delayed and the infant be fretful, feeding with some substitute milk may be deemed advisable. For the first month it is difficult to obtain regularity in nursing, but the importance of regular feeding should be impressed on the mother, and she should be told that crying and fretting during the intervals are in general due not to hunger, but to colic, which may be aggravated by irregular nursing. After the second month an interval of at least two hours between two successive nursings should be insisted on for the day; during the night this should be lengthened to three or four. As the child grows older its stomach becomes capable of taking larger quantities at a time, and the intervals should accordingly be gradually lengthened to four hours. In some cases the breast milk of the mother does not agree with the infant and gives rise to more or less pronounced symptoms of indigestion associated with much fretfulness, sleeplessness, and either an actual loss of, or a failure to gain in weight. This condition of the milk is sometimes due to over-anxiety, insufficient sleep, an improper dietary, or irregular habits on the part of the mother, and may be remedied by securing for her a correct dietary, regular outdoor exercise, sufficient sleep and freedom from undue worry and excitement. In a few instances, however, the fault appears to be irremediable, and artificial feeding with a properly constituted food must be attempted. (See article *Infants, Artificial Feeding of.*)

In estimating the suitability of any food to an infant's requirements the important test is the weekly increase in weight. If the food is digestible, and sufficient in amount for its wants, the infant should be free from colic, happy in disposition, should sleep quietly, and gain regularly in weight. No fixed rule can be stated as to the proper time to allow artificial food in connection with breast milk. While robust mothers, with an abundant supply of milk, can easily satisfy their infants up to the age of twelve or fifteen months, many begin to feel the drain upon them by the second or third. In others, the milk, though abundant, fails to satisfy and sufficiently nourish the child, and must be early supplemented by artificial food.

Bathing.—The first bath of the infant should be given in a warm room, free from draughts, and in water of a temperature of 96° F. The infant should be dried beneath some warm flannel covering. In general, nurses are not sufficiently alive to the necessity of preventing undue chilling of the surface. From the fifth to the ninth day the navel string becomes detached, and not till that occurs is a second general bath advisable. After that the bath should be given daily in water at a temperature of about 92° F. This temperature, after the age of eight or nine months, may be lowered carefully to 90° or 85°, according to the strength of the infant and the vigor of its reaction. Too prolonged chilling of the surface during bathing and dressing is the frequent beginning of catarrhs of all sorts.

Clothing.—In the dressing of the new-born care should be taken that there is no injurious dragging on the navel, that the usual abdominal band is not applied so tightly as to interfere with respiration or digestion, and that sufficient warmth be secured for the extremities. Later on, caution should be enjoined that none of the clothing press unduly on either chest or abdomen—all should hang loosely from the shoulders; neck bands should not be tight, and the extremities should always be efficiently and warmly covered. No sudden change in the amount or character of the clothing is, on any account, to be permitted. Special care is also to be given to the shoes. The leather should be pliable, and the shoes made broad and loose about the toes, so as to allow freedom for movement and growth.

Sleeping.—For the first few weeks of its life an infant should sleep eighteen hours out of the twenty-four. As it grows older, it gradually requires less. A fretful and wakeful baby is ailing in some way, and the cause of its fretfulness should be found out and remedied. When possible, the nursery should be large and well ventilated. For the first few days of infant life it may be desirable that the room in which it is kept should be somewhat darkened, but after that fresh air and sunlight should never be excluded. At the same time draughts and rapid changes of temperature are fraught with much danger.

Exercise is important, but the manner of it is equally so. No infant should be carried about upright until it is able to raise its head and rotate it easily; nor should it be encouraged to walk or stand till nearly a year old, and if there be any tendency to rachitis this must be postponed still later. After an infant is three months old—a little later, in the winter season—it should be "short-coated," and the fullest liberty given to its arms and legs. It should be encouraged to lie on its back in its crib with loose clothes and enjoy, as it will do, the liberty of kicking. Every day it should be taken out regularly during the more suitable portion of the day, unless the weather be blustery. When it is sufficiently old, walking forms a pleasant exercise, but it should never be carried to the extent of much fatigue.

Weaning should, if possible, be effected gradually, and the digestive organs should be accustomed to some suitable artificial food before lactation is altogether stopped. Abrupt changes in its food try an infant's digestion, and frequently upset it. In selecting the time to make the alteration, attention should be given to the following points: 1. An interval between the eruption of the several sets of teeth should, if possible, be chosen, as we sometimes notice at these times irritation of the nervous system with hyperæmia and increased peristalsis of the alimentary canal. 2. It is never desirable to take the breast from an infant while it is sick or recovering from sickness, unless it is manifest that the milk of the mother is injurious. Even an inadequate supply will often be all-important for the nourishment of such an one (Busey). 3. Regard must be paid to the season of the year. Any change during the hot months is very undesirable.

