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THE STERILIZATION OF MILK

AND THE

STATUS OF OUR KNOWLEDGE UPON THE SUBJECT.

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BY

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In presenting this subject, I feel that I am going over ground well elaborated before me, yet even in the face of this it is somewhat surprising to find the lack of systematic idea entertained by physicians upon the subject of milk or its sterilization. This most important innovation upon infant-feeding has even in our journals been granted faint praise in occasional paragraphs.

Though the work done thus far in this field has been most painstaking and scientific, it has not fully reached those for whose benefit these investigations are mostly undertaken,—the medical public. There are scattered through the French and German literature some very classical articles upon this subject, but no English writer has of late attempted to systematize and classify the ideas presented. If this article will deal with some scientific and abstruse data, it will endeavor to bring these in direct relation with our daily practice and therapy. For a long period past, the author has been going over old and recent ground, and this paper will endeavor to formulate the landmarks of our knowledge in this field.

Milk as it exists in the udder of the healthy cow is devoid of bacteria, as is also that of the human subject; germs of an offending nature reach the milk after it has left the animal.

Speaking only of healthy animals and their milk, it is a matter of daily observation that various samples of milk will contain varying quantities of foreign matter, due, no doubt, to varying conditions of cleanliness at the first dairies. Soxhlet and Renk called attention first to the palpable detritus to be found in milk, and this has been often confirmed by my own observations. Aside from straw or dirt from the hands, if milk be allowed to stand in large quantities, small black specks may be seen at the bottom of the containing vessel, if this be glass. These small specks are manure from the udder or teats of the animal; thus it is easy to see how even healthy milk may contain very obnoxious elements. Renk found that different dairies varied in this respect as to the quantity of sediment. Here, in New York, I am happy to say, we can, with care, obtain a milk moderately free, though not entirely so, from those elements; but I have during the summer season (a year ago) seen these black specks very abundant in milk in large quantities. Thus the bacteriology of milk must vary vastly with the varying amount of care or cleanliness with which the milk is collected,—and results of different authors will also vary, according to the source from which the milk is obtained. But the main principles are fixed, and can guide us in our practice.

If milk bè allowed to stand at the ordinary temperature of the room, either in summer or winter, it becomes "sour,"—acid in reaction; there is a disturbance noticed in the consistency and appearance due to a precipitation or coagulation of the caseine elements of the milk and their separation from the fluid portion of the liquid. This is the acid fermentation of milk found under normal conditions, and in ordinary milk, and was systematically studied by Pasteur, who described the "*ferment lactique* or lactic acid bacillus as the cause and prime factor in this change. The rapidity of fermentation must vary with the temperature and varying conditions of bacteric invasion of the fluid. During the heated term these conditions are presented at their best, and it is then that the above changes set in most rapidly.

In order to understand the true value of our present methods in dealing with artificially-fed children, it is necessary to go over some historical ground, and I promise only to take you where my own studies and observations have led me.

The most admirable work of Hueppe upon milk, its decomposition by micro-organisms, is known to you all. I will collect some data from this article first in my *résumé.*

As an example of the older doctrines upon the decomposition of milk, we may mention the views of Stahl, who, writing in 1697, considered fermentation and putrid decomposition as analogous processes, fermentation being only a variety of decomposition. He assumed that in fermentation there was the formation of new combinations, and the cause of the decomposition resulted from the transmission of molecular movement to easily decomposible combinations. The great advance in our knowledge of lactic acid fermentation presupposes that once for all lactic acid is a very characteristic combination, and on this ground its separation from other decompositions. Scheele, in 1780, first discovered lactic acid in milk with its great resemblance to acetic acid. It will not aid us to go into a long *résumé*, so that our purpose will be subserved if we next look at the work of Pasteur, who, in 1857, described a ferment which was always present when lactic acid resulted from sugar in organic fluids. He described this ferment minutely as small spheroidal bodies forming short links. With this theory of Pasteur, the lance was again taken up for the bacteric as against the chemical theory of fermentation. Later, 1858, Pasteur proved that in various fermentations, if lactic acid be present and formed, the lactic acid ferment was always present, although there were numerous others and with difficulty isolated ferments. By excluding the air, his fluids remained unchanged, so that he concluded that the organisms were derived from the atmosphere, and did not result from spontaneous generation. He found, what is important in relation to sterilized milk, that in spite of subjecting milk to a temperature of 100° C. coagulation resulted,—not with acid but alkaline reaction. There was no lactic acid ferment, but " infusoria" (potato or butyric acid bacilli). At a temperature of 110° C. to 112° C. and 1½ atmospheres, there was a destruction of all life, no infusoria found, and no fermentation resulted.

