In partial peptonization the process is carried on for from five to twenty minutes, according to the degree of peptonization required. The temperature is then allowed to rise to a degree sufficient to kill the enzyme,—140°–150° F. is quite enough. The action of the enzyme may be checked but not destroyed by placing the bottle at once upon the ice. If complete conversion of the proteids to peptones is desired, the process must be continued for two hours. The taste of the milk is altered by the process, becoming bitter and unpalatable; but this change does not occur in the shorter intervals of five or ten minutes. The object of the process is to reduce the proteids to a non-coagulable form capable of easy or direct absorption, either when administered by mouth or by rectum as nutrient enemata. Peptonizing powder is now dispensed in convenient tubes or tablets ready for use.

Vieth gives the following analyses of undiluted peptonized milk:

	Per cent.		Per cent.
Water	89.20	Albumin	0.07
Fat	3.41	Albumose	1.88
Sugar	3.80	Mineral matter	.68
Casein	.96		

Koumyss.—Koumyss was originally made by the Tartars by the addition, to mare's milk, of a ferment derived from kephir grains. Both alcoholic and lactic-acid fermentation took place. The mare's milk was placed in leathern vessels, with portions of the previous brewing and the yeast from the kephir grains, and kept at a temperature of from 30° to 40° C.; it was shaken occasionally until the process was completed. It was formerly made of skimmed milk. The process of to-day has been considerably changed. Many manufacturers use whole milk or milk to which cream, cane sugar, and some water are added. Ordinary yeast is used for the ferment and cow's milk is employed in preference to mare's milk. Holt gives the following formula for the domestic manufacture of koumyss:

One quart of fresh milk, half an ounce of sugar, two ounces of water, and a fresh piece of yeast cake half an inch square, are put in wired bottles and kept at a temperature between 60° and 70° F. for one week; the bottles are shaken five or six times a day. They are then put upon the ice and kept ready for use.

The following analyses by König show the composition of koumyss under the different conditions under which it may be made:

	Mare's milk.	Cow's milk.	Skimmed milk.
Fats	1.46	1.33	0.88
Proteids	2.24	2.66	2.89
Sugar	1.47	4.09	3.95
Alcohol	1.91	1.14	1.38
Lactic acid	.91	.55	.82
Salts	.42	.43	.53
Water	91.29	89.30	89.55

The term "kephir" or "kefir" was formerly used for the product obtained by the action of kefir grains on cow's milk.

Matzoon.—Matzoon or mazoum is a thick, partly coagulated fluid, resembling cream which has soured. It is made by the action of a ferment imported from Armenia upon cow's milk. On warming, it settles into a liquid whey and an insoluble curd. The milk is first boiled and then allowed to ferment with the matzoon ferment in an open vessel kept at 105° F. The process is carried for twelve hours, the temperature being gradually lowered to 70° F., after which it is put upon the ice. It will keep under proper conditions for two or three weeks. It is used in cases of the same kind as those for which koumyss is prescribed.

The composition of matzoon as given by Dadirrian is as follows:

	Per cent.		Per cent.
Proteids	3.48	Alcohol and other products of fermentation	0.13
Fat	3.49	Mineral matter	.69
Milk sugar	3.68	Water	87.63
Lactic acid	.90		

Percentage Modification of Cow's Milk.—The idea of modification of milk according to definite percentages of fats, sugar, and proteids in order to adapt it to the varying requirements of infant feeding has very appropriately been called the American system of infant feeding. It was in this country that it really had its inception, and its development and practical application have been under the fostering care of a few eminent and far-sighted American physicians, chief of whom is Dr. Thomas Morgan Rotch, of Boston, whose name has been associated with the idea more closely than that of any other American physician.

The essential principle underlying this system is the now generally accepted fact that it is not intolerance for milk as a whole which causes so much disturbance in infants, but an incapacity of the individual child to digest certain ingredients of milk. In other words, there is a variable ability of the infant to digest fats, sugars, and proteids, giving rise to what may be spoken of as fat indigestion, sugar indigestion, and proteid indigestion. In one child it may be the fat which causes the trouble; in another, the sugar; in still another, the proteid material; while in a fourth, all three elements may be at fault. Obviously, therefore, the ideal system must provide for percentages of fat, sugar, and proteids in any desired combination. The Meigs milk formula devised by Arthur V. Meigs in 1882 recognized in a limited way the importance of definite percentage combinations. He started on the basis of the results of forty-three analyses of human milk and found the composition to be approximately, fat four per cent., sugar seven per cent., and proteids one per cent. Then he worked out the formula by which, by the use of creams, milk, milk sugar, lime water, and water, he was able to duplicate the composition of human milk. This formula corresponded closely to one which the elder Meigs had used and recommended in a long and successful practice among infants.

The formula of Meigs assumed that mother's milk was of constant quality and that, therefore, a mixture made to correspond to it in its percentage composition would satisfy the demands of infant feeding. We know now, however, that human milk is of very variable quality, and in practice we also find that infants require very different percentage combinations, according to their age, development, state of health, and many other conditions.

The scope of our subject limits us to the theory of percentage modification of milk and the practical methods of obtaining the different combinations of fat, sugar, and proteids. The practical application of these modifications to the subject of infant feeding is treated in its appropriate place.