In the Examination of infants much tact and observation are necessary. All appearance of abruptness is to be avoided; no harshness in voice or manner is allowable; the physician's hands must be warm; and a full supply of patience must ever be ready to be exercised if demanded. If the infant be asleep on the physician's arrival, it should on no account be awakened until he has seen its decubitus, counted its pulse and respirations, and noted their character, and made such other superficial examinations as are possible without disturbing it. The pulse and respirations in an infant just awakened are always extremely rapid. With regard to its decubitus, a healthy young infant in sleeping generally assumes the position he is supposed to have had *in utero*. An older infant, even if lying on its back, should incline its head to one side or the other, so that its cheek comes in contact with the pillow. If it be found with closed eyes and face directed straight upward, it is probably suffering from serious disease. If it be lying with its head retracted, cranial disease should be thought of. If it sleep on its belly, or resting on elbows and knees, it is probably suffering from abdominal discomfort. Healthy children should sleep quietly. Much tossing, any twitching of the muscles, or screaming and talking in sleep, indicate feverishness or digestive derangement.

Much may be learned from the character of the child's cry. Unappeasable screaming, without any other symptom, often results from earache. The temperature should always be taken with a sensitive thermometer, preferably in the rectum; if not convenient there, in the groin. The armpit is not so good, as infants object to the necessary restraint of the arm. In many abdominal troubles the skin and extremities may be quite cool, yet the thermometer in the rectum show a temperature of 104° or 105°. The respirations, if practicable, should always be counted. At the first examination we should always insist on having the infant stripped, otherwise no thorough examination can be made. Care should at the same time be taken that the infant be not chilled by a too prolonged examination. Passing downward, we note: (1) shape of child's head and state of fontanel; (2) shape of chest, character of the breathing, whether there be any retraction of chest walls or intercostal spaces. With warm hands palpation should be made, and the expansion, and also the presence, if any, of rhonchal fremitus should be noted; (3) shape of abdomen, whether protuberant or retracted, whether the walls are tense or lax. Gentle pressure may be made by the hand, and any tenderness of the abdomen or enlargement of liver or spleen detected; (4) condition of the lymphatic glands.

In addition, the color and elasticity of the skin and the general nourishment of the tissues should be observed at this time. In auscultating the chest, the infant should be placed on the left arm of the nurse, leaning over her left shoulder, with its arms around her neck. In this way only are the muscles of the back equally relaxed and correct results obtained. Percussion should always be gentle. Immediate auscultation never gives the exact results obtained by the use of the stethoscope, but any painful pressure by the instrument must be carefully avoided. In infants, symptoms of disease are more frequently found at the back than at the front, and at the base rather than at the apex. Nevertheless, no part should be omitted in the examination. Inspection of the mouth and fauces should always be left to the last, as giving rise to more or less resistance. To effect this the infant should be seated on the nurse's lap before a bright window. Sometimes with a little gentle pressure on the chin the mouth is opened and the tongue seen. To examine the fauces requires the use of a depressor, for which nothing is better than the smooth handle of a spoon. This can always be slipped in behind the teeth and over the tongue to its base. When the pharynx is reached the mouth involuntarily opens, and, if the physician be on the alert, a good view of the fauces is obtained. Lastly, the secretions should be examined, if in any way at fault. Trouble is sometimes experienced in obtaining the urine. If necessary, a small silver catheter may be passed and a sample drawn off.

In making our diagnosis and prognosis in infancy, the following points must always be remembered as modifying disease at this period:

1. The wide diffusion of symptoms met with at the onset of an acute attack.
2. The severity of the initial symptoms often bear no proportion to the gravity of the local lesion.
3. The extremely rapid rise and fall in the temperature of the body frequently observed.
4. The rapidity with which functional mischief may pass into organic.
5. The extent to which local disease is modified by certain diatheses.

For an account of the special diseases to which the infant and new-born are liable, the reader is referred to the separate articles on these diseases.

Alexander D. Blackader.

The following papers and treatises have been referred to and made use of:

Thomas Rotch: Pediatrics, 1901.
L. Emmett Holt. Diseases of Infancy and Childhood, 1897.
Colton: Lessons on Anatomy, Physiology and Hygiene of Infancy and Childhood, Chicago, 1900.
Alfred Vogel: A Practical Treatise on Disease in Children; translated by H. Raphael, 1885.
Fred. Treves: The Anatomy of the Intestinal Canal and Peritoneum in Man. London, 1885.
A. Jacobi: Infant Hygiene. Buck's Hygiene and Public Health, 1879.
Thomas B. Curtis: Infant Mortality. Buck's Hygiene and Public Health, 1879.
A. Jacobi: Anæmia in Infancy and Early Childhood. Arch. of Medicine, vol. v., No. 1, New York, G. P. Putnam.

