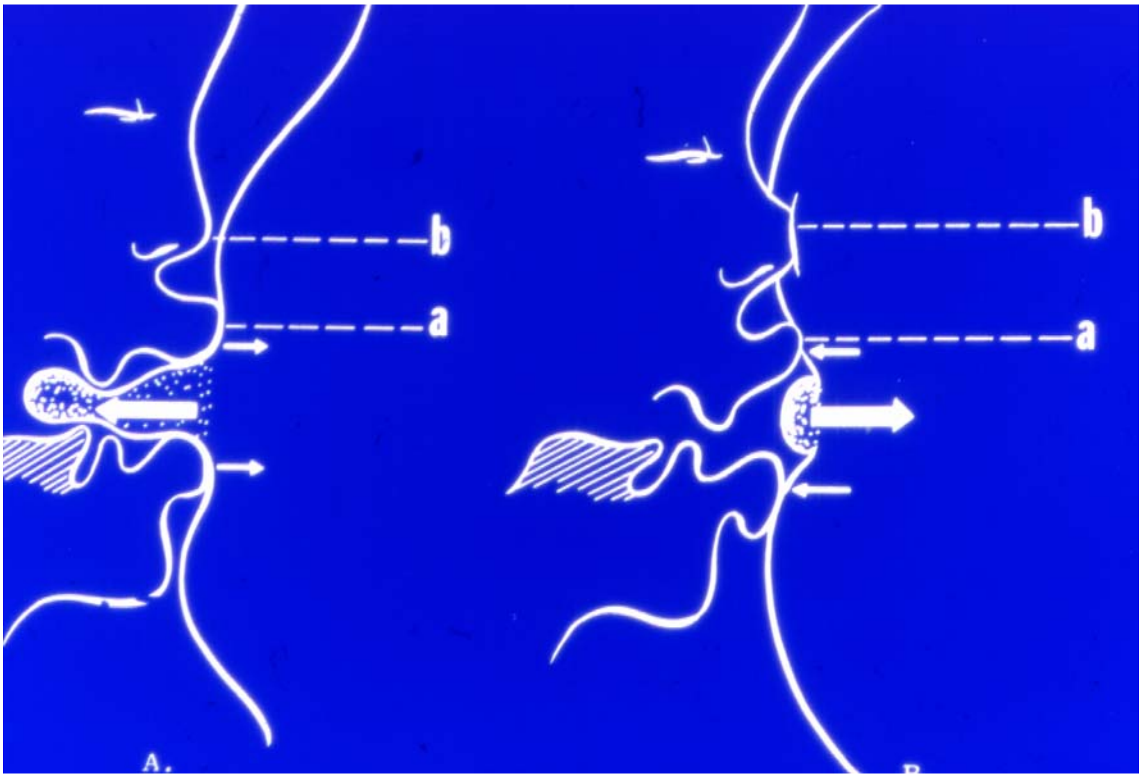


Figure 5.36 Breathing difficulties during nursing.

A. Normal. (a). The infant's lips can take proper grasp of the nipple in the concavity between the areola and the nipple. (b). The nostrils are well away from the breast tissue so that breathing is free.
B. Engorged breast or retracted nipple. The baby's lips are unable to grasp the nipple, leading to repeated chewing movements and trauma causing cracked nipples. (b). The soft breast tissue presses against the baby's nostrils causing difficulties with breathing.

After the first week difficulties are rare. On discharge from hospital the mother should be given a clear indication of how long breastfeeding should continue. In many parts of the world infants are breast-fed until they are 1.5-2 years old, with of course suitable solids being introduced from the age of 6 months onwards. When the baby is able to eat solid food well, the mother may decide to take him off the breast gradually. On the other hand there is the essential minimum period of the first 6 months when breast milk should be the predominant food of the infant. Breast milk has properties other than those which are purely nutritional, which protect the infant from infection and allergies besides promoting the growth and development of the gut. Such protection is necessary in the early months when the infant is vulnerable.

Once the process of lactation has been well established, its maintenance will depend upon the emotional and professional support the mother receives when she returns home with her newborn baby. Unfortunately, the tendency among health professionals in recent times has been to be passive spectators and, at times, even active instigators of artificial feeding. This is especially so in cases where the mother *is* in some kind of employment. It is easier and more fitting to the 'professional role' to write a prescription for the newest brand of powdered milk than to sit down with an anxious mother and painstakingly work out a schedule to suit her convenience. In communities where breast-feeding is universal and offered 'on demand', it has been observed that about a third of the total volume of milk consumed daily, and a third of the total number of feeds in 24 hours, are during the night between 8 p.m. and 6 a.m. Thus, even for a working mother, with adequate nursing breaks in the day it should be possible to provide a considerable proportion of the daily requirements of milk for her baby with minimal supplementation.

A disastrous mistake is sometimes made when a nursing mother is admitted to hospital for an illness. The infant is not thought of by the admitting physician in a busy out-patient department, with the result that by the time the mother is discharged from hospital her milk has dried up and she is faced with finding an alternative as soon as possible. A similar situation can also arise when a sick infant is admitted to hospital without the mother. A little forethought in such circumstances can avoid a great deal of misery later.

To conclude, the health worker carries a heavy responsibility not only of ensuring the establishment of lactation at the time of delivery but also of its maintenance through various family situations so that the infant can continue to derive the benefits of his mother's milk until such time as he is ready to be weaned on to solid food.