The earlier methods of the simple dilution of whole milk with varying parts of water has, as its principle, the reduction of the proteids to a proportion similar to that which occurs in human milk. The dilution, however, affects the fats and sugars as well; and the general effect in comparison with human milk is seen in the following table:

	Fats.	Sugar.	Proteids.
Cow's milk	4.0	4.50	3.50
Cow's milk diluted 1 to 2	1.33	1.50	1.16
Human milk	4.00	7.00	1.50

Obviously, simple dilutions of whole milk with water or any other diluent, cannot suffice to produce a milk resembling mother's milk.

The next step in advance was the dilution of creams with water and the addition of milk sugar to make up the deficiency of that constituent. The results obtained by this method may be illustrated as follows:

	Fats.	Sugar.	Proteids.
Cream	12	4.30	3.30
Cream diluted 1 to 2	4	1.43	1.10

In this way fats and proteids are easily obtained, and the amount of sugar can be raised to any desired percentage by the addition of dry milk sugar, or of sugar solutions of varying strength in place of the water.

The question here presents itself, What are the limitations to the combinations which are possible under the employment of this method of diluting creams? As the composition of cream varies according to the percentages of fat, we must agree on a fixed standard for the composition of the materials used. It is fully appreciated that the figures given below do not accurately represent the analyses of all varieties of cow's milk, and that therefore in any given case there is always a possible error; but unless milk is analyzed daily, which is impracticable, we have no alternative but to adopt an average standard and let that be the basis on which we make our calculations. The average analysis, therefore, which we shall use, unless otherwise stated, is that which has been given above, but which for convenience may be tabulated as follows:

	Fats.	Sugar.	Proteids.
Fat-free milk	Trace.	4.60	3.60
Whey	Trace.	4.79	1.00
Whole milk	4	4.50	3.50
Eight per cent. cream	8	4.40	3.40
Ten per cent. cream	10	4.30	3.35
Twelve per cent. cream	12	4.20	3.30
Sixteen per cent. cream	16	4.05	3.20
Twenty per cent. cream	20	3.90	3.10

The traces of fat in the fat-free milk obtained by using the lowest eight ounces of a quart jar of milk after setting eight hours, or by means of a centrifugal machine properly regulated, and the traces of fat in whey made from fat-free or skim milk, as shown by numerous analyses at the Walker-Gordon Laboratory, rarely exceed 0.05 per cent., and can therefore be excluded in our calculations.

The following table, therefore, shows the lowest possible proteids which may be obtained with fat percentages in our mixtures of from 1 to 4, in which creams of from 8 to 20 per cent. fat are used:

Eight-per cent. cream gives with

Fat one per cent. lowest possible proteids of	0.47
" two " " " " "	.85
" three " " " " "	1.27
" four " " " " "	1.70

Ten-per-cent. cream gives with

Fat one per cent. lowest possible proteids of	0.38
" two " " " " "	.67
" three " " " " "	1.00
" four " " " " "	1.34

Twelve-per-cent. cream gives with

Fat one per cent. lowest possible proteids of	0.27
" two " " " " "	.54
" three " " " " "	.82
" four " " " " "	1.08

Sixteen-per-cent. cream gives with

Fat one per cent. lowest possible proteids of	0.20
" two " " " " "	.40
" three " " " " "	.60
" four " " " " "	.80

Twenty-per-cent. cream gives with

Fat one per cent. lowest possible proteids of	0.15
" two " " " " "	.31
" three " " " " "	.46
" four " " " " "	.62

It is obvious from the above table that in simple dilutions of cream we are limited in our proteid percentages. To get low proteids with high fat percentages in our mixtures, we must use concentrated creams. To get high proteids with creams of any strength, with the exception of eight-per-cent. cream, we must add whole milk or fat-free milk to supplement the deficiency of proteids obtained from the diluted creams.

Much credit is due to Thompson S. Westcott, of Philadelphia, for his elaborate monograph on the scientific modification of milk which was published in *International Clinics*, October, 1900. Taking the previous formulæ of Taylor and those of Baner, he has worked out mathematical formulæ which are of universal application, and has established the principles of modification on a truly scientific basis.

These formulæ may be briefly expressed as follows. For detail the reader is referred to the original monograph.

F = prescribed percentage of fat.
S = prescribed percentage of sugar.
P = prescribed percentage of proteids.
C = total quantity of cream in ounces.
M = total quantity of milk in ounces.
W = total quantity of water in ounces.
L = total quantity of dry milk-sugar in ounces.
Q = total quantity of mixture.
a = known percentage of fat in cream.
a′ = known percentage of fat in milk.
b = known percentage of proteids in cream.
b′ = known percentage of proteids in milk.
c = known percentage of sugar in cream.
c′ = known percentage of sugar in milk.

Since the actual quantity of proteids in a percentage mixture is the sum of the quantities of proteids contributed by the milk and cream; and again, since the actual quantity of fat is the sum of the quantities of fat contributed by the milk and the cream, the following fundamental formulæ may be stated: (1) $Q \times P = b'M + bC$; (2) $Q \times F = a'M + aC$.

By transposing, we may get value for M in equation (1), giving $M = \frac{Q\,P - bC}{b'}$.