Failure to sterilize the milk was due not to spontaneous generation, but to the presence of a very resistent organism.

Schroeder and Pasteur came simultaneously to the conclusion that milk is difficult to sterilize, because it contains organisms which are very tenacious of life. But while Schroeder assumed that these organisms were present in the milk itself, Pasteur thought they were derived from the surrounding atmosphere. Pasteur first (1861) divided the butyric acid ferment from that of lactic acid, and minutely described the butyric ferment, which he called "vibrio," and classified it among the infusoria (bacilli). The lactic acid ferment was also minutely described. Lister, in 1878, established that the particular organism which he named bacterium lactis caused the acid fermentation of milk, and he, by a method of dilution by which each drop of his fluid held a ferment germ, caused sterilized milk to undergo lactous fermentation with acid reaction; he described this organism also very minutely. He proved that other fluids, as water added to sterilized milk, caused other fermentations, as butyric but not lactic acid fermentation. Up to this time the doctrine was promulgated by Schroeder, Schmidt, Hoppe, Seyler that though an organized ferment may cause lactous fermentation, yet, under all circumstances, this was not necessarily the case, but that there were lactous fermentations dependent upon a chemical ferment pre-existing in the milk and derived from the mammary gland.

W. Roberts, in 1874, succeeded in retaining milk drawn from the breast into glasses free from fermentation, and Lister and Cheyne had similar results. Meissner first established in a scientific way that milk as other fluids could under certain precautions be drawn from the animal and retained free from decomposition,—that is, that decomposition was due to organisms which reached the fluid from surroundings and air. Therefore the milk in the presence of antiseptic means and high temperature acts not like an enzymotic solution, but as a medium which contains organisms capable of certain resistant powers. Therefore, the cause of lactic acid fermentation is an external one always, and the germs gain access in the stalls and storage places of the milk. These are only avoided with such caution as to give rise to the idea that, as formerly in vogue, the milk itself contained the primary cause of fermentation in the form of a chemical substance.

I have in the above given a short *résumé* of the principal steps which led to the closer bacteriological study of milk; yet it is surprising that, though Pasteur so long ago established the fact that the acid fermentation of milk could be avoided, and gave data, no systematic attempt at milk sterilization was thought of in connection with infant therapy until the work of Soxhlet, preceded by that of Hueppe, appeared, and this is explained by the enormous impetus given to modern bacteriological researches by the doctrines and methods of Robert Koch, which has permeated every branch of our professional work.

When we subject milk to heat, we have to meet the insurmountable obstacle of an organic fluid which not only may contain bacteria which are resistant to a considerably higher temperature than that of ordinary steam, but by the nature of its composition, milk is apt to protect to a very effective degree contained bacteria from the action of the externally acting heat. Again, milk if heated to too high a temperature changes in color, and there is a separation of certain elements (butter) and a change in others (caseine and sugar elements). From the temperature of 75° Celsius upward there is a separation of the serum albumen of the milk; the caseine loses its coagulability to rennet, and at 85° C. amounts of rennet, which for the raw condition of milk are found sufficient to act, cease to be effective. J. Munk found that in milk sterilized under three atmospheres four times the ordinary quantity of rennet was necessary in order to act satisfactorily. Hueppe has confirmed this, as has also in another manner Dr. Chapin, who has, it seems, come to the independent conclusion that the caseine of the milk suffers a change in sterilization. (*Med. Rec.*, 1890.)

Hoppe found that milk sugar at 80° C. to 90° C. suffers a change, which increases at 100° C. to such an extent that, after two hours' exposure to this temperature, milk and milk-sugar solutions become of a brownish tint; at a temperature of 110° C. this is more marked. Pasteur found that, at a temperature of 110° C. to 112° C. and 1½ atmospheres, there is a slight oxidation of the fats in the milk, which gives it a tallowy odor.