INFANTS, ARTIFICIAL FEEDING OF.—When for any reason the infant is deprived of its mother's milk, its natural and most perfect food, the necessity of supplying it with nourishment from some other source is forced upon us. This may best be done by means of a healthy, efficient wet-nurse, if such can be obtained; but this is always a difficult matter. Very seldom can one be found who fulfils all the requirements demanded by the physician, and who is willing to submit to the careful dietary and regular mode of life necessary to insure a wholesome and even supply of breast milk to the foster child. In the great majority of cases, therefore, we have to find some artificial nutriment which shall fulfil the important conditions of being easily digested by the infant and at the same time of supplying in due amounts all the elements required for nutrition.

Nitrogenous material it must have to provide for the wants of the growing tissues; without a sufficient quantity of this element in the food, growth and development will be defective. Carbohydrates must also be present. Not only are they essential to nutrition, but they are also necessary for the production of heat in a being whose muscular activity is comparatively slight, yet in whom the activity of the vital processes would be much impaired were the body heat lowered in any degree. These carbohydrates must be in a condition easily assimilated, and it is to be remembered that during the early months of life no provision is made by nature for the digestion of starch; they must, therefore, be supplied in the form of some sugar, and of the various sugars milk-sugar appears for the infant to be the most assimilable. Fats appear to be closely associated with new cellular growth, and must be supplied in a state of fine emulsion. The food must also contain a due amount of mineral matter, calcium phosphate for the hardening bone, and sodium chloride and iron for the blood, daily increasing in amount. Salines are also undoubtedly of much service in the vital processes of digestion, absorption and nutrition; processes for which water is demanded in larger amounts than required by the more adult constitution.

To supply a food suitable in all these respects to the wants of the infant organism, and yet easily digested and assimilated by the imperfectly developed alimentary tract of the infant, is a problem demanding much thought and care. Its importance will be appreciated when we consider the disastrous results which frequently follow attempts made in thoughtlessness and ignorance to hand-feed infants. The enormous death rate which in all countries occurs among those deprived in early days of maternal milk is appalling, while among those that survive, poor health, defective nutrition, and stunted growth plainly attest the defective nourishment supplied. As a recent writer says, it is proper or improper nutriment which makes or mars the perfection of the coming generations.

The problem, although at all times demanding careful thought, is one of very varying difficulty. If the powers of digestion are naturally strong, and especially if the infant has received the advantage of maternal nursing until the gastric and intestinal secretions have become to some degree developed, the task of supplying a suitable food may be a comparatively easy one. But if the infant inherit a weak constitution with feeble powers of digestion and assimilation, still worse, if it must be bottle-fed from its birth, much difficulty will be experienced; our difficulties are still further increased during the hot season and under the unsanitary influences associated with city life. It is only within the last few years that advancing knowledge has enabled us to cope, for the most part successfully, with these various difficulties, and it must be acknowledged that for the greater part of this advance we are indebted to American physicians.

In the preparation of a substitute food for infants, it must be our aim to copy as closely as possible in all particulars the food which nature supplies. The substitute food must resemble maternal milk in the elements entering into its composition, in the percentage of them present in the food, in its freedom from the presence of noxious micro-organisms, and in the fact that it is an animal food. To enable us to attain this result, many careful analyses have been made to find out the exact composition of mother's milk.

Rotch gives us the following as a summary of several of the more recent analyses of human milk:

AVERAGE HUMAN MILK. (Rotch.)

Reaction	Amphoteric or slightly alkaline.
Specific gravity	1.028 to 1.034.
Water	87 to 88 per cent.
Total solids	12 to 13 per cent.
Fats	3 to 4 per cent.
Milk-sugar	6 to 7 per cent.
Proteids	1 to 2 per cent.
Total mineral matter	.1 to .2 per cent.

As an indication of the differences which may exist in the breast milk of different women, the following analyses, made by Harrington and quoted by Rotch, are interesting:

HUMAN BREAST-MILK ANALYSES.

(Mothers Healthy and Infants Digesting Well and Gaining Weight.)

	I.	II.	III.	IV.
Fat	5.16	4.37	3.28	3.16
Milk-sugar	5.68	6.30	5.70	7.20
Proteids	4.14	3.27	1.08	1.65
Mineral matter	.17	.16	.20	.21
Total solids	15.15	14.10	10.80	12.22
Water	84.85	85.90	89.20	87.78

In connection with these analyses it is to be noted that, although the several infants digested and throve well on their own mother's milk, when supplied with milk from another mother colic and disturbed digestion frequently resulted. Breast milk may also vary according to the period of lactation at which it is drawn. Baginsky quotes the following as the result of numerous analyses made by Pfeiffer:

Period of lactation.	8th day.	65th day.	371st day.
Water	89.62	89.72	87.72
Total albuminoids	2.365	1.496	1.552
Casein	1.665	.844	.718
Albumen	.108	.228	.183
Undetermined albuminoids	.592	.424	.651
Fat	3.345	1.827	3.984
Sugar	3.574	6.29	6.088
Salts	.446	.180	.126

