count of their cost, whether in the field or in garrison. This is particularly true of unseasoned troops, but I believe it holds good for all. The suppression of music for military reasons at the siege of Yorktown, I am confident, injured the troops by the gloomy silence that resulted. On the other hand, the use Heintzelman made of martial music at the battle of Williamsburg shows its value as a moral stimulant.

No sketch of military hygiene, however meagre, should omit a tribute to the late Dr. E. A. Parkes, of the British service, whose copious experience and clearly expressed knowledge have done so much to improve the well-being of enlisted men the world over. Parkes' "Hygiene" is the general reservoir from which for many years the military student must draw his theoretical information.

The officer, whether medical or line, who would properly care for the troops must keep an ever-vigilant watch over their interests. But concern should not degenerate into friction and worry. Perpetual nagging, too curious supervision, is almost as bad as contemptuous neglect. He must love his duty, must love soldiers and a soldier's life, and, while commanding with impartiality, must under all circumstances lead and protect his men.

Alfred A. Woodhull.

MILIUM.—Grutum, Strophulus albus, Acne albida, Tubercula miliaria, Tubercula sebacea. It consists of small, round, or pointed bodies which contain sebaceous matter and epithelial cells, and are situated immediately beneath the epidermis. Their size varies from that of a pinhead to that of a small pea; they are white or yellowish in color, rather hard in consistence, especially so when calcified, in this instance being termed cutaneous calculi.

They are most commonly situated on those parts of the skin which are well supplied with sebaceous glands; therefore they will be found generally about and upon the eyelids, on the cheeks, and in the neighborhood of the lips. Another favorite locality for this affection is on the genital organs of both sexes: in the male, on the scrotum and penis; in the female, on the labia minora.

The affection seems to occur more frequently in women, at about middle life, being the cause of real suffering from the attendant disfigurement. In men I have seen it attack the genital organs more frequently than any other part of the body. The disease is far from uncommon, but it is so trivial in its nature that people seldom seek treatment for it, and our advice is sought only when the number of milia is large, or when they are large in size, or, finally, when they occasion distress on account of their prominent position on the face. Fortunately, these little tumors do not grow continuously unless injured; otherwise, after attaining a certain size they remain permanently quiescent.

These little tumors consist of accumulated sebaceous matter and of epithelial cells within a sebaceous gland and its obliterated duct. In the centre there is a core of sebum and, arranged concentrically about it, layer upon layer of epithelial cells. This symmetrical arrangement of the layers Kaposi happily compares to the structure of an onion. The milia are situated directly under the epidermis. Kaposi claims that they also have over them a very thin layer of corium.

Virchow and Rindfleisch believe that the seat of the disease is in different portions of the hair follicles, but the fact that these little tumors occur in localities totally devoid of hair or lanugo, as the glans penis, would not support this idea. No cause has ever been discovered for this disease; it would seem that there must be another cause for it besides the mere mechanical occlusion of the ducts, but thus far it has escaped us.

Diagnosis.—With the exercise of some care there is little chance of confounding milium with anything else. The disease most apt to be mistaken for it is comedo, but the following points ought to differentiate them: In milium the color is white or yellowish-white, it is covered by epidermis; it cannot be pressed out unless the epidermal layer is incised, and as a rule it is the sole lesion present, although cases do occur in which several affections coexist (as acne with milium, or comedo with milium, etc.).

Prognosis.—The disease is obstinate. It remains in the same condition for years, or the little tumors become calcified, forming the so-called cutaneous calculi.

Treatment.—This should be incision of the thin layer of epidermis over each individual little tumor and the extrusion of the mass as a whole by pressure. This little operation is almost bloodless and leaves no scar.

N. J. Ponce de Léon.

MILK.—There is no one article of food more important to the human race than milk. In health it is in universal use; in pathological conditions it serves as the basis of dietetic treatment; and in the feeding of infants, both by natural and by artificial means, it is the one essential source of nourishment. A knowledge of the physiological and chemical properties of milk is therefore of far-reaching importance to physicians, and deserves more attention and study than are generally accorded it.

It is the milk of cows which has been most extensively investigated, the knowledge of which must underlie our consideration of the subject in general.

Secretion of Milk.—In the mammary gland of mammals, nature has provided a mechanism of extreme delicacy for the elaboration of milk. It is a storehouse for its product in a limited degree only, its principal function being the secretion of milk, in accordance with demands made upon it by the nursing offspring, or, in case of the domesticated cow, by the artificial conditions which surround it. It draws its material from the various parts of the animal economy by means of the blood, recombining them and building them up into the constituents of milk—the fats, sugar, proteids, mineral matter, and water.

The specific secretory action of the mammary gland, as opposed to simple filtration and excretion, is shown by the chemical analysis of milk. We do not find, for instance, the milk-sugar or lactose, one of its principal constituents, in the blood. The lactalbumin also differs in certain respects from serum albumin; and the mineral matter is found in different proportions from those which exist in the blood. Filtration and excretion, therefore, are only parts of the general process, while the synthetic property of the mammary gland depends, probably, upon the activity of the epithelial cells lining the ducts of the gland. The gland is of the compound racemose variety, and thus presents a large surface for the exercise of its function.