Hueppe concludes that between 75° C. and 100° C. the milk is gradually changed in its chemical composition, but these changes are of such a nature that the digestibility of the milk is scarcely diminished and its taste and odor but little changed. Temperatures of 140° C. may coagulate the caseine (Hoppe), and at 120° C. coagulation begins to set in if this temperature is kept up for any length of time.

I have here tubes in which the milk has been subjected to only the Pasteur temperature, 1½ atmospheres, and 112° C., with only the brown discoloration to be noticed, from inspection.

The above facts are, and will be, useful in guiding future work upon this subject, and the law laid down by Hueppe still remains true, that from a physiological stand-point milk is best sterilized (if possible) under a temperature of 75° C., but it may be admissible as far as 100° C.

We have, of late years, been recipients of many suggestions as to sterilization, but if we look at the mass of matter and suggestions, we will find that though the above principles still hold good and have been established for decades, the only direction towards which ingenuity of physiologists and clinicians has exerted itself has been mostly in the empirical direction of some form of "apparatus." Thus, in the great struggle to invent some unique form of cooking-utensil, some great truths have been lost sight of and buried in the *débris* of apparatus. The sterilization of milk may be performed, according to Pasteur, absolutely at a temperature of 110° C. to 112° C. and an increase of ½ an atmosphere; this has its objections, and these are, as it seems, very formidable, not only from an æsthetic stand-point, but the physiological also. The caseine, which even at 75° C. begins to change, certainly approaches the coagulation-point (from heat alone) at the Pasteur temperature. Not only this, but there is reason to believe that such caseine is even less acted upon by the weak stomach juices of the infant than we at present are led to believe from physiological experiment. Another method of sterilizing the milk is also a gift of the genius of Pasteur, and that is the so-called Pasteurization of milk. In the *Zeitschrift für Hygiene*, vol. viii., heft 2, Bitter has attempted this method: Milk is heated in large masses up to 70° C. to 75° C., and maintained at this temperature for half an hour, then rapidly cooled; this is done by passing the milk over coolers; the temperature of 18° C. to 19° C. is attained, when the milk will keep quite well for some time,—twenty-four to forty-eight hours; but this scheme is scarcely practicable,—what I mean by this is that no means are as yet at our disposal to place this in every household. Strub (*Centralb. für Bact.*, 1890) gives details of a method by which milk heated to 70° C. and very rapidly cooled to 40° C., or even 20° C., for about five successive times, has given satisfactory results in mercantile departments of the milk industry, but the apparatus necessary for this, it is needless to say, must be very elaborate.

We next take up the sterilization of milk at the heat of boiling water, in a water bath, that of Soxhlet, of Munich. To this man will always remain the great merit, not of having done anything new, but of practically placing milk-preservation within the reach of every housewife, and of putting into practice certain principles for whose reception the therapeutic world was not hitherto prepared, though these principles were well known. Soxhlet (*Mun. Med. Wochen.*, 1886, p. 253) brought forward in a striking way the advantages of protecting the infant from the acid fermentation of milk, and he eliminated it very easily by, as you all know, placing the nursing-bottles in boiling water and leaving them thus for forty minutes. He also called attention to the external sources of uncleanliness at dairies, such as pots, hands, and the state of the udder of the animals. Soxhlet, at that time, said that milk thus treated could be kept at a room temperature three or four weeks without spoiling or becoming acid. This, I will show, is true to a certain extent. It is a misleading statement. He gives some interesting data as to the time and temperatures at which ordinary acid coagulation of milk takes place. Thus: at 35° C., in nineteen hours; 25° C., twenty-nine hours; 10° C., two hundred and eight hours; 0° C., three weeks. In any acid milk, fermentation at 35° C. results in the production of three per cent of alcohol, almost as much as that contained in beer. Soxhlet placed great stress upon his peculiar stopper, which I will take up later. It remains that the Soxhlet plan is that of the boiling-water bath, and it has its drawback in a certain amount of irregularity of heat conductivity by which the methods and results are less uniform than that of the next method, which, I think, is the most satisfactory, and that is the sterilization of milk by the plan first advocated by Hueppe in 1884 ("Mittheillungen aus der Kaiserlich Gesundheitsamt"). By this method, the milk is sterilized in small quantities, but the water does not reach the containing-flasks, and steam alone is the means of sterilization. The results are certainly more uniform by the sterilization in steam ; by this uniformity I simply desire to mean that we are first certain that every flask being surrounded by steam receives the benefit of the same quantum of heat, 212°, and the latent heat of steam. The conclusions of Hueppe were that steam was most satisfactorily and rapidly generated in the ordinary protected tin pot of Koch, and milk which in reagent glasses had to be subjected to the boiling bath for one hour were easily protected and sterilized from acid fermentation in twenty minutes in the live steam; this is of great economic as well as of scientific importance, and is another guiding post for future work. Occasionally, in this short space of time, the milk sterilized in reagent glasses would subsequently coagulate, but in forty-five minutes the sure sterilization resulted. Hueppe noticed that in milk which was certainly sterilized at 100° C. there appeared gradually a sediment, which, he thinks, contained the separated albumen and coagulated caseine, and the milk above this sediment was more watery than the milk sterilized below 75° C. Thus the milk sterilized under 75° C. differs from that sterilized at 100° C. in the more marked appearance of sediment and its insolubility. Nægeli noticed changes even in milk heated to 110° C. to 120° C. after four to six months both in appearance and taste. Meist (Hueppe) records appearance of peptone, tyrosin, and leucin and ammonia in milk apparently sterilized. As far as our knowledge goes, milk may be absolutely protected from future *acid fermentation* by subjecting it to a temperature of 100° C. in live steam.