If this value of M is substituted in equation (2), we have, by transposition and collecting, an equation which will give us the quantity of cream to be used in any combination; *i.e.*, (3) $C = \frac{(Q\,b'\,F - a'\,P)}{ab' - a'b}$.

In the same way by finding a value for M in equation (2) instead of (1) we have (4) $M = \frac{QF - aC}{a'}$.

The amount of sugar in a given mixture is that contributed by the cream, by the milk, and the dry sugar added. This may be expressed in the following formula: $\frac{Q \times S}{100} = \frac{c'\,M}{100} + \frac{cC}{100} + L$.

By transposition, we obtain the value of L, viz., (5) $L = \frac{QS - c'\,M + cC}{100}$.

The amount of water to be added is calculated by the following formula: (6) $W = Q - (C + M)$.

Formulæ (3), (4), (5), and (6) therefore represent the formulæ necessary for obtaining the quantities of cream, milk, sugar, and water called for in any combination. They are of universal application, the values for the different letters varying according to the strength of the creams and milk used.

Example. Let us suppose that we wish to calculate for twenty ounces of 4 per cent. fat, 7 per cent sugar, and 1.50 per cent. proteids, using 16 per cent. cream and whole milk.

Sixteen per cent. cream = { Fat = a, 16 — Proteids = b, 3.20 — Sugar = c, 4.05
Whole milk = { Fat = a′, 4 — Proteids = b′, 3.50 — Sugar = c′, 4.50

By substituting these values in formulæ (3), (4), (5), and (6), we obtain the following result:

(3) Cream (C) $= \frac{20\,(3.50 \times 4 - 4 \times 1.50)}{16 \times 3.50 - 4 \times 3.20} = \frac{160}{44} = 3.63$ ounces.

(4) Milk (M) $= \frac{(20 \times 4) - (16 \times 3.63)}{4} = \frac{21.92}{4} = 5.48$ ounces.

(5) Sugar (L) $= \frac{20 \times 7 - (4.50 \times 5.48 + 4.05 \times 3.63)}{100}$

$= \frac{100.64}{100} = 1$ ounce.

(6) Water (W) $= 20 - (3.63 + 5.48) = 10.89$ ounces.

If we so contrive as to obtain all our fat from the

cream and use fat-free milk in place of whole milk to obtain a greater percentage of proteids than that contributed by the cream, we simplify our formulæ and the work of computation, for we can substitute 0 for the fat value (a') of the milk in formulæ (3), (4), and (5), and we get the following:

Formula (3) becomes: Cream $(C) = \frac{QF}{a}$.

Formula (4) becomes: Fat-free milk $(M) = \frac{QP - bC}{b'}$.

Formula (5) becomes: Sugar $(L) = \frac{QS - 4.50\,(M + C)}{100}$.

The formula for the amount of water to be added remains the same, *i.e.*: Water $(W) = Q - (C + M)$.

Westcott has also prepared formulæ by which one may calculate combinations of fats and sugars with different proportions of caseinogen and lactalbumin.[8]

For purposes of convenience in the management of large clinics and also for teaching, the writer has prepared the following table, by which practically all the percentage combinations which a physician is likely to use in practice can be more easily and quickly calculated than by means of formulæ, which to some minds are complicated and difficult to understand. It is so arranged that the physician may exercise a choice in the percentage of creams to be used, and can see at a glance what combinations are impossible with creams of different strength. The calculations are made for twenty-ounce mixtures; for each additional five ounces it is only necessary to multiply each ingredient by one-quarter, and add it to the amount of twenty ounces. The percentage of lime water may be increased at will by remembering that each additional ounce in a twenty-ounce mixture increases the alkalinity five per cent., and the amount of lime water added beyond what is given in the table, must be subtracted from the amount of water used as a diluent. For accuracy the milk sugar should be dissolved in a portion of water and then water added up to the amount called for. The amount of sugar required is expressed in measures. The measure is a small tin dipper obtained at any milk laboratory. It holds just three and three-eighths drachms.

Whey Cream Mixtures.—Whey cream mixtures may be obtained by using whey as a diluent, in place of the boiled water, preferably in the combinations containing low proteid percentages. Each two ounces of whey replacing an equal quantity of water in a twenty-ounce mixture will raise the whey proteid percentage 0.10, and will increase the sugar percentage 0.50. The total sugar percentage is, therefore, the amount contributed by the cream and fat-free milk, which is indicated in the last column of the table above—plus that of the whey. The amount of dry sugar which must be added to make the desired final sugar percentage can be easily calculated by reference to the following table:

	Per cent. of sugar.
One measure of dry lactose in a 20-ounce mixture gives	2.00
One-half measure of dry lactose in a 20-ounce mixture gives	1.00
One-quarter measure of dry lactose in a 20-ounce mixture gives (One measure is approximately one level tablespoonful.)	.50

Example.—If in formula 21 fourteen ounces of whey are added in place of the same quantity of water, the whey proteids are increased 0.70 per cent., making total proteids of 1.30 per cent. The sugar contributed by the cream is 0.78; that by the whey 3.50—making a total of 4.28. The desired percentage of sugar is 6, therefore the balance of 1.72 per cent. may be obtained by adding a little short of one measure of sugar.