It is evident from these analyses that we have to deal with a fluid which, while containing all the elements necessary for the perfect nutrition of the growing infant, contains them in quantities which may vary considerably in each individual case, and to some extent from time to time. Of its several constituents the proteids and the fats are the most variable in their amounts, while the sugar in all is comparatively constant. This perhaps is only what we should expect from what we know of the secretion of milk, and considering how liable mothers are to the influences of worry, overexcitement, and disturbed sleep. In the majority of cases infants digest and assimilate their own mother's milk easily, but in a few instances, in which the mother's milk has contained a high percentage of proteids with a low percentage of fats, it has proved indigestible and has given rise to colic and much disturbance of the digestive tract. We may, therefore, infer that more or less variation in the composition of our substitute food will be necessary in many cases to secure a product that will suit the digestive idiosyncrasies of the infant as an individual and yet be efficient as a source of nutriment to its growing tissues.

ANALYSES OF THE MILK OF VARIOUS ANIMALS. (After König.)

	Cow.	Goat.	Ewe.	Mare.	Ass.
Water	87.41	86.91	81.63	90.71	91.40
Caseinogen	3.01	2.87	4.09	1.24	1.23
Lactalbumin	.75	1.19	1.42	.75	
Fat	3.66	4.09	5.83	1.17	3.01
Sugar	4.92	4.45	4.86	5.70	6.93
Mineral matter	.70	.96	.73	.37	.45

At the outset of our endeavors to prepare such a food we naturally turn to the milk of other mammals, and of these the milk of the cow, goat, ewe, ass, and mare have been by various writers recommended for this purpose. Careful analyses have been made of these various milks, with the results shown in the last preceding table.

It is evident that the milk of the ass and mare approaches more nearly that of the human being than does that of the cow, but as it is impossible to obtain from these animals a supply in any way adequate to our wants, they may be dismissed from our present consideration. Goats' milk, although more frequently available, possesses no advantage over cows' milk. The quantity of casein in it is large, and its peculiar odor is often very objectionable. Cows' milk, on the other hand, has many advantages; it is plentiful and cheap, and can with due care be obtained fresh and pure. The following analyses of the two milks, as given by Rotch, shows us how closely they resemble one another in composition:

	Cows'. Per cent.	Woman's (directly from breast). Per cent.
Reaction	Slightly acid.	Amphoteric, generally alkaline.
Water	86–87	87–88
Mineral matter	.70	.20
Total solids	14–13	13–12
Fats	4.00	4.00
Milk-sugar	4.50	7.00
Proteids	4.00	1.5–2
Caseinogen	2.88	.59
Lactalbumin	.53	1.23

Although on comparing these two tables we see much similarity between the two fluids, nevertheless important points of difference may be noted. While human milk is almost always alkaline and remains so for many hours, the reaction of cows' milk is acid, owing partly to the presence in it of potassium biphosphate, and partly to the formation of small quantities of lactic acid; especially is this the case when the cow is stall-fed or the milk a few hours old. Our knowledge does not as yet permit us to recognize any difference between the fats in the two milks. The milk-sugar is notably deficient in cows' as compared with human milk. The mineral matter is more abundant in cows' milk. An analysis of the saline ingredients in the two milks shows that the potassium salts are in larger proportion in breast milk, while the lime salts are more abundant in cows' milk. Cows' milk also contains more phosphoric acid, less chlorine, less iron, and less sulphur. These differences, however, may be regarded as comparatively unimportant. The most important practical difference exists in the proteids, of which we notice that in cows' milk the greater part may be readily coagulated, forming tough and dense curds, while in human milk the coagulable proteids exist only in small amount. König's analysis shows that, while in human milk the caseinogen forms one-third and the lactalbumin two-thirds of the proteids, in cows' milk the caseinogen forms four-fifths and the lactalbumin only one-fifth. As a result of this difference, it is noticed that on coagulation of the proteids of human milk by acids or rennet the curds form slowly and are small and flocculent, whereas in cows' milk they form comparatively rapidly and are large and tenacious. Similar results are observed when the two milks are acted upon by artificial gastric juice in a test tube; the proteids in woman's milk are precipitated slowly and imperfectly and are easily redissolved in excess of the juice, while the proteids of cows' milk are precipitated in large masses which are redissolved only with difficulty.