I will ask you to notice that there is another fermentation of milk, the alkaline concerning which a great deal of misunderstanding exists, but about which there are certain well-known facts, to which I beg your present attention.

The acid fermentation of milk is brought about chiefly by a species of micro-organisms called by the author Hueppe, who very closely studied its growth and behavior, the bacillus of lactic acid fermentation. The milk as it reaches the purchaser is very rich in micro-organisms, but this one alone is chiefly responsible for the sour reaction of spoiled milk. I show you a culture of this in various media and fluids, and you will see it was well described by Hueppe.

I do not think this is the place for close bacterial descriptions, but let me call your attention to some very interesting data. This micro-organism is of small oval form, occurring single and in pairs. It does not fluidify gelatin, and grows upon all media when it is inoculated into absolutely sterile milk (milk subjected to temperature of 112° C. and 1½ atmospheres); there is in a short space of time a coagulation of the caseine elements, but what is most interesting is the accumulation of bubbles of CO_2 gas at the top of the milk and near the top. I show you a potato culture of the bacillus of lactic acid and you can see the bubbles of CO_2 in this culture also. The coagulum of the milk is peculiar in that it is traversed by fine spaces and cracks, in which are entrapped bubbles of CO_2. The spaces become larger and wider; the coagulum contracts after a few days. In these spaces there is a serous fluid. The micro-organism measures 1 to 1.7 μ. long and .3 μ. to .4 μ. thick; the bacteria may reach .2 μ. in length. Hueppe thinks they contain spores, especially in sugar solutions; he also found these spores in sour milk. (But this is difficult to reconcile with some statements of Lœffler, which will be referred to below.) This organism grows from 10° C. up, and its maximum growth between 35° C. and 42° C.; it also stops growing and the acidity no longer forms at 45.3° C. to 45.5° C.

It is not necessary to go into further details, but we must remember that the heat of steam, while it may in twenty minutes destroy the lactic acid bacillus, does not entirely destroy the spores so that a prolonged steaming is necessary to absolutely render these spores innocuous (forty-five minutes). Thus, as mentioned, Hueppe found that test-tubes of milk sterilized for twenty minutes in steam did not always remain free from acid fermentation, the spores subsequently growing and causing acid fermentation, and I myself have seen tubes heated with steam for twenty minutes undergo subsequent acid fermentation in the thermostat, turning the litmus which was mingled in some of the tubes red, and finally decolorizing it. The lactic acid bacillus of milk is able for a time to resist the temperature of steam.