Whey should be made of fat-free milk, and should be heated to 150° F. (65° C.) before it is added to the cream mixture, to destroy the rennin enzyme. One quart of fat-free milk will yield about twenty-four ounces of whey.

The conditions under which the different percentages of creams may be obtained are given above on page 831.

Milk Laboratories.—The first laboratory in the world for the exact modification of milk was established in Boston in 1891, under the name of the Walker-Gordon Laboratory. Its scientific development has been under the fostering care of Dr. Thomas Morgan Rotch, professor of diseases in children in Harvard University. The extension of the system and many details in connection with the practical management of the laboratories have been accomplished by the joint efforts of Mr. George E. Gordon, Mr. G. H. Walker, and Mr. J. H. Waterhouse.

Eighteen laboratories have now been established in different parts of this country, in Canada, and in London.

The purpose of the milk laboratory may briefly be stated to be first, to insure a clean, constant, and reliable milk supply, and second, to provide a place where different combinations of milk may be put up according to the prescriptions of physicians, with accuracy and under such conditions of cleanliness and asepsis as to insure the best possible food for infant feeding. Whole milk and creams of guaranteed composition are also provided, with which modification at home may be carried on with the minimum chance of errors in calculations, which in ordinary home modification of milk come from the uncertain quality of the milk purchased, in the great majority of cases, from unknown or unreliable sources.

The milk laboratory is to the physician engaged in the feeding of infants what the apothecary is to the therapeutist. Details as to the nature of the milk laboratories and their use will be found in the article on *Infants, Artificial Feeding of*, and especially in Rotch's "Pediatrics," 1901.

Maynard Ladd.

TABLE FOR THE PERCENTAGE MODIFICATION OF COW'S MILK. (LADD.)

Number.	By 20-oz. Mixtures Percentage of—				Ounces of Cream.				Ounces Fat-free Milk Used with Creams of—				Ounces.		Milk sugar measure.	Sugar per cent. without dry sugar.
	Fat.	Sugar.	Proteid.	Alk.	Ten per cent.	Twelve per cent.	Sixteen per cent.	Twenty per cent.	Ten per cent.	Twelve per cent.	Sixteen per cent.	Twenty per cent.	Lime water.	Boiled water.		
1	1.50	4.50	0.25	5	*	*	*	1¼	*	*	*	0	1	17½	2	0.33
2	1.50	4.50	.50	5	3	2½	2	1½	0	½	1	1½	1	16	3	.61
3	2.00	5.00	.25	5	*	*	*	2	*	*	*	0	1	17	2¼	.75
4	2.00	5.00	.50	5	*	3¼	2½	2	*	*	½	1	1	15¾	2¼	.73
5	2.00	5.00	.75	5	4	3¼	2½	2	¾	1¼	2¼	2¾	1	14½	3	1.01
6	2.00	5.50	1.00	5	4	3¼	2½	2	1¾	2½	3¼	3¾	1	13¾	2¼	1.30
7	2.50	5.00	.50	5	*	*	3¼	2½	*	*	0	¾	1	15¾	2¼	.78
8	2.50	5.50	.75	5	*	4¼	3¼	2½	*	¼	1¼	2	1	14½	2¼	1.01
9	2.50	6.00	1.00	5	5	4¼	3¼	2½	1	1¾	2¾	3¼	1	13½	2½	1.23
10	3.00	6.00	.50	5	*	*	3¾	3	*	*	0	¾	1	15¾	2½	.84
11	3.00	6.00	.75	5	*	5	3¾	3	*	0	1¼	2	1	14	2½	1.12
12	3.00	6.00	1.00	5	6	5	3¾	3	0	1	2¼	3	1	13	2¼	1.35
13	3.00	6.00	1.25	5	6	5	3¾	3	1¼	2¼	3½	4¼	1	11¾	2¼	1.35
14	3.00	6.50	1.50	5	6	5	3¾	3	2½	3½	4¾	5½	1	10½	2¼	1.91
15	3.00	6.50	2.00	5	6	5	3¾	3	5½	6½	7¾	8½	1	7½	3	2.68
16	3.50	6.00	.50	5	*	*	*	3½	*	*	*	0	1	15½	2½	.78
17	3.50	6.00	.75	5	*	*	4¼	3½	*	*	0	1	1	14½	2½	1.01
18	3.50	6.50	1.00	5	*	5¾	4¼	3½	*	0	1¼	2¼	1	13¾	2½	1.26
19	3.50	6.50	1.25	5	7	5¾	4¼	3½	½	1¾	3	4	1	11½	2½	1.68
20	3.50	6.50	1.50	5	7	5¾	4½	3½	2	3¼	4½	5½	1	10	2¼	2.02
21	4.00	6.00	.00	5	*	*	*	4	*	*	*	*	1	15	2½	.78
22	4.00	6.00	.75	5	*	*	5	4	*	*	0	1	1	14	2½	1.12
23	4.00	7.00	1.00	5	*	*	5	4	*	*	1	2	1	13	2¾	1.35
24	4.00	7.00	1.25	5	*	6¾	5	4	*	¾	2½	3½	1	11½	2¾	1.68
25	4.00	7.00	1.50	5	8	6¾	5	4	1	2¼	4	5	1	10	2½	2.02
26	4.00	7.00	2.00	5	8	6¾	5	4	3½	4¾	6½	7½	1	7½	2¾	2.56
27	4.00	7.00	2.50	5	8	6¾	5	4	6¼	7½	9¼	10¼	1	4¾	2	3.20
28	4.00	7.00	3.00	5	8	6¾	5	4	9¼	10½	12¼	13¼	1	1¾	1½	3.88
29	4.00	6.00	3.00	5	8	6¾	5	4	9¼	10½	12¼	13¼	1	1¾	1	3.88
30	4.00	5.50	3.00	5	8	6¾	5	4	9¼	10½	12¼	13¼	1	1¾	¾	3.88