Another important difference between the two milks still remains. While breast milk is always practically sterile, commercial cows' milk invariably contains many bacteria, from one hundred thousand to several million in each cubic centimetre, and if old it also contains the toxins evolved by their actions. It is therefore extremely important that milk to be employed in the feeding of infants should be obtained from healthy, vigorous animals, cleanly kept under the best hygienic conditions, and carefully fed and watered. The milking should be done with careful precautions to avoid contamination by impurities (see article *Milk*). The milk should at once be cooled and aërated and delivered to the consumer with as little delay as possible; prolonged transportation is to be avoided. Milk may acquire noxious properties and be rendered dangerous as a food, especially for infants, by (1) poisonous weeds taken with the food; (2) by diseased conditions in the cow; (3) by contamination with pathogenic organisms communicated during either milking, or storing, or transportation. Whenever the temperature of milk is allowed to rise above 7° C. (45° F.), it becomes an excellent culture medium for the growth and development of the many forms of bacteria which, even with our most careful precautions, are always present to a greater or less extent. Milk containing micro-organisms in excess of ten thousand per cubic centimetre must be regarded as unfit for infant feeding.

Cows' milk also varies considerably in its percentages according to the special breed supplying it, according to the character of the food on which they are fed, and the amount of exercise permitted. It is therefore desirable that before employing cows' milk for the feeding of delicate infants, for whom fine adjustments may be necessary, an analysis of the milk supplied by the herd should be obtained. Afterward an effort should be made to maintain uniformity by careful regulation of the food.

Obtained with the above precautions, we have in pure cows' milk a food which, compared with breast milk, contains an equal amount of fat, an excess of indigestible proteids, an insufficiency of sugar, and an excess of saline matter; our efforts must therefore be directed so to modify its composition and the character of its proteids as to render it suitable and digestible by the young infant.

Many plans have at various times been recommended. Simple dilution lessens the amount of the proteids, and to a slight extent renders the curd formed by them less dense. It reduces, however, the fats and sugars much below the amount demanded by the infant organism. Keller has also shown us that with a low percentage of carbohydrates in the food there is a very low retention percentage of nitrogen in the system, and general nutrition is defective. Mere dilution, therefore, is not to be commended.

Lehmann many years ago pointed out the effect of the addition of an alkali in rendering the curd less dense. He writes that human milk when acid yields a much thicker coagulum than when alkaline, and cows' milk when alkaline a much looser coagulum than when acid. We also know that casein is precipitated from its solutions by acids, while its precipitation is retarded by the presence of neutral salts. It is, therefore, always desirable to have the acidity of cows' milk well neutralized by an alkali, and for this purpose either lime water or sodium bicarbonate may be employed. It is to be remembered, however, that milk, when recently drawn from pasture-fed cows, is much less acid than the milk of cows stall-fed on dry fodder and grain. Milk also increases in its acidity on standing, owing to the conversion of some of the milk-sugar into lactic acid by the numerous lactic-acid-producing bacteria always present in milk. Harrington ascertained by experiment that ordinary milk, twenty-four hours old, required the addition of one-sixteenth of its volume of lime water to make its alkalinity correspond with that of breast milk. The addition of one-eighth of its volume of lime water rendered it strongly alkaline. Fresh milk from cows on pasture required a much smaller quantity. When constipation is present in the infant, sodium bicarbonate may be used in place of lime water to the extent of from five to ten grains to the pint of milk.

Another plan, frequently recommended as preventing the formation of firm, tough curds is to dilute the milk with a thin gruel, which by its physical consistence is able to diminish the density of the coagulum. This method is an old one, as we read that Van Swieten, in the fifteenth century, used decoctions of wheat or barley for this purpose; but its utility has of late years been very strongly urged by Dr. Jacobi and Dr. Chapin. That it has a distinct value has also been proved by Professor Leeds, who, in a series of careful experiments, showed that the coagulum which forms in a thin gruel encloses much material which, by honeycombing the curd, acts as an attenuant. Coagulation also takes place more slowly—a very positive advantage, as it affords the digestive fluids a better opportunity for action. Many substances have been used for this purpose. Dr. Jacobi recommends well-boiled decoctions of barley or oatmeal. He says: "I have always preferred barley when an article for steady diet was to be recommended, for the reason that oatmeal, on account of its containing fat and mucin, tends to relax the intestines more than barley meal. Otherwise the chemical composition of both is so nearly alike that it would make but little difference upon which the choice would fall. . . . In the case of very small children, the whole barley corns ground for the purpose should be employed, on account of the proteins being mostly contained just inside and very near to the husk." When the smaller pearl-barley is used, Dr. Jacobi thinks that much of the gluten is lost with the husk. Gum arabic and gelatin may also be employed in the case of very young infants.

Dr. S. C. Busey urged the advantage occasionally obtained by substituting rice water, prepared in a similar way, for the barley gruel, and says that he has often witnessed its beneficial effects in cases of diarrhœa and vomiting.