The proportion of solids secreted in milk is not constant. It varies with the variety of mammal and with the variety of species, that is, according to the breed of the animal. It is also influenced in an individual animal by such factors as changes in the atmosphere, *i.e.*, the seasons, by changes in food, by the hygienic surroundings, by emotions, fatigue, sickness, and at different stages of the milking period, being more watery in the early periods, and more concentrated in the late periods. In nursing women the catamenia and pregnancy are also conditions which influence the composition of the milk.

The *quantity* of milk secreted, especially in human breasts, in the natural state, is adapted to the age and gastric capacity of the infant, but this function is modified greatly by artificial conditions.

That the mammary gland has also the function of excretion is shown in its power of eliminating certain drugs ingested by the mother. The most important of these are morphine, opium, atropine and belladonna, iodine, arsenic, bismuth, antimony, zinc, lead, mercury, and iron. It is interesting to note, however, that other substances, such as bile acids and bile pigments, are not excreted by the mammary gland.[16] Toxins, on the other hand, may be eliminated and secondarily react upon the nursing infant. The majority of drugs, however, are not excreted in the milk.

Certain classes of foods contain substances which may be excreted and modify the taste of milk, notably turnips, onions, garlic, mouldy hay and grain, etc. The

taste of milk may also be influenced by exposure of milk to volatile substances. This property of absorption of odors is very great. The odors of strong disinfectants, kerosene oil, and similar articles, if brought in close contact with milk, are readily taken up and impart their properties to the absorbing medium.

Origin of Fat in Milk.—Microscopically, the fat globules may be seen in the epithelial cells of the mammary gland. They are discharged into the milk ducts either by a breaking up of the cells themselves or by a contractile extension similar to that which occurs when the amœba ejects its food.[5] The question of how much fat is produced by the secretory mechanism of the milk glands, and of how much is obtained from other organs and tissues and eliminated from the blood by the milk glands, has not been determined. Winternitz[14] has proved by experiments with iodized fats that fat may be extracted directly from the blood by the mammary glands and be eliminated with its secretions. Similar observations have been made by Spampani and Daddi with sesame oil.[15] It is also now conceded that fat may be formed from carbohydrates in the animal organism, and it is possible that the milk glands may produce fats from the carbohydrates brought to them by the blood.[16]

Origin of Milk Proteids.—The epithelial cells are rich in proteids and nucleo-proteids, which are probably the sources of the casein or its mother substance, the caseinogen.[16] Basch has attempted to show that the casein is formed in the mammary gland by the nucleic acid of the nucleus set free, uniting the intra-alveolar with the transudated serum, thereby forming a nucleo-albumin, called caseinogen. The origin of the proteids is, however, far from being settled.

Origin of Milk Sugar.—The origin of milk sugar or lactose is not definitely known. Among the nucleoproteids just mentioned is one which yields a reducing substance when boiled with dilute acids, but the relation of this substance to the formation of lactose has not been thoroughly investigated.[16] Muntz believes that milk sugar may be formed in herbivora by syntheses from dextrose and galactose, but this theory does not hold in the case of carnivora which may produce milk sugar even when fed exclusively on a diet of lean meat.[16]

Composition of Cow's Milk.—Milk consists of an emulsion of fat in minute subdivision suspended in the milk plasma which consists of milk sugar, or lactose, proteids, extractives, mineral matter, and water. It is therefore apparent that we have represented all the great subdivisions of foodstuffs, that is, fats, carbohydrates, proteids, mineral matter, and water. The proportion in which these substances occur in the milk varies in different animals and also in the same animal at different times.

The average of a large number of analyses made in this country showed the following result:[17]

Fat	4.00	per cent.
Sugar	4.95	"
Proteids	3.30	"
Mineral matter	.75	"
Total solids	13.00	"
Water	87.00	"
	100.00	"

Droop-Richmond[19] gives the composition of cow's milk in England based on the analyses of two hundred thousand specimens as:

Fat	3.90	per cent.
Lactose	4.75	"
Casein	3.00	"
Albumin	.40	"
Mineral matter	.75	"
Water	87.10	"

The analyses of milk by French and German chemists, as well as by many English and American investigators, show varying results, which serve to emphasize the fact, which cannot be too strongly impressed upon the reader, that the composition of milk of large herds of cows, as well as of individual cows, varies sometimes within wide limits of any average that one may attempt to establish. These variations depend upon the breed of cow, the methods of feeding, the health of the animal, the season of the year, and other conditions.