For 25-ounce mixtures multiply the amount of each ingredient by 1¼; for 30-ounce mixtures, by 1½; for 35-ounce mixtures, by 1¾; for 40-ounce mixtures, by 2; for 45-ounce mixtures, by 2¼.

* Combination impossible with strength of cream indicated.

REFERENCES.

[1] Harrington: Practical Hygiene, 1901.
[2] Sommerfeld, Dr. Paul: Methods for the Examination of Milk. Translated, 1901.
[3] Camerer and Söldner: Zeitschr. f. Biologie, Bd. xxxiii. and xxxvi.
[4] Munk: Virchow's Archiv, Bd. 134.
[5] Rotch: Pediatrics, 1901.
[6] White and Ladd: Phila. Med. Journal, of February 2d, 1901.
[7] Westcott: International Clinics, October, 1900.
[8] Westcott: Am. Jour. of Med. Sc., vol. cxii., 1901.
[9] Leffmann and Beam: Analysis of Milk and Milk Products, 1893.
[10] Bartley: Med. Chem., 1899.
[11] Bitter: Zeitschrift für Hygiene, viii., p. 240.
[12] Smith: Journal Exp. Med., 1899, p. 217.
[13] Bunge: Lehrbuch d. physiol. and pathol. Chem., 3 Aufl., S. 93.
[14] Zeitsch. f. physiol. Chem., Bd. xxiv.
[15] Maly's Jahresber., Bd. xxvi., S. 298.
[16] Hammarsten: Text-book of Physiol. Chem., 1900.
[17] American Experiment Station V., No. 10.
[18] Storch: Maly's Jahresber., Bd. xxvii.
[19] Richmond, H. Droop: Dairy Chemistry, 1899.
[20] Judson and Gittings: Infant Feeding, 1902.
[21] Sommerfeld, Paul: Archiv für Kinderh., Bd. xx., 1896.
[22] Woodward: Journal of Experimental Medicine, March, 1897.
[23] Szontagh: Maly's Jahresber., Bd. xxii., S. 168.
[24] Leeds: Proceedings College of Physicians, Philadelphia, 1884.
[25] Farrington and Woll: Testing Milk and its Products, 1901.
[26] Conn, H. W.: Twelfth Annual Report of Storr's Agricultural Experiment Station, Connecticut, 1899.
[27] Marfan: Traité de l'Allaitement, Paris, 1899.
[28] Filligre: Zeitschrift für Hygiene und Infectionskrankheiten, Bd. xvii., 1894.
[29] Holt: Infancy and Childhood, 1899.
[30] Van Slyke: Journal of the Am. Chem. Soc., 1893, p. 605.

MILK IN RELATION TO PUBLIC HEALTH: MILK-BORNE DISEASES.—In view of the dietetic importance of milk for all classes, but especially for infants, invalids, and the sick and convalescents, it is perfectly natural that much study should have been given to this foodstuff, and that of late years the sanitarian and bacteriologist should have found it a profitable field for research. Indeed, the production of pure milk might well be considered one of the most important problems which confront the sanitarian. Few countries until recently have deemed it necessary to do more than prevent adulteration of the milk, and some of the legislators appear to think that as long as the milk has not been skimmed or watered, and contains the standard of total solids and fats, we need not worry about the germs we eat or drink. This may be a pleasing reflection to persons who do not know that such hydra-headed diseases as scarlet fever, diphtheria, and cholera infantum have been disseminated in the milk supply, that typhoid-fever epidemics have been thus caused, and that milk may be the vehicle of the germs of tuberculosis and other infectious diseases and morbific agents. Space will not permit to do more than briefly point out some of the circumstances under which milk may be the cause of disease.

1. MILK WHICH IS OBJECTIONABLE BY REASON OF COLOR, ODOR, TASTE, AND CONSISTENCY.—(*a*) *Abnormally Colored Milk.*—Fuchs was the first to point out that *blue milk* may be due to the presence of chromogenic microorganisms, and Neelson and Hueppe proved that this was caused by the bacillus cyanogenes, which may even invade the udder of the cow. Mosler and Uffelmann refer to cases of gastro-intestinal catarrh produced by the consumption of such milk. A uniform blue color is imparted by adulteration with water and certain kinds of cow's feed, and by some drugs. *Yellow milk* may be due to the addition of coloring matter such an annatto or saffron or the development of the bacillus synxanthus (Schrötter), but may also be caused by the ingestion of rhubarb (Mosler). *Red milk* may be caused by rhubarb or by the presence of the bacillus prodigiosus or of the spirillum rubrum, or by the admixture of blood, especially when the milk looks streaky, but it is most often due to giving the animals madder or bedstraw for food. *Brown milk* may be due to the presence of foreign matter or the products of certain fungi. A *bluish-red* color is caused by the bacterium lactis erythrogenes (Hueppe), while *green milk* is generally the result of an excess of fat and incomplete emulsification, sometimes due to the presence of the bacillus fluorescens, and occasionally, as in suppurative affections of the udder, to the presence of green pus.