It has been noticed (Pasteur, Nægeli, Hueppe, Meyer, Lœffler) that milk which has apparently been thoroughly sterilized will, after a space of time, vary in each case with circumstances of temperature and previous state of the milk, undergo changes and a distinct precipitation, or rather coagulation, sometimes with the formation of peptone, leucin, and tyrosin. Pasteur, as above mentioned, established that these changes always occurred in the presence of an alkaline reaction; when milk was sterilized at 100° C., acid reaction was never present. He named the bacteria thus found in the milk so decomposed infusoria; we know now that they are always rod-shaped or bacilli. Acid reaction is never present except to a slight degree at first with the butyric acid bacillus (Hueppe), but alkaline reaction soon results even here. Hueppe first described the butyric acid bacillus (aerobic) which he found in milk which had been subjected to three atmospheres of pressure with corresponding high temperature. This milk was decomposed, and contained a bacillus which was very resistant and could withstand very high temperatures; even much higher, as you see, then the 1½ atmospheres of Pasteur. This bacillus or microbe contains spores, and it is in this the resistance to temperature exists. Hueppe described this bacillus minutely, and we are able to find it to-day in milk (Lœffler). I have been able to isolate a bacillus very much resembling it with others from milk sterilized by various apparatus, and have found it in a sample of milk which had been sterilized by the Escherich new large sterilizer, in which the milk is sterilized in quantities of about a quart. The milk was taken from the sterilizer on the second day after sterilization. The milk was slightly alkaline, and subsequently became very alkaline in reaction with small and large soft clots of a peculiar odor. This is nothing new, but it will explain other facts hereafter to be stated. The ordinary potato bacillus (bacillus mesentericus vulgatus of Flügge) was also present at the same time. Lœffler (*Berlin. Klin. Wochen.*, 1887) not only confirmed Hueppe's investigations, but found other bacteria, all varieties of the ordinary potato bacillus, in milk which had been subjected to the temperature of steam for ten minutes. This temperature destroys the bacilli and other bacteria, but not the spores, except those (this not always, as Hueppe found) of lactic acid fermentation. These spores subsequently decompose the milk through their proliferation, but always with alkaline reaction. The coagulation of the caseine is also of a more flocculent character. There are first the ordinary potato bacillus (the bacillus mesentericus vulgatus of Flügge), then the white bacillus, a subvariety, as also the gummy (bacillus liodermos of Flügge), and a third variety of the same organism, which Lœffler calls the white bacillus. It would be sufficient to mention these here and to show how they grow only in sterilized milk. In sterilized milk the potato bacillus (first described by Hueppe), after a few days in the thermostat, causes the appearance of a clear zone underneath the cream zone at the top of the milk. This zone varies from a clear to a cloudy one, according to the varieties of potato bacillus which is inoculated or growing in the milk. Crystals of leucin and tyrosin appear at the bottom, in case of the white bacillus. The reaction of the milk is distinctly alkaline. The most important lesson to be learned from the above is that milk well sterilized by steam with any apparatus (Koch, Soxhlet, Escherich, Arnold steam cooker) will after a time decompose with an alkaline and no acid reaction. The time at which macroscopic changes appear has been regarded by some authors as the surest sign of decomposition, but they have mostly, even in late times, talked of the milk becoming sour, as you see it does not undergo acid fermentation but alkaline fermentation.

Strub (*Centralb. für Bact.*, 1890) has experimented with almost every known apparatus, and was able to establish, even immediately after sterilization, the potato bacillus in the samples of milk which she used. She also established that repeated fractional sterilization in a Koch apparatus was not sufficient, even after many repeated steamings, to entirely destroy this bacillus (its spores).

Especially interesting is the behavior of bacteria when inoculated into milk (sterilized) to which litmus (one to ten), according to Liber and Marpiman, has been added. There is a gradual decolorization of the litmus in some, showing that there is something formed aside from pure alkalinity or acidity, which has an oxidation action upon the litmus.

I show also that the lactic acid bacillus turns the milk with litmus red and finally decolorizes it. The streptococcus pyogenes turns the milk acid, litmus red, and finally decolorizes it. The typhus bacillus (Lœffler) turns litmus (sterilized) milk slightly red. Tubercle, diphtheria, and cholera microbes grow very well in milk without causing any marked change in the same. The substance which with the lactic acid bacteria and potato bacillus and streptococcus causes decolorization is not, as yet, established.