The variation according to the breed is shown in the following table, compiled from average analyses, by Mr. Gordon of the Walker-Gordon Laboratory:

	Durham or Shorthorn.	Devon.	Ayrshire.	Holstein-Friesian.
Fats	4.04	4.09	3.89	2.88
Sugar	4.34	4.32	4.41	4.33
Proteids	4.17	4.04	4.01	3.99
Mineral matter	.73	.76	.73	.74
Total solids	13.28	13.21	13.04	11.94
Water	86.72	86.79	86.96	88.06
Daily quantity	large	moderate	large	very large

	Brown Swiss.	Jersey.	Common native.	American grade.
Fats	4.00	5.21	3.69	4.01
Sugar	4.30	4.52	4.35	4.36
Proteids	4.00	3.99	4.09	4.06
Mineral matter	.76	.71	.73	.74
Total solids	13.06	14.43	12.86	13.17
Water	86.94	85.57	84.14	86.83
Daily quantity	moderate	large	moderate	moderate

Analyses of milk from Guernsey cows closely approach those of the Jersey cow, but with slightly lower percentages of fat.

As it is of much importance to have some average upon which to base our calculations, we may accept the figures of Holt, Adriance, and others, as fairly representative of the average of American milk, bearing in mind, however, that there is a wide variation possible in any individual case.

Fats[20]	4.00	per cent.
Lactose	4.50	"
Proteids	3.50	"
Mineral matter	.75	"

As an illustration of the variations in the percentage composition of milk during the three periods of a milking, we may quote the following analysis by Harrington.[5]

	Fat.	Total solids.	Water.	Mineral matter.
"Fore milk"	3.88	13.34	86.66	0.85
"Middle milk"	6.74	15.40	84.60	.31
"Strippings"	8.12	17.13	82.87	.82

Seasonal and monthly variations in the composition of cow's milk are quite distinct as shown in the following table by Droop-Richmond[19] prepared from analyses covering a period of sixteen years:

Month.	Specific gravity.	Total solids. Per cent.	Fat. Per cent.	Solids not fat. Per cent.
January	1.0322	12.88	4.02	8.86
February	1.0322	12.78	3.93	8.85
March	1.0322	12.71	3.88	8.83
April	1.0322	12.66	3.84	8.82
May	1.0323	12.66	3.82	8.84
June	1.0322	12.59	3.79	8.80
July	1.0317	12.66	3.93	8.73
August	1.0316	12.73	4.02	8.71
September	1.0319	12.92	4.12	8.80
October	1.0322	13.13	4.21	8.92
November	1.0322	13.19	4.30	8.89
December	1.0322	13.04	4.16	8.88

It will be seen from this table that the year may be divided into four periods: 1. In November, December, and January, the milk is rich in both fats and solids not fat. 2. In February, March, and April, the solids not fat do not show much variation, but the percentage of fat is diminished. 3. In May, June, July, and August, the lowest percentage of fat is reached, and the solids not fat also show slightly lower averages. These monthly variations are much less marked in herds, the feed of which is the same throughout the year, and are most marked in herds which are turned out to pasture during the spring and summer.

The evening milk is almost invariably richer than the morning milk if the interval between milkings is from nine to ten hours; but this difference is much less marked if the interval is twelve hours.[19] Other factors which are important in influencing the composition of milk are a change in milkers, variations in the rapidity of milking, rough treatment, exposure to rain or bad weather, and unusual excitement or sickness.

In reference to the influence of feed upon the quality of milk, Farrington, and Woll[25] say: "The increase which has often been observed in the amount of butter produced by a cow, as a result of the change of feed, doubtless, as a rule, comes from the fact that more, but not richer, milk is produced. The quality of milk which a cow produces is as natural to her as is the color of her hair and is not materially changed by any special system of normal feeding." This opinion is in accordance with the conclusion arrived at by the director of the Copenhagen Experiment Station, who has for ten years supervised the feeding of two thousand cows. He states that the change in feed in the different lots of cows has had practically no influence on the chemical composition (fat content) of the milk produced. It is interesting to record that by careful selection and breeding of the best specimens of a given herd of cows, the quality of milk may, in the course of several generations, be raised to a considerably higher standard. There are herds of Holstein cows on the farms of the Walker-Gordon Company which have been carefully selected and bred, which now in the tenth or twelfth generation yield a milk which will average four per cent. of fat, an increase of about one per cent. over the average Holstein milk.

It should be borne in mind that the quality of the milk is not the only factor to be considered. The quantity of milk must always be considered in determining the value of a particular breed of cow for dairy purposes.

Reaction.—Perfectly fresh milk is amphoteric, but cow's milk is relatively more acid than human milk. The acidity is due to the presence of phosphates; the alkalinity to the presence of alkaline carbonates.

