The coagulation of milk depends upon the reduction of caseine from a liquid to a semi-solid condition. When milk is allowed to coagulate spontaneously, the change is effected by the action of the lactic acid which results from a transformation of a portion of the sugar of milk. Caseine, in fact, is coagulated by any of the acids, even the feeble acids of organic origin. It differs from albumen in this regard and in the fact that it is not coagulated by heat. If fresh milk be slightly raised in temperature and be treated with an infusion of the gastric mucous membrane of the calf, coagulation will take place in five or ten minutes, the clear liquid still retaining its alkaline reaction. Simon has observed that the mucous membrane of the stomach of an infant a few days old, that had recently died, coagulated woman's milk more readily than the mucous membrane of the stomach of the calf.

Non-Nitrogenized Constituents of Milk.—Non-nitrogenized matters exist in abundance in the milk. The liquid caseine and the water hold the fats in the condition of a fine and permanent emulsion. This fat may easily be separated from the milk, and is known under the name of butter. In human milk, the butter is much softer than in the milk of many of the inferior animals, particularly the cow; but it is composed of essentially the same constituents, although in different proportions. In different animals, there are developed, even after the discharge of the milk, certain odorous matters, which are more or less characteristic of the animal from which the butter is taken.

The greatest part of the butter consists of palmitine. Butter contains in addition, oleine, and a small proportion of peculiar fats, which have not been very well determined, called butyrine, caprine, caproïne, capriline, with some other analogous substances. Palmitine and oleine are found in the fat throughout the body; but the last-named substances are peculiar to the milk. These are especially liable to acidification, and the acids resulting from their decomposition give the peculiar odor and flavor to rancid butter.

Sugar of milk, or lactose, is the most abundant of the solid constituents of the mammary secretion. It is this that gives to the milk its peculiar sweetish taste, although this variety of sugar is much less sweet than cane-sugar. The chief peculiarities of milk-sugar are that it readily undergoes change into lactic acid in the presence of nitrogenized ferments, and that it takes on alcoholic fermentation slowly and with difficulty. In the fermentation of milk, the lactose is changed first into galactose, and then into alcohol and carbon dioxide. In some parts of the world, alcoholic beverages made from milk are in common use.

Inorganic Constituents of Milk.—It is probable that many inorganic salts exist in the milk, which are not given in the table; and the separation of these from their combinations with organic matters is one of the most difficult problems in physiological chemistry. This must be the case, for during the first months of extraüterine existence, the child derives all the inorganic as well as the organic matters necessary to nutrition and development, from the breast of the mother. The reaction of the milk depends upon the presence of the alkaline carbonates, and these are important in preserving the

fluidity of the caseine. It is not determined precisely in what form iron exists in the milk, but its presence here is undoubted. A comparison of the composition of the milk with that of the blood shows that most of the important inorganic matters found in the latter fluid exist also in the milk.

Hoppe has indicated the presence of carbon dioxide, nitrogen and oxygen, in solution in milk. Of these gases, carbon dioxide is the most abundant. It is well known that the presence of gases in solution in liquids renders them more agreeable to the taste, and carbon dioxide increases very materially their solvent properties. Aside from these considerations, the uses of the gaseous constituents of the milk are not apparent.

In addition to the constituents given in the table of composition, the milk contains small quantities of peptone, nucleine, dextrine, urea, lecithine, hypoxanthine, fluorine and silica.

A study of the composition of the milk fully confirms the fact that this is a typical alimentary fluid and presents in itself the proper proportion and variety of material for the nourishment of the body during the period when the development of the system is going on with its maximum of activity. The form in which its different nutritive constituents exist is such that they are easily digested and are assimilated with great rapidity.

Variations in the Composition of Milk.—If the composition of the milk be compared at different periods of lactation, it will be found to undergo great changes during the first few days. In fact, the first fluid secreted after parturition is so different from ordinary milk, that it has been called by another name. It is then known as colostrum, the peculiar properties of which will be considered more fully under a distinct head. As the secretion of milk becomes established, the fluid, from the first to the fifteenth day, becomes gradually diminished in density and in its proportion of water and of sugar, while there is a progressive increase in the proportion of most of the other constituents; viz., butter, caseine and the inorganic salts. The milk, therefore, as far as one can judge from its composition, as it increases in quantity during the first few days of lactation, is constantly increasing in its nutritive properties.

The differences in the composition of the milk, taken from month to month during the entire period of lactation, are not so distinctly marked. It is difficult, indeed, to indicate any constant variations of sufficient importance to lead to the view that the milk varies much in its nutritive properties at different times, during the ordinary period of lactation. The differences between the milk of primiparæ and multiparæ are slight and unimportant. As a rule, however, the milk of primiparæ approaches more nearly the normal standard.

In normal lactation, there is no marked and constant difference in composition between milk that has been secreted in great abundance and milk which is produced in comparatively small quantity; and the difference between the fluid first drawn from the breast and that taken when the ducts are nearly empty, which is observed in the milk of the cow, has not been noted in human milk.