The disadvantage of all such diluents, however, for young infants, is that they introduce a material quite foreign to milk, and one with which their digestive powers are unfit to grapple until their salivary and pancreatic secretions become somewhat developed. For such, therefore, the addition of a gruel to milk has no nutritive value, but serves only as an attenuant of the casein. Dr. Jacobi, however, considers that a small amount of starch may be digested at the very earliest age. It is nevertheless important that in all cases the percentage of starchy matter should be small, and that it should be very thoroughly cooked. Recently Chapin has strongly advocated the use of a gruel made from wheat, barley, or oatmeal, the starch of which has been predigested or dextrinized by the addition of some form of diastase. His directions are as follows: "A heaping tablespoonful of flour made from one of these cereals is boiled with a pint and a half of water for fifteen minutes. It is then removed from the stove and set in cold water till cooled to about 120° F., when a teaspoonful of some good preparation of diastase is added; this dextrinizes the starches and renders the gruel thin, watery, and easily assimilated by the infant, though it still remains an efficient attenuant of the curd."

In addition to these methods of preventing the firm coagulation of the casein, it is always practicable to predigest the proteids of the milk by means of one of the numerous preparations of pancreas, and thus to do away more or less completely with the formation of the curd. A peptogenic milk powder has also been prepared, containing pancreatin and bicarbonate of soda, along with milk-sugar. When the food is wanted the powder is added to a mixture of milk, cream, and water, and the whole is kept at blood heat for some minutes. When properly prepared the resulting milk should closely resemble mother's milk in the reaction of its proteids and its composition.

In practical use, however, predigestion of milk does not appear to have given as excellent results as was at first anticipated. It is a method that may be employed occasionally with benefit in cases of severe exhaustion accompanying or following acute disease, and in some forms of gastric disorder associated with a temporary inability to digest the proteids in milk. The degree to which the predigestion must be carried at first will de-

pend on the power of proteid digestion present in the infant, but in all cases as soon as possible the time of predigesting the milk and therefore the amount of peptonization it undergoes should gradually be lessened; predigestion of food for any lengthened period appears to be quite opposed to the teachings of physiology.

In all these methods, however, with the necessary dilution of the milk, the quantity of fats and sugar falls far below the requirements of the growing infant organism and requires to be increased. In reference to the deficiency in the fat, Dr. Jacobi puts in a strong plea against allowing any excess to be present in our mixtures. He says that the infant does not digest all the fat contained even in its mother's milk, and we ought not therefore to increase the amount of the indigestible ingesta by adding to them. In opposition to this, Dr. Rotch very pertinently remarks: "We have no right to conclude from the fact that a certain amount of surplus fat is found in the napkins, that only a small per cent. is sufficient for nutrition. It is more probable that nature introduces a certain percentage of fat in human milk with a purpose which can only be accomplished by that percentage,and it will be an error on our part not to conform to our standard." My own experience confirms that of many others, that average infants can digest from two to four and one-half per cent. of fat; more than this is liable to give rise to gastric disturbance, and may induce vomiting or diarrhœa; a deficiency in the fat, however, will interfere very distinctly with the infant's nutrition. Biedert also says that while remarkably small amounts of proteid may be sufficient for the good development of infants during the first few weeks of life, an increase in the amount of fat considerably above what is contained in dilute cows' milk spares albumin, renders digestion easier, and increases the growth of the child.

To make good the deficiency in the fat, we have to rely on creams of known strength. The only serious drawback to its employment is the difficulty of obtaining it fresh and sterile. Freeman has told us that when milk is set the great majority of the bacteria rise with the cream, leaving the separated milk comparatively free. In the food of infants cream more than twelve hours old should not be employed.

In correcting the deficiency of the sugar the majority of pediatrists prefer to use milk-sugar, the form found in the milk of all mammals. Jacobi, however, prefers cane sugar, considering that the identity of the lactose in human and cows' milk is very doubtful and that the commercial milk-sugar is often very impure. He also thinks that as milk-sugar readily undergoes the lactic-acid fermentation, any excess of it tends to increase the elimination of calcium phosphate and may thus favor the development of rickets. On the other hand, Vaughan considers that milk sugar is more readily assimilated by infants, and Escherich states that milk-sugar when acted on by the Bacillus lactis aerogenes develops lactic acid, which tends to prevent the development of many noxious forms of bacteria. In general, milk-sugar would appear the preferable form to employ, but should it at any time give rise to symptoms of indigestion, or should pure milk-sugar be difficult to obtain, cane sugar may be employed, but in smaller quantities, owing to its greater sweetness.