Specific Gravity.—The specific gravity varies from 1.028 to 1.0345. It increases very slightly for a few hours due to molecular modification of the casein. It is dependent upon the presence of solids not fat which are in solution, which tend to raise the specific gravity, and on the fat itself which by virtue of its being lighter than water tends to lower the specific gravity. It is lowered by the addition of cream or water and is raised by the removal of cream. The specific gravity of milk is therefore not an absolute test of the quality of milk; for instance, if whole milk of specific gravity 1.032 is separated from its cream, the specific gravity will rise to 1.036, which may be reduced to 1.032 again by the addition of ten per cent. of water. On the other hand, if cream is added to milk of 1.032 specific gravity, so as to raise the fat percentage four per cent., the specific gravity will be lowered to 1.028.[19]

Fats.—The fat of milk exists entirely in the form of the fat globules suspended in the plasma. These globules vary greatly in size. It is a disputed point whether the globules are purely fat. Storch[18] maintains that they are surrounded by a slimy substance which his analyses show to be neither casein nor lactalbumin, but a nitrogenous material containing fourteen per cent. of nitrogen and also a reducing substance on boiling with mineral acids. Others have held the opinion that there is a stratum of caseinogen surrounding each globule and held to it by molecular attraction, thus preventing the globules from uniting with one another. On shaking milk with ether, the fat is separated but slowly; but when the caseinogen is precipitated by alkalies, acids, or rennin, the solution of the fat in ether is easily obtained. The percentage of fat in milk, as seen above, varies according to the breed of the cow, the season of the year, the feed, and many other conditions. Four per cent. is taken as a fair average of good milk.

The non-volatile milk fat consists chiefly of palmitin, stearin, and olein, the source of butter. The volatile class is composed of butyric acid, caproic acid, and small traces of myristic acid, caprilic acid, capric acid, lauric acid, and arichidic acid. Lecithin, cholesterin, and a yellow coloring matter are also present.[16] The butyric and caproic acids constitute over seven per cent. of the whole fat.[1]

Milk Plasma.—Milk plasma contains in solution, or pseudo-solution, the remaining constituents of milk, that is the milk sugar or lactose, the proteids—caseinogen, lactalbumin, lactoglobulin—and the mineral matter. These proteid substances are of complex composition, containing C, O, N, H, P, and S, but the composition of the proteid molecule is not known. Certain extractives are also present; that is, faint traces of urea, creatin, creatinin, xanthin, lecithin, cholesterin, and citric acid. The gases of milk consist chiefly of CO_2, N, and traces of O.[16]

Milk Sugar or Lactose.—Lactose is found in nature in milk alone, but has been detected pathologically in the urine of pregnant women. It occurs ordinarily as colorless, rhombic crystals with one molecule of water of crystallization. When heated to 170–180° C. it is converted into lactocaramel, but when heated in solution it begins to undergo decomposition at 70° C., which is a point of some significance in connection with the subject of sterilization of milk in infant feeding. It is less sweet and less soluble than dextrose, it dissolves in six parts of cold or 2.5 parts of hot water, but is insoluble in ether and absolute alcohol. Solutions of lactose are dextrogyrate (+ 52.5°).

Milk sugar does not undergo alcoholic fermentation with pure yeast, but is fermentable by the action of certain schizomycetes and by the enzyme *lactase* which exists in yeast, being split by hydrolytic cleavage into glucose (dextrose) and galactose. The manufacture of "koumyss" from mare's milk and "kephir" from cow's milk is based upon the above facts. Lactose readily undergoes lactic-acid fermentation as already described. Lactose is not acted upon by invertase, diastase, rennin, pepsin, or trypsin.[19]

Chemically, lactose has the property of reducing Fehling's solution, but like maltose it fails to respond to Barfoed's test. It may be distinguished from maltose by the characteristic burr-like ozazones, formed by heating with phenylhydrazin acetate. Commercially it is prepared by extraction from sweet whey, a by-product in the manufacture of cheese.

Caseinogen.—Caseinogen is the term applied to the chief proteid of milk when in a state of solution. After precipitation, it is more correctly spoken of as casein. It constitutes eighty per cent. of the total proteids, and amounts to about 2.8 per cent.[30] It is a nucleo-albumin and occurs only in milk. Whether the caseinogen from different kinds of milk is identical has been the subject of considerable investigation and discussion. The analyses of the casein of human milk and cow's milk by Hammarsten and Wroblewsky show certain marked differences in the proportions of C, H, N, P, S, and O, but it is by no means certain as to how much these differences affect the digestibility of the two caseins. Szontagh[23] maintains that human milk yields no pseudo-nuclein in pepsin digestion, and hence the caseinogen cannot be a nucleo-albumin like that of human milk.

Caseinogen is coagulated by the rennin ferment in the presence of enough and not too much calcium salts. In the absence of calcium coagulation does not take place, but the rennin effects a change in the casein so that even

if it is killed by heat the casein will coagulate when the calcium salts are supplied,[16] showing that the lime salts are necessary only for the separation of the curd. According to Hammarsten, the caseinogen, in rennin coagulation, is split into an insoluble body, paracasein or curd, which is the chief product, and into a soluble substance similar to albumose, called "whey proteid," which is formed only in very small amounts. This paracasein has not the property, possessed by caseinogen, of holding the calcium phosphate of the milk in solution, and the latter is precipitated in considerable quantities in the curd. The soluble lime salts alone are of much importance in the coagulation of the caseinogen.