The object of this paper being a review of our knowledge of sterilized milk and its value, as also the writer's observations in this line, it is foreign to consider here the decompositions or contaminations of milk as we find it in the stores. The heat of steaming is a protection against those micro-organisms which cannot withstand this high temperature and maintain life (tuberculosis diphtheria), as also against the occasional animal diseases. The blue milk and stringy, slimy milk (Hueppe), as also even tuberculous milk, form such a distinct field of work that a separate paper could be written upon them alone. The practical deductions which can be drawn from what has been stated above concerning ordinarily good milk and its sterilization seem very evident. The first is that milk can be thoroughly protected from subsequent rapid acid decomposition by exposure for a certain time to the temperature of steam, and to accomplish this the several apparatuses in the market are entirely efficient. It matters very little how many or what variety of micro-organisms exist prior to steam; after this only those micro-organisms remain capable of proliferation whose spores have a resistance against continued application of 100° C. These, in normal milk, have been shown to be the butyric acid bacillus and the various varieties of the ordinary potato bacilli. If milk be sterilized and it is found to contain these micro-organisms after steaming, their number and capability of doing injury to the milk will vary very much with the conditions under which the milk has been collected. If these micro-organisms preexisted in enormous quantities, the alkaline fermentation will, under a favorable temperature, set in sooner. If in small quantities, the macroscopic changes of the milk will be scarcely perceptible for some time. If milk could be sterilized after careful collection at the dairies, it might keep very long after sterilization. Thus it is seen that even directly after steaming the micro-organisms and their spores exist in sterilized milk if they cause the subsequent decomposition. Strub (*Centralb. für Bact.*, 1890) found that the variety of cork or method of closure of the bottles in children's apparatus had very little to do with this subsequent decomposition. Bacteria were present in the sterilized milk, no matter what kind of closure (Soxhlet, cotton, ordinary rubber) was used. But the most important point here to remember, and what is known to those who have given thought to this subject, is that the bacteria of the alkaline milk fermentation are very slow to proliferate in sterilized milk: at room temperature the changes in the milk are at best delayed for a few days, even a week, and when the changes are not so marked as to be detected by the eye, such milk has been sold in the stores and given by others to infants without *seeming* deleterious results, at least not such as are immediately apparent after administration of sour milk. Therefore, the influence of bacteria which remain in normal cow's milk after sterilization is of little practical bearing for infants, inasmuch as most families prepare milk daily, and I have never, nor can I find data where any one else has, found the alkaline fermentation in milk so marked after, say, forty-eight hours as to cause macroscopic marked changes. I refer only to the infant apparatus and summer temperatures, and not to those experiments in the laboratory where sterilized milk is inoculated with masses of active potato bacilli spores and bacilli themselves, specimens of which I show here. I would not approve, therefore, of the use of any city milk which, however well sterilized, was kept for days, and, though its color was good, as also its appearance, and it tasted well, is the seat of advanced changes. We find such milk sold in stores where the bottles have been kept even two weeks after sterilization. True, the alkaline fermentation has not been investigated to such an extent that we can with certainty pass upon the deleterious or non-deleterious effect upon infants of the products of this decomposition. It is enough that it takes place, and certain alkaloid elements are surely produced, but very slowly, and if the milk is steamed, as in the household, daily, may be disregarded; but the storage of sterilized milk and its subsequent use, after prolonged periods, is to be strongly discountenanced. Therefore, in the future, we will know how to interpret those authors who condemn sterilized milk with faint praise by stating the number of bacteria (?) they have found in sterilized milk without stating the whole case. I had this "clear statement of the case" in view when I undertook the above work, and I hope I have, to a degree, succeeded.

To state that bacteria exist means very little; we must know their variety and their behavior. There is an important practical point which, to the writer, seems pertinent here: Many physicians have often told me, and no doubt you also, that they find the boiling of the milk sufficient sterilization, or that they cannot see why it is not fully as good as continued steaming. Never was a greater fallacy born of empiricism. Hueppe has shown that milk in small test-tubes (ten cubic centimetres) exposed for twenty minutes to the action of live steam at 100° C. is not surely protected from subsequent acid fermentation, and that some of his tubes thus treated turned sour after a time. Here is a tube of milk stained with litmus originally, and exposed for twenty minutes to the action of steam in the Koch pot. After placing it in the thermostat at a temperature of 35½° C. to 36° C. it turned red in twenty-four hours; this became more marked until full coagulation of caseine resulted and with decolorization of the litmus. Thus simple, single boiling of the milk, as it is performed in the kitchen ordinarily, is insufficient to protect milk, aside from facts of exposure of milk to atmosphere and handling subsequently, which enhances chances for decomposition.