FACTORS THAT HELP TO PROMOTE BREAST-FEEDING: A PRACTICAL CHECK LIST

1 Preparation of mothers for breast-feeding.

a) The best time for preparing a mother for breast-feeding is during pregnancy, by means of individual counseling and group discussions.

b) Commence the counseling as early in pregnancy as possible. At each visit talk about a different aspect of lactation, reinforcing aspects that have been discussed previously.

c) The best counselor is one who believes strongly in the virtues of human milk, and has personal experience of counseling mothers or has successfully breast-fed children.

d) Include fathers in the counseling and in group discussions.

2 Nutrition of the mother during pregnancy and lactation.

a) Give advice about eating a mixed diet made from locally available foods. The mother must eat enough to satisfy her appetite.

3 Practices in the maternity unit.

a) Immediately after the birth hand the baby over to the mother to see and cuddle. If the local culture allows it, put the baby on the mother's chest straight after the delivery, ensuring skin-to-skin and eye-to-eye contact.

b) Encourage the mother to put the baby to the breast soon after delivery, and at first contact.

c) Ensure rooming-in for all babies unless there are strong medical contra-indications.

4 Personal privacy for breast-feeding.

a) In clinics, wards, special-care units and such places, set aside space where mothers can breast-feed. The group interaction between mothers is useful and can be mutually supportive.

5 Commercial promotion of breast milk substitutes.

a) These lower the mothers' morale by engendering doubt in their minds. Their adverse effects should be pointed out to mothers, and no form of promotion should be allowed in health facilities.

6 Emotional support during breast-feeding.

a) Appreciation and support from health workers, family members and friends is essential for the breast-feeding mother. Traditional practices and behavioral patterns which help with breast-feeding, for example the doula; periods of bed rest in isolation with the baby; the use of high energy foods, and so on, should be encouraged.

7 Dealing with problems.

a) The health worker should be able to deal competently with minor difficulties, such as engorgement, correct attachment of the baby to the breast, positioning during breast-feeding and so on, as they arise,

b) Try to avoid an excessively theoretical approach concerning timing of feeds, the duration of feeds, rigid feeding schedules, test weighing, changing over from one breast to the other in the middle of a feed, and so on. A competent and commonsense approach based on knowledge of the physiology of lactation and experience is all that is needed.

INTERVENTIONS AT THE COMMUNITY LEVEL

The importance of community groups like the La Leche League and Consumers' Associations in reversing the trend from bottle feeding has been well documented in Western Europe and North America. Besides being supportive of local mothers who are breast feeding, such groups also help to collate and exchange information nationally as well as internationally. Such community groups can also act as watchdog bodies monitoring the promotional practices of the baby-food manufacturers.

INTERVENTIONS AT THE NATIONAL LEVEL

Community pressure groups and national professional bodies can often mother and child welfare. Many governments now recognize the unique role of the mother in national development through raising the citizens of tomorrow. In addition, the concepts of human breast milk as a national resource, and the wastage in foreign exchange if breast feeding is allowed to decline, are now fully appreciated by most national planners. The most effective step for any government to take is to enforce the ethical code suggested by the World Health Organization with regard to the promotion of infant feeding formulae. To create general confusion the infant-food industry has come up with meaningless codes and has persuaded some countries to adopt them. Good examples of forceful national legislations are those of Burma and Papua-New Guinea where the sale of formulae and feeding bottles is prohibited except on prescription. The legislation also prohibits advertising in the mass media. In Mozambique, besides control of advertisements, free importation of a variety of brands of powdered milk has been stopped. Instead the government imports the "best-buy' brand and distributes it through the health facilities with a national label.

As more women enter the labour force, there will be a growing need for a variety of facilities to enable the working mother to breast feed her baby. Many such facilities may need to be backed by appropriate legislation. Thus, adequate and paid maternity leave, crèches near work-places, nursing breaks during the work day and flexi-hours for the working mother are all examples of ways in which a society can acknowledge the unique contribution of the working mother to the national economy.

The Baby Friendly Hospital Initiative

The above initiative was launched at the World Summit for Children in 1990 by UNICEF. Representatives of the World Health Organization, UNICEF, 71 Heads of States, health experts and representatives of non-governmental organizations agreed that a new momentum for the support and protection of breast feeding was needed and that the health care systems as well as health workers in all countries need to be mobilized for the purpose. To be recognized as baby friendly a hospital must fulfill the following conditions:

The hospital must have a written policy with regard to breast feeding.
All the health care staff should be trained in skills necessary to implement the policy.
Educate pregnant women attending the hospital in prenatal classes and visits about the benefits and management of breast feeding.
Help mothers to initiate breast feeding within 1 hour of birth.
Demonstrate to mothers how to breast feed and how to maintain lactation.
Give newborn infants no food or drink other than breast milk unless medically indicated.
Practice rooming-in. Allow mothers and infants to stay together all 24 hours.
Encourage breast feeding on demand.
Give no artificial pacifiers or dummies.
Foster the establishment of breast feeding support groups.

In a study to evaluate the effect of Baby Friendly Hospital Initiative (BFHI) 16 491 mother-baby pairs were followed up for 12 months. Those born in BFHI hospitals were significantly more likely to be exclusively breast fed at 3 and 6 months of age. In addition they had half the risk of experiencing diarrhoea and atopic eczema.

FURTHER READING

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