Caseinogen is not coagulable by heat, in marked contrast to the other proteids, lactalbumin and lactoglobulin. It is, however, coagulated by small amounts of acetic acid or mineral acids and is soluble again in an excess of the acid. The acid solutions thus obtained are again precipitated by strong mineral acids in excess.

Caseinogen is precipitated from neutral solutions by ammonium sulphate, sodium chloride, and magnesium sulphate when added to full saturation, without changing its properties. It is also precipitated from neutral solution by metallic salts.

Lactalbumin.—The lactalbumin, including the small traces of lactoglobulin, and of the other nitrogenous extractives, form about twenty per cent. of the total proteids of milk or 0.70 per cent.[30] In human milk, it is of much greater importance, constituting two-thirds of the total proteids (König). It is characterized by its property of coagulating at 72° to 84° C., the degree depending upon the amount of salt in solution. It is not coagulable by dilute acids or rennin. It is very similar chemically to serum albumin but has a lower specific rotatory power (– 37°). It is not precipitated by magnesium sulphate added to saturation nor by half saturation with ammonium sulphate. When heated at the above temperature it is not entirely coagulated, but is so changed that it is readily precipitated by magnesium sulphate.

Other Nitrogenous Substances in Milk.—Various laboratory products may be produced from the proteids of milk, such as albumose, peptone, and lactoprotein, but it has not been proved that they occur in nature.[16] Lactoprotein is a mixture of casein and changed albumin. Storch has described a nucleo-proteid which also occurs in milk in minute traces.

A part of the nitrogen of milk exists as extractives and is estimated as the difference between the total nitrogen contents and the protein nitrogen. This difference, according to Munk's analyses, amounts in cow's milk to about one-sixteenth of the total nitrogen and in human milk to one-tenth of the total nitrogen.[16] The extractives consist chiefly of xanthin, creatin, creatinin, lecithin, cholesterin, and urea.

	Harrington and Kinnicutt.[5] Human milk.	Richmond.[20] Cow's milk.
Lime	15.69	20.27
Magnesia	1.92	2.80
Potash	24.77	28.71
Soda	9.19	6.67
Phosphoric acid	10.73	29.33
Chlorine	20.11	14.00
Carbonic acid	7.97	.97
Sulphur	2.19	A trace.
Ferric oxide and alumina	.40	.40
Silica	.70	
Oxygen (calculated)	6.16	
Unconsumed carbon	.71	
Total	100.54	103.15
Less oxygen and chlorine	......	3.15

Mineral Matter.—The total mineral matter obtained by the analyses of König[16] was 0.70 per cent. It consists chiefly of K, P, Ca. Cl, and S, with very small traces of Si, Fe, and Mg. A part of the calcium is combined with casein, the remainder with phosphoric acid. The preceding table represents the results of two different investigations of the mineral matter of cow's milk as compared with human milk.

A comparison of the salts of human and cow's milk is seen in the following table:[20]

Human Milk—Harrington and Kinnicutt.	Per cent.
Sodium chloride	21.77
Potassium chloride	12.05
Potassium sulphate	8.33
Potassium carbonate	23.47
Calcium phosphate	23.87
Calcium carbonate	2.85
Calcium sulphate	2.25
Calcium silicate	1.27
Iron oxide and alumina	.37

Cow's Milk—Adapted from Söldner.	Per cent.
Sodium chloride	10.62
Potassium chloride	9.16
Potassium citrate	5.47
Potassium phosphate	21.99
Calcium phosphate	16.32
Calcium citrate	23.55
Lime combined with proteids	5.13
Magnesium citrate	4.05
Magnesium phosphate	3.71

The chief differences between the above analysis of Harrington and Kinnicutt and all other analyses of human milk are as follows[5]: (1) The phosphoric acid is less than half as much as previously reported. (2) The magnesium is also less than half as much. (3) Silica and alumina are present. The analyses were made from six quarts of human milk collected by Rotch and his assistants from a large number of nursing mothers. This represents an unusually large amount of breast milk for experimental purposes, and the results are therefore of exceptional value. It has not been found practicable, however, to make use of these differences in the mineral matter of human and cow's milk in the adaptation of cow's milk to infant feeding.

Gases.—Oxygen, nitrogen, and carbon dioxide are present in fresh milk and are probably due to absorption from the air. Boiling and sterilization of milk in open bottles causes the carbon dioxide to volatilize, and to this fact, rather than to chemical changes, is due the unpleasant taste of milk heated in open vessels. The pleasant taste can be restored if carbon dioxide is artificially incorporated with the milk. A large portion of the gas also disappears in centrifugation of milk.[21]

Action of Heat on Milk.—When milk is heated to 70° C. a certain amount of the lactalbumin and lactoglobin is coagulated, but the major part of the lactalbumin is converted into a form which is precipitated by acids, by magnesium sulphate, and by the other precipitants of casein which do not act upon the lactalbumin in its natural state. At 80° C. certain organized principles undergo a change, the nature of which is not known, but the evidence of which is found in certain chemical reactions.[17] At 100° C. calcium citrate is deposited, some oxidation of the sugar takes place, and a deposition of albumin and certain salts on the fat globules occurs, causing the latter to rise and coalesce.