(*b*) *Abnormal Odor, Taste, and Consistency.*—This may be caused by the character of the food, by exposure of the milk to air charged with foul vapors, or by the presence of foreign matter. The odor of onions is imparted when any of the alia are eaten, and after the ingestion of even a small quantity of skunk cabbage the milk yields the characteristic odor. The consumption of turnips, cabbage, or decaying leaves frequently affects the flavor of the milk. Milk is said to acquire a bitter taste after the ingestion of wormwood or when the animal suffers from disease of the liver, interfering with the proper elimination of the biliary acids and salts; but it is most frequently due to the presence of certain forms of bacteria, generally present in dark, damp, and badly ventilated milk houses; a salty milk often results from cattle grazing upon marshy salt grasses.

Occasionally we see a stringy or filamentous milk which is due to the presence of certain micrococci, very generally found in dirty milk pans or other utensils; sometimes the milk is slimy, and several species of bacteria have been described as the cause of this condition; chief of these organisms is the bacillus lactis viscosus, isolated by Adametz. In rare instances milk presents a soapy taste, which, according to Weigmann, is due to a specific bacillus. It is needless to add that all such milk is unfit for use.

(*c*) *Colostral Milk* and the milk yielded for from ten to fifteen days before calving differ in composition from normal milk; the former frequently contains blood corpuscles from the vaginal passages. Dr. Heisch reports the case of a family using such milk who were attacked with symptoms resembling severe influenza, with high fever and great soreness of the inside of the mouth, throat, and tongue, which were covered with small pustules. The servants, who took the skimmed milk only, remained unaffected. According to Höhne, milk yielded by animals a few days before calving has induced diarrhœa and colic in the consumers. For these reasons it has been deemed best to exclude from sale the milk yielded by animals fifteen days before and five days after parturition.

(*d*) *Milk Sediments.*—Every consumer of milk has doubtless observed the presence of more or less foreign matter at the bottom of the vessel or bottle in which it is kept; indeed, it is a matter of such common occurrence that it hardly excites our attention, and many are disposed to look upon it as a matter of course. Professor Soxhlet, of Munich, was perhaps the first to point out that these deposits are largely made up of excrementitious matter from the cow, which, adhering to the udder of the animal, gained access to the bucket during the act of milking. These sediments are obtained by the centrifuge or by permitting a bottle of milk to stand for two hours; then siphon off half of the top milk and add the same quantity of distilled water, and repeat this process

several times until the suspended matter remains in pure water, which may then be collected on filtering paper and weighed before and after drying. If these sediments are subjected to microscopical examination, we shall find, as shown in the accompanying microphotographs, prepared by Dr. Gray, of the Army Medical Museum, that they are composed of epithelial débris, hairs of the cow, excrementitious matter, vegetable fibres, organic and inorganic dust particles, bacteria, fungi, and spores of every description; fully ninety per cent. of the germs are fæcal bacilli—all of which is not only disgusting, but extremely suggestive of danger. The number of micro-organisms in such milk is largely increased, and while there is no evidence that milk of this description, when taken perfectly fresh, has proved injurious to the consumer, we know that bacterial development and consequent decomposition are materially hastened in such a medium, and

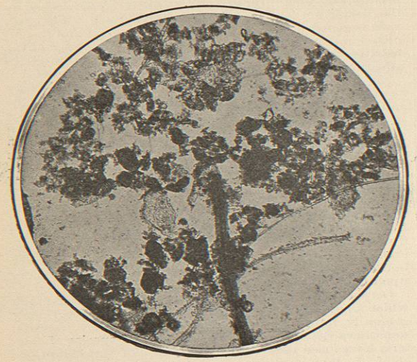

FIG. 3355.

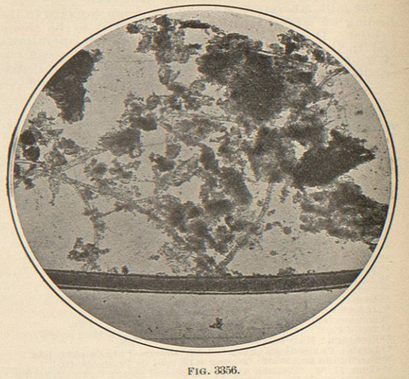

FIG. 3356.

FIGS. 3355 AND 3356.—Milk Sediments.

that the conversion of lactic sugar into lactic acid, apart from impairing the nutritive value, may cause gastro-intestinal disorders in delicate infants.

The greatest danger from milk of this class is the possible presence of tyrotoxicon and other toxins. Professor Vaughan believes that the former poison is developed by the growth of a saprophytic germ, which under favorable conditions multiplies with astonishing rapidity. The presence of the very filth referred to, a summer heat, and the pernicious habit of placing the milk before cooling in covered cans or bottles, perhaps dirty besides, constitute favorable environments for the development of this poison. Flügge (*Zeitschrift f. Hygiene*, July, 1894) found among the milk bacteria, especially those which are liable to resist the temperature of boiling, several varieties capable of evolving toxins. The views of Vaughan, Booker, Jeffries, Escherich, Baginsky, and others on the relation of saprophytic germs and toxins to cholera infantum and the summer diarrhœas in bottle-fed children are gaining ground and will doubtless lead to a great reform in the management of dairies.