Physiological.—There have lately been some experiments, and notably by E. M. Hiesland and H. D. Chapin, upon the digestibility of sterilized milk and the chemical changes in milk brought about by steaming. Their conclusions are so much in accord with those of Hueppe and Munk that their quotation here would only repeat what has been recorded above. Dr. Hirst (*Med. Rec.*, February, 1891) has gone so far as to suggest the addition to milk of some pancreatin powder before sterilization, in order to digest and help the digestion of the caseine made difficult of digestive solution during steaming. Whether this will prove a valuable suggestion remains to be seen. For myself, I must say, I still hesitate to put any digestive powder in the milk of the healthy infant, but in a stomach which proves rebellious I have been in the habit, like many others, of adding powders to sterilized milk, but have hitherto done this after sterilization and just before giving the milk to the infant. The physiological data of our knowledge in this department of infant dieting are still very meagre, nor has the stomach-washing of infants before and after ingestion of foods thus far aided us materially in coming to definite conclusions. Interest has lately been aroused in the discussion of the amounts of milk to be administered to the infant at each feeding. On the one hand, we have Dr. Escherich, who is still guided mostly by the age of the infant, and on the other, in our own country, Seibert has advocated the weight as the only criterion for infant-feeding. Seibert would reject all past methods and ask his adherents to give certain amounts to certain weights of children. Seibert gives us a table. But these agitations have had their uses, and now attention is being directed more fully to this subject than hitherto.

I have always been guided as follows: I weigh my children always at the beginning of treatment; if their weight comes up to the standard, or nearly so, they are given the amount of food which long series of experiments by physiologists and clinicians have proved to us to be adequate for normal children at certain ages. (*Vide* Fleischman *Pœdiatrische Studien*, Vienna, 1875.) If the infant is markedly atrophic, and, as I have seen at three months, only weighing less than an average infant at birth, a proportionate amount of food is given, and subsequent improvement noted, the weight of the child, divided by the weight that would be normal, multiplied by the amount of food (grammes) necessary to an infant of normal weight and development at each feeding.

X = Weight of infant;

Y = Weight of normal infant of same age;

Z = Amount of food at each feeding which is normal to an infant at that age.

As far as our knowledge goes:

$\left(\frac{X}{Y}\right) \times Z =$ amount of food to be given at each feeding.

The above digression is warranted by the close connection it bears to any theme of infant-feeding, and especially in sterilization, where the size of the individual bottles are a matter of care to the mother.

I cannot close this paper without some practical suggestions, and if they appear trite, they have at least the value of being based upon a large experience. The ideal method would first be to either sterilize the milk in small or large quantities at the dairies, but this has not yet been attempted in the city.

The writer uses as a sterilizer the ordinary wire basket with eight bottles sold everywhere with the ordinary rubber cork. If the patient can afford it, and wishes a rapid steam generator, the patent cookers are good; if not, any pot will do which is big enough to hold the wire basket of bottles. The milk or milk and diluent are placed in the bottles, which have been thoroughly cleaned with hot soda water, and an inch and a half of water is placed in the bottom of the pot; when the water is boiling the basket of bottles (without corks) is lowered into the pot and the same is covered. They are steamed thus for ten minutes to drive residual air out of the bottles. The pot is opened and each bottle is firmly corked, and the pot covered and steaming continued for forty-five minutes longer, when it may be considered completed in any weather. The basket of bottles are then placed in a shady, cool place. If the family be intelligent, and the bottles are not to be transported, the baked or even ordinary cotton may do as closure for the bottles. The fault with the sterilizers now in the market (Arnold's cooker excepted) is that there is not room beneath the basket for the requisite water (one and a half inches) to steam one hour, though they can all be used *à la* Soxhlet. A Baltimore firm is now constructing a sterilizer from plans given by the author, which, I think, will enable the user to sterilize with steam, and there will be no danger of the bottles touching the water and cracking. The completed apparatus—steam-pot, bottles, and basket—is to be sold at a price within the reach of the most modest household. Future efforts must also be made in order to obtain for the infants a milk which will be as free from contaminating elements as possible. If the sterilization in small quantities or bulk is not possible at the dairies, a strict hygienic surveillance of dairies by competent persons who can recognize diseased animals and milk, and a strict accountability as to cleanliness of animals, utensils, and hands, ought to be inaugurated. The rejection of receptacles which are unclean or composed of objectionable material will render milk-sterilization in the household still more effective than it is at present.