At temperatures exceeding 60° C. a skin is formed on the surface of the milk, consisting probably of an oxidized product of casein together with calcium salts and some fat. When heated above 70° C. the taste and smell of milk are altered.

Fresh amphoteric milk does not coagulate on boiling, but when lactic-acid fermentation has proceeded sufficiently far coagulation occurs on the application of heat—a phenomenon often noticed in summer when the conditions are especially favorable to lactic-acid fermentation. This is probably due to the acid developed displacing the casein from its combination with an alkali, the free acid manifesting its properties.[19] Lactic-acid fermentation is checked by the action of heat.

Heat does not destroy the ptomaïns or toxins which have been formed by the growth of micro-organisms in milk; it only checks for a variable length of time the growth of bacteria with their deleterious products; hence the pasteurization or sterilization of an already contaminated and infected milk can never make up for a lack of a clean, uncontaminated milk supply.

According to H. Bitter[11] all pathogenic germs are killed with certainty at a temperature of 68° C. (154.4° F.) continued for one-half hour, and the milk is thereby not altered in taste or appearance. Ordinarily twenty minutes' exposure is sufficient. Most bacteria are killed at from 60° to 64° C. (140°–147° F.), but Theobald Smith[12] has demonstrated that the tubercle bacillus may survive an exposure for one hour at 65° C. (149° F.), so that these lower temperatures are not to be relied upon. The spores of the bacteria, however, and some of the casein ferments are not destroyed by a single pasteurization. Sterilization of milk under pressure for two hours at 120° C. (248° F.) is sufficient to destroy spores.[1] At such temperatures, however, the sugar is converted into caramel, many of the natural ferments are destroyed, the casein is partially precipitated, and in the opinion of many the nutritive value of the milk is seriously interfered with. A temperature 68.3° C. (155° F.) is the temperature which may most profitably be relied upon for the pasteurization of milk. It is sufficiently high to kill most of the organisms which are found in milk, and at the same time does not produce any chemical changes that may be detected in the milk.

It is not known with certainty, despite the many opinions expressed on the point, as to how far the heating of milk affects its digestive qualities. A heated milk is curdled less readily by rennin than is unheated fresh milk, but there is reason to believe that this is due to the deposition of the calcium salts rather than to any change in the casein.[19] On the other hand it has been claimed that sterilized milk is easier of digestion in the stomach and does not produce so firm a clot.

Effect of Cold on Milk.—Cold is a most important factor in preventing the growth of bacteria in milk. If the temperature is sufficiently low, about 15.5° C. (31° F.), the milk will freeze. The frozen portion does not show the same composition as the milk itself, but contains a larger proportion of water.

The preservation and adulteration of milk will be considered under another heading, bearing on the relation of milk to the public health.

Separated Milk.—Separated milk is the term applied to a milk from which the fat has been wholly or partially removed, either by the centrifuge or by gravity.[5] Obviously, therefore, it has no constant composition. Milk from which the fat has been removed by the ordinary process of skimming contains from 0.4 to over two per cent. of fat.[19] The proportions of the other ingredients depend upon the proportion of fat removed. They are increased by the removal of the fat. If the centrifugal separator is worked to its maximum capacity practically all the fat is separated out as cream, leaving a slimy residue, and the milk plasma, and to the latter the term "fat-free milk" is now given.[5] Many analyses of this fat-free milk at the Walker-Gordon Laboratories have shown the fat to be approximately only 0.05 per cent. About the same percentage of fat (0.05) is to be found in the lowest eight ounces of a jar of milk which has been setting eight or twelve hours, so that a milk practically fat-free can be obtained both by gravity and by centrifugal methods.

The slimy residue mentioned above consists of 0.04 part in one hundred parts of milk separated, and in very contaminated milk the proportion may be as high as 0.15 per cent. In consists of inorganic impurities such as dirt, vegetable matter from the fodder, substances from the cow, such as hair, pavement cells from the udder, empty gland cells, micro-organisms, and sometimes pus and blood. While centrifugal cream is much cleaner than the milk from which it is derived, the process of separation does not materially diminish the number of micro-organisms.[19]

Creams.—Cream is the term applied to the separated part of the milk which is especially rich in fat. It is of the same qualitative composition as milk, but with different proportions of the ingredients. The richer the cream is in fat, the lower is its percentage of proteids and sugar. The following table, based on analyses by Adriance and others, represents with a fair degree of accuracy what we may assume to be the composition of creams of different density:[20]

	I. Per cent.	II. Per cent.	III. Per cent.	IV. Per cent.	V. Per cent.	VI. Per cent.
Fat	4.00	8.00	10.00	12.00	16.00	20.00
Sugar	4.50	4.35	4.30	4.20	4.05	3.90
Proteids	3.50	3.40	3.35	3.30	3.20	3.05
Salts	.75	.70	.67	.65	.60	.55

The above represents a somewhat lower average of proteids than was formerly accepted, but Rotch, Holt, Adriance, and others consider these figures more accurate than the four per cent. of proteids formerly accepted as the standard of average whole milk.