Colostrum.

Near the end of utero-gestation, during a period which varies considerably in different women and has not been accurately determined, a small quantity of a thickish, stringy fluid may frequently be drawn from the mammary glands. This bears little resemblance to perfectly formed milk. It is small in quantity and is usually more abundant in multiparæ than in primiparæ. This fluid, as well as that secreted for the first few days after delivery, is called colostrum. It is yellowish, semi-opaque, of a distinctly alkaline reaction and is somewhat mucilaginous in its consistence. Its specific gravity is considerably above that of the ordinary milk, being between 1040 and 1060. As lactation progresses, the character of the secretion rapidly changes, until the fluid becomes filled with true milk-globules and assumes the characters of ordinary milk.

The opacity of the colostrum is due to the presence of a number of different corpuscular elements. Milk-globules, very variable in size and number, are to be found in the secretion from the first. These, however, do not exist in sufficient quantity to render the fluid very opaque, and they are frequently aggregated in rounded and irregular masses, held together, apparently, by some glutinous matter. Peculiar corpuscles, supposed to be characteristic of the colostrum, always exist in this fluid. These are known as colostrum-corpuscles. They are spherical, varying in size between $\frac{1}{2500}$ and $\frac{1}{500}$ of an inch (10 and 50 μ.), are sometimes pale, but more frequently quite granular, and they contain very often a large number of fatty particles. They behave in all respects like leucocytes and are described as a variety of these bodies. Many of them are precisely like the leucocytes found in the blood, lymph or pus. In addition to these corpuscular elements, a small quantity of mucine may frequently be observed in the colostrum on microscopical examination.

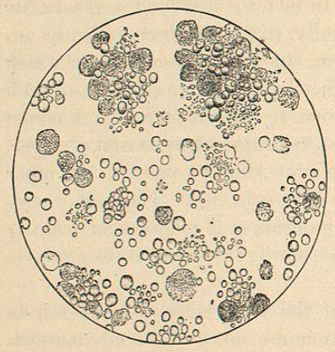

Fig. 104.—*Colostrum, from a healthy lying-in woman, twelve hours after delivery* (Funke).
The smaller globules are globules of milk. The larger globules, *a*, *a*, filled with granulations, are colostrum-corpuscles. As lactation advances, the colostrum-corpuscles gradually disappear, and the milk-globules become more abundant, smaller and more nearly uniform in size.

On the addition of ether to a specimen of colostrum under the microscope, most of the fatty particles, both within and without the colostrum-corpuscles, are dissolved. Ammonia added to the fluid renders it stringy, and sometimes the entire mass assumes a gelatinous consistence.

In its composition, colostrum presents many points of difference from true milk. It is sweeter to the taste and contains a greater proportion of sugar and of the inorganic salts. The proportion of fat is at least equal to the proportion in the milk and is generally greater. Instead of caseine, pure

colostrum contains a large proportion of serum-albumin; and as the character of the secretion changes in the process of lactation, the albumin becomes gradually reduced in quantity and caseine takes its place.

The following, deduced from the analyses of Clemm, may be taken as the ordinary composition of colostrum of the human female:

COMPOSITION OF COLOSTRUM.

Water	945·24
Albumin, and salts insoluble in alcohol	29·81
Butter	7·07
Sugar of milk, extractive matter, and salts soluble in alcohol	17·27
Loss	0·61
	1,000·00

Colostrum ordinarily decomposes much more readily than milk and takes on putrefactive changes very rapidly. If it be allowed to stand for twelve to twenty-four hours, it separates into a thick, opaque, yellowish cream and a serous fluid. In an observation by Astley Cooper, nine measures of colostrum, taken soon after parturition, after twenty-four hours of repose, gave six parts of cream to three of milk.

The peculiar constitution of the colostrum, particularly the presence of an excess of sugar and inorganic salts, renders it somewhat laxative in its effects, and it is supposed to be useful, during the first few days after delivery, in assisting to relieve the infant of the accumulation of meconium.

As the quantity of colostrum that may be pressed from the mammary glands during the latter periods of utero-gestation, particularly the last month, is very variable, it becomes an important question to determine whether this secretion have any relation to the quantity of milk that may be expected after delivery. This question has been studied by Donné, who arrived at the following conclusions:

In women in whom the secretion of colostrum is almost absent, the fluid being in exceedingly small quantity, viscid, and containing hardly any corpuscular elements, there is hardly any milk produced after delivery.

In women who, before delivery, present a moderate quantity of colostrum, containing very few milk-globules and a number of colostrum-corpuscles, after delivery the milk will be scanty or it may be abundant, but it is always of poor quality.

When the quantity of colostrum produced is considerable, the secretion being quite fluid and rich in corpuscular elements, particularly milk-globules, the milk after delivery is always abundant and of good quality.

From these observations, it would seem that the production of colostrum is an indication of the proper development of the mammary glands; and the early production of fatty granules, which are first formed by the cells lining the secreting vesicles, indicates the probable activity in the secretion of milk after lactation shall have become fully established.