Cases of poisoning by milk and ice cream were reported, long before we knew the nature of this poison, by Haschek, Hagner, Cameron, Barruel, Orfila, Marjolini, Bonorden, Hasset, Schroff, and others; the symptoms in these cases being nausea, vomiting, dryness and a sense of constriction of the throat, vertigo, colic, and purging, with a tendency in some cases to collapse, in others to numbness of the extremities and stupor.

In 1884 Vaughan isolated a poison found in poisonous cheese and called it *tyrotoxicon;* in November, 1885, he found the same substance in old milk; in June, 1886, he demonstrated its presence in poisonous ice cream, and in milk which had already undergone lactic-acid fermentation, and he called attention to the probable relation of tyrotoxicon to cholera infantum and other kindred diseases. In July, 1886, he found this poison in a sample of milk which had evidently caused the symptoms of cholera infantum in a babe seven months of age. In April, 1887, Dr. Stanton, the health officer of Cincinnati, demonstrated tyrotoxicon in poisonous cream puffs.

2. MILK MAY BE RENDERED UNFIT FOR USE BY IMPROPER FOOD AND CARE OF THE ANIMAL.—The disease described as milk sickness or trembles by some American writers, and characterized by great weakness, constipation, vomiting, fetor of breath, and muscular twitching, is believed to be due to cows feeding on Rhus toxicodendron. Cases of diarrhœa, and even severe forms of gastro-enteritis, have been traced by Sonnenberger, Ratti, and Mackay to the milk of cows and goats feeding upon meadow saffron and euphorbiaceous plants. The milk of animals fed on carrots, turnip tops, and the common artichoke, and often that which is yielded after they have been turned out to pasture for the first time in the spring, is changed in an unaccountable manner, and has frequently caused vomiting, abdominal pains, and diarrhœa in hand-fed children. Among the meadow plants, apart from species of Euphorbia and Ranunculus, Husemann regards the Gratiola officinalis, Æthusa cynapium, or fool's parsley, Cytisus ramentaceus, and different varieties of sorrel and mushrooms, as being especially objectionable.

The milk of swill-fed animals has often a peculiar taste and odor, and is said to cause hyperacidity of the urine and consequent eczema. M. Toussaint called attention to the fact that in the district of Argenteuil deaths from gastro-intestinal diseases have increased in frequency among bottle-fed children since the establishment of a large distillery, the cows being fed on brewers' grain and other distillery products, and the milk presenting an acid reaction. But this acidity is by no means constant, as Uffelmann and Ohlsen have often found it alkaline.

Ostertag states that the milk of animals fed with expressed sugar beets is destructive to calves on account of the excess of potassium, and hence objectionable for

human consumption. Bollinger reports injurious effects from castor-oil cakes, and Schmidt-Mühlheim attributes diarrhœal attacks to the admixture of wild mustard in the rape-seed-oil cakes fed to cows.

3. MILK MAY ACQUIRE INJURIOUS PROPERTIES WHILE THE ANIMALS ARE BEING TREATED WITH STRONG REMEDIAL AGENTS WHICH ARE EXCRETED IN THE MILK.—This is true of the following substances: arsenic, lead, iodine, copper, mercury, tartar emetic, carbolic acid, opium and morphine, colchicum, and euphorbium. Dr. James Law reports an extensive outbreak of ergotism among animals, affecting also calves, presumably through the milk; and Baum refers to salicylic acid, atropine, veratrum, strychnine, croton oil, aloes, senna, and turpentine as likely to affect the milk. The remedy is obvious; animals which are being treated with medicaments for any cause cannot produce a pure or sound milk and should be excluded.

Venomous Poison in Milk.—Dr. Francis reports a remarkable case of this kind, the details of which were furnished him by Dr. Fayrer, of Eastern Bengal, and which indicate that the milk of an animal bitten in the udder by a poisonous serpent will convey the venom.

4. MILK ITSELF MAY BE MORBIFIC AS THE PRODUCT OF A DISEASED ANIMAL.—(*a*) *Inflammatory Conditions of the Udder and Teats* (*Garget*).—There is an abundance of evidence to show that cows frequently suffer from various degrees of mammitis and other septic processes of this secreting organ. It is obvious that the character and composition of the milk in such instances are changed, and, apart from the disgusting admixture of pus, it may prove dangerous by the transmission of septic germs, such as the various forms of streptococci and staphylococci, which have actually been demonstrated in such milk by Kruger, Nocard and Mollerau, Kitt, Bang, and others; and, besides, we know from Löffler's experiments that milk also offers a suitable culture medium for such germs.

Dr. James Niven, health officer of Manchester, describes in the London *Lancet*, January 19th, 1895, p. 145, an epidemic affecting one hundred and sixty consumers of a particular milk supply, with symptoms of diarrhœa, sickness, and abdominal pains. The milk had an odor resembling that of sweet pus, and examination revealed the presence of streptococci and a microbe having the characters of the bacillus coli communis. A searching inquiry at the farm resulted in the admission of the farmer that he had sold a cow on November 8th because she was suffering with garget, and that her milk had been mixed with the other supply. A similar milk infection was reported by Dr. Boxall, in the London *Lancet*.