One hundred and ten analyses at the Walker-Gordon Farm have shown that if the mixed milk, containing four per cent. fat, be bottled and immediately cooled, the upper eight ounces will, after four hours, contain nearly all the fat that will rise as cream, and that the upper layers of fat will have nearly the same percentage of fat whether the fat has stood for four hours, for eight hours, or over night.[20]

Assuming that the milk contains four per cent. of fat, we may secure different percentages of cream with approximate accuracy under the following conditions:

Fat in the upper	16 ounces	after setting	6	hours	=	7 per cent.
" " "	8	" " "	6	"	=	10 "
" " "	10	" " "	8–12	"	=	10 "
" " "	8	" " "	8	"	=	12 "
" " "	6	" " "	8	"	=	16 "
" " "	4	" " "	4–6	"	=	20 "

If the milk is known to be rich in fat (five per cent. or over), from two to three ounces more should be removed for each formula, and if poor in fat (three per cent.) about two ounces less than the specified amount. The accuracy of the above statements is by no means absolute, as the results depend upon many varying conditions, but the figures represent a fair average of the investigations of Rotch, Holt, Chapin, the Walker-Gordon Laboratory, and others. Creams of thirty-two and forty per cent. of fat, and even higher may be obtained by means of centrifugal separators.

BACTERIOLOGY OF COW'S MILK.—Under this heading we may consider briefly the chemical action of micro-organisms and ferments upon the composition of milk. Their influence in the transmission of disease and their relation to the public health will be separately treated.

Richmond[19] makes the following practical dairy classification of the micro-organisms which may be found in milk:

I. Micro-organisms acting on milk sugar causing fermentation.
  (a) with the production of lactic acid.
  (b) with the production of butyric acid.
  (c) with the production of alcohol.

II. Micro-organisms acting on proteids.
  (a) Curdling milk without acidity and not dissolving the curd.
  (b) Curdling milk without acidity and afterward dissolving the curd.
  (c) Peptonizing the proteids without curdling the milk.

III. Micro-organisms producing coloring matter.

IV. Micro-organisms having no direct action on the milk.

V. Micro-organisms which are pathogenic, giving rise to specific pathological conditions.

The line between these groups cannot always be sharply drawn; one variety may belong to two or more groups. Conn,[26] in a series of investigations covering a period of ten years, has isolated over two hundred different types of bacteria. The large number of micro-organisms is explained by the great exposure to infection which milk undergoes from the time it leaves the milk ducts of the udders to its final disposition as an article of food, and also by the fact that milk is one of the best culture media for the growth of bacteria we have, containing, as it

does, in an assimilable form, all the varieties of food necessary for the sustenance of life.

It is quite possible to obtain cow's milk which is practically sterile by throwing away the first portions of milk withdrawn from the teats, as bacteria penetrate more or less deeply from the outside into the ducts of the teat. Practically, nearly all of the bacteria come from without, although there is evidence that in the case of tuberculosis and sepsis elsewhere in the body the tubercle bacilli and septic bacteria may find entrance into the milk through the mammary gland. (Consult also p. 840.)

Lactic-Acid Fermentation.—Fermentation of the lactose with the production of lactic acid and subsequent coagulation of the caseinogen by the lactic acid, is one of the most common changes which milk undergoes. This process is the ordinary souring of milk. It is due to Hueppe's "bacillus of lactic acid," which seems always to be present. Over one hundred other kinds of bacteria seem to have this same property.[2] The "bacillus lactis aerogenes" described by Escherich is closely allied to Hueppe's bacillus and also to the bacillus coli communis, which has the same power of inducing lactic-acid fermentation. The organisms belonging to this group are considered by Marfan to be varieties of the bacillus coli communis and like the latter may at times become pathogenic. They are easily killed at low temperatures, and their growth is checked when lactic acid has been formed to the extent of one per cent. According to Biedert, Escherich, and Richet, the formation of lactic acid by the bacillus lactis aerogenes prevents the other forms of fermentation in the stomach and intestines.

Butyric-Acid Fermentation.—When butyric-acid fermentation occurs, the milk coagulates, but the casein may be redissolved. The butyric acid which is formed can usually be detected by its unpleasant, characteristic odor. It is caused by many micro-organisms, but does not occur readily in the presence of lactic acid.

Alcoholic Fermentation.—Alcoholic fermentation does not readily occur in milk, except in very small quantities as by-products of the growth of certain micro-organisms.