Until very recently, in our attempts to modify cows' milk by any of the above methods, we spoke and thought in measures of milk, cream, and sugar, without a very clear idea of the exact percentages in which the elemental constituents of the milk—the fat, the caseinogen, the lactalbumin, and the sugar—were present in our mixtures. A few years ago Dr. Rotch introduced the method and emphasized the value of thinking, working, and speaking entirely on the percentage plan, and of making our modifications from a cream containing a known and definite percentage of fat, and from a milk containing a known and definite percentage of proteids, fat, and sugar. By this plan scientific accuracy was substituted in our modifications for much indefiniteness, and we were not only enabled to prepare a food which we could feel sure exactly resembled breast milk in its physical characters and chemical composition, but also to vary the percentage of the several constituents so as to render it suitable to the varying wants of the different individual infants. On this subject Dr. Rotch says: "While in quite a number of cases rather gross changes in the percentages of the different elements of the milk may be sufficient for the range of the individual digestion and for the nutrition of the special case, yet in a large number of infants whose vitality is low and digestive powers feeble, good results can only be obtained by gradual and minute changes in the percentage combinations of the milk elements."

For such we must have the power of making use of modifications as precise as our knowledge at the present time renders possible. Even slight changes in the percentages of the fat, the sugar, and the proteids are of real value in the management of the digestion and nutrition of the infant.

The substitute food must be adapted, not only to the infant's stage of development, but also to its individual capability of digesting the several elements of its food. To enable us to obtain these varying combinations of the milk elements and to have them regularly and exactly supplied to our patients, Dr. Rotch originated *milk laboratories*, which have been established in many of our large cities, equipped with special machinery and placed under the management of men specially trained for the work. The milk employed in these laboratories is obtained with the strictest precautions to insure its absolute cleanliness, from vigorous cows of a carefully selected breed. The feeding and housing of these cows are under careful supervision, and are so arranged that milk of a known and almost uniform composition is obtained. From this milk, by means of the centrifugal separator, the fat is separated and a cream of uniform percentage obtained. The milk remaining is almost fat-free, and is found by frequent analysis to contain a fairly uniform percentage of proteids, milk-sugar, and mineral matter. It is now a simple matter to dilute, with distilled water, either the cream or fat-free milk, so as to obtain the requisite amount of proteid; milk-sugar is added to make up the defective percentage in that element, and cream supplies the exact quantity of fat. With a knowledge of the exact percentages in the cream and fat-free milk, a simple calculation suffices to obtain the formula within certain limits for dispensing whatever percentage of the elements the physician may prescribe. These limits are as follows:

Fat from	.03 to 36.00
Sugar	.87 to 20.00
Proteids	.22 to 4.00

The amount of mineral matter may be disregarded, as the dilution required by the proteid practically makes a sufficient reduction in its amount.

The milk thus modified may be sterilized, at the temperature deemed necessary by the physician, and is then placed in bottles, each containing the amount ordered for one feeding of the infant; the total number of feedings for the day, securely packed in a small basket, are delivered each morning to the consumer.

The following is an illustration of the method in which this modified milk may be ordered by the physician:

Fat	3.00	No. of feedings	9
Milk-sugar	7.00	Amount at each feeding	75 c.c. (2½ oz.)
Albuminoids—		Infant's age	3 weeks.
Caseinogen	.25	Infant's weight	9 pounds.
Lactalbumin	.75	Alkalinity	5 per cent.
Mineral matter	...	Pasteurize at	155° F.

Although this is a very great advance on our previous crude methods of modifying cows' milk, nevertheless many instances occur in which even the small amount of casein present in the diluted milk overtaxes the feeble digestive powers of the infant. In these Rotch has recommended that the amount of proteids be reduced at the

first to a minimum, and then gradually, as the infant's digestion becomes stronger, their amount may be increased until the quantity necessary for perfect nutrition is attained. Thus, beginning with a proteid percentage of 0.25, he advises that it be slowly increased up to 1 and afterward 1.50. Many physicians, however, experience much difficulty in making this increase as rapidly as the demands of nutrition appear to require, and a recourse has been had to the addition of one of the cereal gruels, which in many instances appear to render the casein more digestible.

Very recently Dr. Rotch has proposed to get rid of the caseinogen, in young infants such a frequent source of trouble, by the use of a whey obtained from fresh cow's milk by the use of rennet. Thus prepared, whey contains all the lactalbumin, sugar, and mineral matter, but none of the caseinogen and almost none of the fat. Its average composition, as compared with that of whole milk, is as follows:

	Whole milk.	Whey.
Fat	4.00	0.32
Sugar	4.50	4.79
Proteids	4.00	.85

Many years ago a similar plan was recommended by Professor Frankland, who employed fresh calf's rennet. Dr. Rotch's directions for its preparation are as follows: For each pint of whey required take one quart of whole fresh milk, or fat-free milk, heated to 37.7° C., and add 8 c.c. of essence of pepsin or an equivalent of one of the liquid preparations of rennet. This will precipitate the casein in the form of curds, which are afterward to be broken up with a fork; the fluid remaining is then strained through several thicknesses of boiled cheese cloth and slowly cooled to a temperature of 10° C. It must be kept on ice till required. If the whey is to be mixed with cream, it must first be heated to 65.5° C., in order to kill the rennet enzyme. Whey mixtures should not be heated above 68.3° C., if one wishes to keep safely under the coagulation point of the lactalbumin. With whey as a basis to which cream and milk-sugar in requisite amounts may be added, a modified milk may be prepared which will exactly correspond in its percentages and reactions to that of breast milk. This modification will be found of great value during the early months of infancy, while the digestive powers of the infant are still feeble.