The secretion of the mammary glands preserves the characters of colostrum until toward the end of the so-called milk-fever, when the colostrum-

corpuscles rapidly disappear, and the milk-globules become more abundant, regular and uniform in size. It may be stated, in general terms, that the secretion of milk becomes fully established and all the characters of the colostrum disappear between the eighth and the tenth day after delivery. A few colostrum-corpuscles and masses of agglutinated milk-globules may sometimes be discovered after the tenth day, but they are rare. After the fifteenth day, the milk does not sensibly change in its microscopical or its chemical characters.

Lacteal Secretion in the Newly-Born.

In infants of both sexes there is generally a certain amount of secretion from the mammary glands, beginning at birth or two or three days after, and continuing sometimes for two or three weeks. The quantity of fluid that may be pressed out at the nipples at this time is very variable. Sometimes only a few drops can be obtained, but occasionally the fluid amounts to one or two drachms (3·7 or 7·4 grammes.) Although it is impossible to indicate the object of this secretion, which takes place when the glands are in a rudimentary condition, it has been so often observed and described by physiologists, that there can be no doubt with regard to the nature of the fluid and the fact that the secretion is almost always produced in greater or less quantity. The following is an analysis by Quevenne of the secretion obtained by Gubler. The observations of Gubler were made upon about twelve hundred children. The secretion rarely continued for more than four weeks, but in four instances it persisted for two months.

COMPOSITION OF THE MILK OF THE INFANT.

Water	894·00
Caseine	26·40
Sugar of milk	62.20
Butter	14·00
Earthy phosphates	1·20
Soluble salts (with a small quantity of insoluble phosphates)	2·20
	1,000·00

This fluid does not differ much in its composition from ordinary milk. The proportion of butter is much less, but the proportion of sugar is greater, and the quantity of caseine is nearly the same.

Of the other fluids which are enumerated in the list of secretions, the saliva, gastric juice, pancreatic juice and the intestinal fluids have already been described in connection with the physiology of digestion. The physiology of the lachrymal secretion will be taken up in connection with the eye, and the bile will be treated of fully under the head of excretion.

Secretory Nerve-Centres.—It remains now to consider the influence of nerve-centres upon certain secretions. Cerebro-spinal centres presiding over secretion have not been determined for all of the glands, although they may exist. No cerebro-spinal centres have been described for the secretions of

mucous membranes, the gastric juice, the intestinal juice, the sebaceous fluids, the milk or the lachrymal fluid.

The centres for the salivary secretions are in the medulla oblongata, near the points of origin of the facial and glosso-pharyngeal nerves. The centre for the pancreatic secretion is also in the medulla oblongata. The centres which act upon the liver and upon certain excretions will be treated of in connection with the physiology of the liver, kidneys and skin.

CHAPTER XII.

EXCRETION BY THE SKIN AND KIDNEYS.

Differences between the secretions proper and the excretions—Physiological anatomy of the skin—Physiological anatomy of the nails—Physiological anatomy of the hairs—Sudden blanching of the hair—Perspiration—Sudoriparous glands—Mechanism of the secretion of sweat—Properties and composition of the sweat—Peculiarities of the sweat in certain parts—Physiological anatomy of the kidneys—Mechanism of the production and discharge of urine—Influence of blood-pressure, the nervous system etc., upon the secretion of urine—Physiological anatomy of the urinary passages—Mechanism of the discharge of urine—Properties and composition of the urine—Influence of ingesta upon the composition of the urine and upon the elimination of nitrogen—Influence of muscular exercise upon the elimination of nitrogen—Water regarded as a product of excretion—Variations in the composition of the urine.

In entering upon the study of the elimination of effete matters, it is necessary to appreciate fully the distinctions between the secretions proper and the excretions, in their composition, the mechanism of their production, and their destination. The urine may be taken as the type of the excrementitious fluids. None of its normal constituents belong to the class of non-crystallizable, organic nitrogenized matters, but it is composed entirely of crystallizable matters, simply held in solution in water. The solid constituents of the urine represent the ultimate physiological changes of certain parts of the organism, and they are in such a condition that they are of no farther use in the economy and are simply discharged from the body. Certain inorganic matters are found in the excrementitious fluids, are discharged with the products of excretion, and are thus associated with the organic constituents of the body in their physiological changes as well as in their deposition in the tissues. Coagulable organic matters, or albuminoids, never exist in the excrementitious fluids under normal conditions; except as the products of other glands may become accidentally or constantly mixed with the excrementitious fluids proper. The same remark applies to the non-nitrogenized matters, sugars and fats, which, whether formed in the organism or taken as food, are consumed in the organism. The production of the excretions is constant, being subject only to certain modifications in activity, which are dependent upon varying conditions of the system. All of the elements of excretion pre-exist in the blood, either in the condition in which they are discharged or in some slightly modified form.

The urine is a purely excrementitious fluid. The perspiration and the