As a matter of fact, many of the epidemics of scarlet fever, diphtheria, and follicular tonsillitis in Great Britain have been attributed to a milk supply from animals suffering with local affections of the teats and udder. Thus, for instance, in November and December, 1885, an epidemic appeared at Marylebone, St. Pancras, and Hampstead, which Mr. W. H. Power, the sanitary inspector, traced to a particular milk farm at Hendon, but could discover no sign of scarlet fever at or near the dairy. Upon examination of the cows some of them were suffering from an ulcerative disease of the teats and udders; and from various other circumstances he inclined to the belief of the bovine origin of this disease. In 1869 Dr. J. Fagan described a case of pseudomembranous stomatitis produced by the milk of a cow with inflamed udder. On inquiry Dr. Fagan was informed by the mother that for some time past she had noticed a sediment of a dirty appearance in the bottom of the vessel. Microscopical examination of this sediment revealed corpuscles of both pus and blood, and on making further inquiry it was found that the cow had suffered from inflammation of the udder, which had at the time formed an abscess. In addition to Klein's testimony as to the presence of a streptococcus in these cases, Prudden reports twenty-four cases of diphtheria, in which in all but two he demonstrated a streptococcus, probably identical with the streptococcus pyogenes and streptococcus erysipelatis. Baginsky (*Berliner klin. Wochenschrift*, 1892, No. 9, p. 183) reports that of 154 cases of diphtheria treated under his supervision, in 118 cases Löffler's bacillus was present, while in the remaining 36 only cocci (staphylococci and streptococci) could be demonstrated. Guillebeau (*Landw. Jahrb. Schweiz*, 1892, p. 27) made an examination of the milk of seventy-six cows suffering from udder inflammation. In all cases he found the milk contaminated with pyogenic germs, and experiments convinced him that they were pathogenic in so far as they produced similar inflammation when inoculated in healthy animals. Adametz, Macé, and Hueppe observed several kinds of pus-producing germs under similar conditions, which multiplied to such an extent in the milk that the gases caused the cheese to "heave." When we further consider that toxins may and do produce a scarlatinous exanthem, we feel warranted in declaring that in all the epidemics of scarlet fever and diphtheria which were traced to milk from cows suffering with some inflammatory lesions of the udder or from puerperal fever, we have typical instances of a streptococcus and staphylococcus infection. These views were presented by the writer as early as 1895, and in August, 1897, Grey Edwards in the *British Medical Journal*, vol. ii., pp. 340-341, published cases of follicular tonsillitis, in which the staphylococcus pyogenes aureus and albus and the streptococcus pyogenes (short form) were not only found by Severn, director of a London Pathological Laboratory, in the suspected milk, and in the milk of a particular diseased cow, but also in the sweepings (culture) from the throat of the patient, and it will often be impossible to differentiate clinically such attacks from true diphtheria and scarlet fever. There is no proof that there is a disease in the cow which is communicable as scarlet fever or diphtheria to man, but when we consider the almost total absence of scarlet fever in countries like Japan, where milk is seldom used except as a medicine, the question should not be regarded as definitely disposed of, but is one that merits the most searching investigation by pathologists and bacteriologists of both medical and veterinary schools.

(*b*) *Fever, Especially Puerperal and Other Septic Fevers.*—The milk of animals suffering from febrile diseases is unfit for use. This is especially true of the puerperal and other septic fevers, in which Karlinski, Escherich, Longard, and Adametz have demonstrated the presence of the micrococcus pyogenes aureus in milk, the last-named author in a sample which had induced vomiting and diarrhœa. There is reason for believing that the germs of septicæmia neonatorum are in many instances conveyed in the milk, since Escherich, who examined thirteen specimens of milk from mothers suffering from puerperal fever, found the pyogenic germs in twelve, and Karlinski not only demonstrated the staphylococci in the milk of the mother, but also in the blood and intestinal contents of the infected infant.

(*c*) *Gastro-enteric Diseases.*—It has long been held that the milk of cows suffering from digestive derangements is of an abnormal character, and, according to Siedamgrotzky, Frölner, and Brüuer, it is usually quite watery, of a bitter taste, and generally coagulates within from six to eight hours after milking, with the formation of very little acid, so-called "sweet curdling." When we remember that if nursing mothers indulge freely in fresh fruit and green vegetables their milk is apt to gripe and purge their infants, we can appreciate how cow's milk, under the above circumstances, may produce mischief.

(*d*) *Acute Specific Enteritis.*—Professor Gaffky has reported several cases with symptoms of nausea, vomiting, diarrhœa, and mental confusion, which he traced to the milk of an animal suffering from this disease, and demonstrated a characteristic organism in the animal as well as in his human patients. He also referred to Professor Husemann's report of an epidemic of gastro-enteritis which prevailed in 1888 at Christiania, and which within three weeks affected over six thousand persons, while sparing infants at the breast.

(*e*) *Foot-and-Mouth Disease* (*Eczema Epizootica*).—The milk from animals suffering from this disease is unfit for