Should whey not be employed, the amount of the proteid element must for some weeks be kept at a minimum and only gradually increased. A slight increase should be arranged for, however, every week or fortnight. Northrup insists that by the ninth month infants should be able to digest full milk, and considers that the slow dentition, anæmia, and loss of weight frequently observed in the later months of lactation are attributable to an insufficient amount of the proteids.

While milk laboratories are not only a great convenience to the physician in the preparation of these various combinations of percentages, but also of value in permitting such combinations to be made with greater exactness than by any method of home modification, nevertheless the advantages of a milk laboratory are not everywhere to be obtained, and in the opinion of many physicians modifications of milk can be carried out at home with sufficient exactness to fulfil the wants of the great majority of infants. To succeed, however, the physician must be capable of giving exact instructions as to the details of the process.

In undertaking home modification it is extremely important to secure a supply of good fresh milk, and one in which the percentage of the fat is known and maintained by careful feeding at a fairly uniform amount. It is to be remembered that the amounts of fat will vary very much according to the particular breed of cows supplying the milk. In an average mixed herd the fat generally amounts to about 4 per cent.; in a herd of Jersey or Alderney cattle it may amount to 5 or 6 per cent. On the other hand, if during the winter season the cows be poorly fed and housed, the fat may not much exceed 2 per cent. Cream obtained by a centrifugal separator contains from 20 to 30 per cent. of fat, together with a slightly lessened percentage of proteids and milk-sugar, and may be employed with advantage in the preparation of mixtures in which a very small amount of proteid is required. For general use, however, the most convenient way of obtaining a cream or superfatted milk, from which to prepare our percentages, is to take advantage of the deep-setting process, *i.e.*, to allow fresh milk to stand in a tall glass jar on ice for some hours. After standing for twelve hours the cream will have almost all separated and will contain about 16 per cent. of fat. If it stand only six hours, the upper fourth will contain about 12 per cent. of fat; if only three hours, the upper third will contain about 8 per cent. of fat. In this top milk when removed the sugar may be regarded as amounting to 4 per cent., and the proteids to very nearly the same.

Chapin recommends that top milk, obtained from milk as ordinarily delivered in quart bottles, be employed, and gives the following assays of various amounts of top milk taken in this way after standing twelve hours:

	Per cent.	Per cent.	Per cent.
Fat in whole milk	3.1	4.3	5.0
Fat in the top 6 ounces	13.4	19.0	23.0
Fat in the top 9 ounces	9.2	12.4	14.6
Fat in the top 12 ounces	7.0	9.6	11.1
Fat in the top 16 ounces	5.8	7.9	9.0

One may in this way obtain a superfatted milk which on dilution will give us the desired percentages of both proteids and fats. Thus if we take a 12 per cent. cream and add to it three parts of water, we shall obtain a milk containing 3 per cent. fat, 1 per cent. proteids, and 1 per cent. milk-sugar. If to each twenty ounces we add one ounce of sugar of milk, we shall then have a milk formula: fat, 3; sugar, 6; proteids, 1—a formula which will agree with most vigorous infants between the second and third months of life. By the use of creams of different strength one may modify the percentage of any of the ingredients and obtain milk of almost any desired strength.

To prevent any impurity arising from the sugar of milk, it is generally deemed advisable that it should be previously dissolved in boiling water and afterward filtered through absorbent cotton. The following table shows the amounts of milk-sugar and water required to make solutions of various strengths:

1 oz.	milk-sugar added to	25	oz. water represents	4 per cent.
1 "	" "	20	" " "	5 "
1 "	" "	16⅔	" " "	6 "
1 "	" "	14	" " "	7 "
1 "	" "	12½	" " "	8 "
1 "	" "	10	" " "	10 "

Baner has prepared a series of simple formulæ for determining the amount of cream, milk, water, and milk sugar required to make any desired quantity of modified milk containing certain given percentages. His formulæ are based on the understanding that good average milk contains fat 4, sugar 4, and proteids 4, and that cream is simply a superfatted milk containing practically the same amount of proteids as milk itself. In the formulæ given:

Q represents the total quantity desired in ounces;
F, the desired percentage of fat;
S, the desired percentage of sugar; and
P, the desired percentage of proteids.

To find in ounces the required amount of:

$$\text{Cream} = \frac{Q}{12} \times (F - P);$$

$$\text{Milk} = \frac{Q \times P}{4} - C;$$

$$\text{Water} = Q - (C + M);$$

$$\text{Milk-sugar} = \frac{(S - P) \times Q}{100}.$$