Succinic-Acid Fermentation may take place as a result of the decomposition of milk by certain forms of bacteria.

The so-called casein ferments or peptonizing bacteria are saprophytes, belonging to the groups of which the bacillus subtilis and the bacillus mesentericus vulgatus are the prototypes.[27] They act on the casein at the end of lactic-acid fermentation through certain enzymes which they are supposed to secrete, and which resemble rennin. They coagulate caseinogen without the production of acids. Some of them have the property of liquefying the casein coagulum. Duclaux calls this ferment "casease" and the resulting peptones "caseone." Still other varieties peptonize the proteids without the preliminary process of coagulation. Leucin, tyrosin, urea, and the other products of advanced intestinal digestion are formed.

The peptonizing bacteria are very resistant to the action of heat and may survive a temperature of 100° C. for three-quarters of an hour.[28] They are directly antagonized by lactic acid; hence the lactose of milk has a tendency to check the growth of putrefactive bacteria in that it favors the development of lactic-acid-producing bacteria.

The micro-organisms which ferment milk without curdling it act also by the secretion of a proteolytic enzyme. In these cases, the milk becomes more and more translucent until it assumes an appearance like liquid jelly.[19]

Another group of bacteria gives rise to the so-called "milk anomalies." Briefly enumerated they are as follows:

Red Milk. This is caused by saprophytic (non-pathogenic) bacteria, such as the sarcina species, the bacillus prodigiosus, the bacillus lactis erythrogenus, the bacillus rubidus, the spirillum rubrum, the micrococcus cinnabareus, and a red yeast.

Yellow Milk. This is caused by the bacillus synxanthus.

Blue Milk. This is caused by the bacillus cyanogenus, the bacillus cyaneofluorescens Zangemeister, and the bacillus janthinus.

Slimy Milk. This is caused by the micrococcus viscosus (Weigman and Zion, G. Leichman).

Bitter Milk. This is caused by the proteus vulgaris Hauser, by the bacillus von Bleisch, by the bacillus and micrococcus liquefaciens lactis amari Freudenreich, and by bacteria described by Hueppe, Flügge, and von Stirling. This reaction is due to the formation of peptones, as may be demonstrated by the biuret reaction.

Poison Milk. This name is given to milk which acts like alkaloids upon animals. It is due to the presence of ptomaïns or toxins produced by bacteria from the albuminoids of the milk. Under certain conditions benzin derivatives are formed, the most important of which is a diazo-benzin, called *tyrotoxicon*, which was isolated by Vaughan, of Ann Arbor, Mich. It is the exciting cause of the toxic symptoms observed in cases of milk poisoning, cheese poisoning, and ice-cream poisoning. *Spasmotoxin* is a similar toxic product found by Brieger in putrefied milk.[19]

Finally we may mention the bacillus of typhoid, the tubercle bacillus, the bacillus of diphtheria, the spirillum of Asiatic cholera, the organism of cholera infantum, the infectious agent of scarlet fever and smallpox, and other varieties of organisms, all of which may find in milk a favorable ground for growth and transmission and prove the source of epidemics in communities. This aspect of the subject will receive due attention in the consideration of milk in its relation to the public health.

COLOSTRUM.—Colostrum is the term applied to the milk which is secreted in the early days of lactation before the equilibrium of the mammary gland has become established. It is characterized by the presence in the milk of the so-called "colostrum corpuscles." These cells measure from 12 to 22 mm. in diameter. They have a small, irregular, extensively degenerated nucleus. The protoplasm contains large and small granules which show the proteid reactions and are not stained by acids, basic or neutral dyes. A few of the granules stain by osmic acid and probably represent fat. Leucocytes are also apt to be present. Czerny considers the colostrum corpuscles lymphoid cells whose function is to absorb and reconstruct unused milk globules and to convey them from the milk glands into the lymph channels. In general, colostrum of cow's milk contains low fats and proteids and high sugar. As lactation becomes established the fats, proteids, and mineral matter increase and the sugar diminishes, the reverse of what occurs in human milk.[19]

Harrington's analysis of the colostrum milk of a cow gives the following composition[5]:

Fat	1.71	per cent.
Milk sugar	4.90	"
Proteids	1.72	"
Mineral matter	.78	"
Total solids	9.11	"
Water	90.88	"
	100.00	"

The human colostrum period covers an interval of about two weeks. It is characterized by fat percentages which may be very low or very high, by low sugar percentages which rapidly increase, and by high proteid percentages which rapidly diminish. These variations are not constant, however. Different analyses show different results. Woodward has analyzed the colostrum of six nursing women, using in each instance the combined twenty-four hours' amount of the middle milk, and following each case for from three to seven days. He found that colostrum corpuscles were not always present in so-called colostrum milk, and that when they were present the percentage of proteids was higher, and as they disappeared the percentage of proteids diminished. The results of his analyses are seen in the following table: