SCIENCE:

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Attention is called to the "Wants" column. All are invited to use it in soliciting information or seeking new positions. The name and address of applicants should be given in full, so that answers will go direct to them. The "Exchange" column is likewise open.

STEPS are being taken to celebrate the seventieth birthday of Professor von Helmholtz, which occurs on Aug. 31. A marble bust of Professor Helmholtz is being made, which will be presented to him on that occasion, and a fund is being raised, the income of which is to be applied, primarily, to the bestowal of a Helmholtz medal on eminent investigators of all nations in the fields of Professor Helmholtz's activity. An international committee, which has been formed to carry out these schemes, solicits contributions, which may be sent to the committee's bankers, Mendelsohn & Co., Berlin. Professor Henry P. Bowditch of Harvard University will forward the contributions of such as may find it more convenient to send to him, with the names of the contributors, to the bankers appointed by the committee. All contributions should be sent as soon as possible.

JULIUS ERASMUS HILGARD.

MR. HILGARD, whose death on May 8 has been announced, was born at Zweibrücken, in Rhenish Bavaria, Jan. 27, 1825. His father was a man of a wide range of accomplishments, — counsellor at law, judge, poet, classical scholar, and author. Being of liberal tendencies in politics, he became dissatisfied with the *régime* under which he lived, emigrated in 1835, and settled in Illinois, where he personally directed the education of his children. The subject of the present notice also studied in Philadelphia, where he made the acquaintance of Professor Bache. In 1845 he obtained an appointment in the Coast Survey, and soon became one of Bache's most trusted assistants.

His administrative and business tact led to his promotion in 1862 to the position of assistant in charge of the Coast-Survey Office. He now took a prominent part in directing the scientific work of the survey, especially in its relation to the International Metrical and Geodetic Commissions, having their headquarters in Paris. Perhaps his most noteworthy work was that done in connection with the determination of the transatlantic longitude in 1872. Soon after the Atlantic cables were put into successful operation, the difference of longitude between Greenwich and the Harvard College Observatory was determined by Dr. B. A. Gould. Shortly afterward the French cable was laid between Brest and St. Pierre, and it was judged expedient to repeat the determination by taking Paris as the starting-point. It happened, however, that the telegraphic determination of the longitude of Paris from Greenwich, made in 1853, was very doubtful, and it became a necessary part of Mr. Hilgard's work to repeat this determination. This he did with the assistance of Mr. Frank Blake, then subassistant on the survey, who observed both at Greenwich and Paris. The result was an important correction to the longitude of Paris, and hence to other European longitudes which depended upon it.

On each occasion of a vacancy in the superintendency of the Coast Survey, Mr. Hilgard was naturally a prominent candidate for the succession. He was, however, disappointed in his aspirations, both on the death of Professor Bache in 1867, and on the resignation of Professor Peirce in 1874. On the death of Capt. Patterson in 1881, his long and efficient service as assistant in charge of the office, and his intimate acquaintance with all the details of the work, made his appointment seem especially fitting; and he was selected for the position with the general concurrence of all parties interested. He had not been long in office before the symptoms of the insidious disease which finally carried him off increased to such a degree that he was obliged to resign in 1886.

Whatever weakness may have been developed in the last years of his life, there can be no two opinions upon the character and value of his life-work in connection with the Coast Survey. He brought into that branch of the public service a rare combination of culture, zeal, knowledge of the world, and executive ability; and no man living will claim to have done more than he did for the character and efficiency of the survey.

THE FERMENTATIONS OF MILK AND THEIR PREVENTION.[1]

SWEET milk is the foundation of the dairy interest. All dairy products are dependent upon milk, and furthermore, they are dependent upon sweet milk, for after it has undergone any of its fermentative changes it becomes worthless either to be used as milk or in the manufacture of butter or cheese. When milk first comes to our hands from the cow it is always sweet, and it has no tendency to undergo any troublesome changes. But this condition lasts only a short time, and sooner or later some form of decomposition begins, and the milk becomes useless. It is our purpose, this afternoon, to study some of these fermentations and to determine if possible some of the facts regarding their prevention. It may be well to say at the beginning that I have no royal road to recommend for the prevention of milk fermentations, since no practical method of preventing them has yet been discovered. But a knowledge of the nature of these troublesome changes and of their causes will go far toward enabling each one to guide himself in avoiding them.

I shall consider the subject under three heads: 1. What are the fermentations of milk? 2. What are the causes of these fermentations? 3. How may the fermentations be prevented?

First, then, we will consider what are these fermentations. We may notice at the outset that they are widely varied. They are by no means confined to the ordinary souring and the fermentation produced by rennet, although these are the only ones that are so well known as to have received special names in the dairy. Everyone, however, who has had any extended dealings with milk, has noticed that it sometimes undergoes changes that are quite different from the normal ones, but which may be none the less troublesome. The various fermentations which are now known to be common to milk have only been recognized within a few years. While the souring of milk has been known for centuries, and the fermentation of milk by the action of rennet has also been long understood, milk has been studied scientifically only about fifty years. During the last fifty years various sorts of decomposition changes have been recognized, one after another, until to-day the number known is quite large. Let us, then, in introduction to our subject, review briefly the most common forms of fermentation which are liable to occur in milk, taking them partly in the order of the commonness of their occurrence.

First, we may notice the ordinary souring of milk, though it is too well known to demand description. This effect is connected with the milk sugar present in the milk. The milk sugar undergoes a decomposition and forms lactic acid, the acid thus formed

[1] An address by Professor H. W. Conn, in December, 1890, before the Connecticut State Board of Agriculture.

rendering the milk sour to the taste and precipitating the caseine in the form of the curd.

Hardly less familiar to you all is the fermentation produced by the action of rennet. You will all recall this action produced by the addition to the milk of a little rennet which you have obtained from a calf's stomach. The milk curdles quickly, and after a little a whey separates from the curd. In this case the action is quite different from that of the souring. It is entirely independent of the milk sugar, and is connected with the caseine of the milk. The caseine undergoes a chemical change under the influence of the rennet. In common sweet milk the caseine is in a condition of partial solution, and while it is in solution the milk is of course a liquid. But under the influence of the rennet a chemical change takes place, the nature of which we do not yet fully understand. So far as we can determine to-day, the change consists of a separation of the caseine into two parts, one of which is soluble, and therefore remains in solution in the whey, while the other is insoluble, and as soon as it is formed it is immediately precipitated as the curd. While, then, the souring of milk concerns the milk sugar alone, the fermentation by rennet is connected only with the caseine.

A third form of milk fermentation is the alcoholic fermentation. Milk does not readily undergo the alcoholic fermentation. When yeast is added to a solution of ordinary cane sugar it causes the sugar to be decomposed into alcohol and carbonic acid. If yeast is put into milk, however, instead of undergoing an alcoholic fermentation, it will under ordinary conditions undergo a change into lactic acid, and will consequently sour. Nevertheless, an alcoholic fermentation of milk does sometimes occur. The Arabs, wandering around the deserts, have been for a long time accustomed to prepare from the milk of their mares an intoxicating drink which contains considerable alcohol. This drink they call "koumiss." It is prepared by simply putting the milk into flasks, and adding to it a little already fermented milk, which starts the process anew, and soon gives rise to a considerable amount of alcohol. In the Caucasus Mountains it has somewhat recently been noticed that the common people have a method of preparing an alcoholic drink from ordinary cows' milk. The milk is placed in leather flasks, and there is added to it some small lumps called "kephir grains." These kephir grains contain various yeasts and bacteria, and they are possessions of the common people, who hand them down from generation to generation. Where they originally came from is unknown. They have the power of setting up fermentation in the milk, at first the ordinary lactic fermentation, but this is soon superseded by the formation of alcohol, and on the second day the milk is in condition to drink. Since it has been found that milk can be made to undergo an alcoholic fermentation, a simple method has been discovered of producing it at will from cows' milk. All that is necessary to do is to add to the milk a little ordinary cane sugar and then a little yeast, and the fermentation that takes place will produce alcohol, and give us a beverage to which the Arab name "koumiss" is applied. This condition of milk is frequently prescribed as a food in hospitals, since it seems to be more easily digested than ordinary milk, the caseine being coagulated into small flakes that are readily acted on by the digestive juices.

The next fermentation that we will notice is that producing bitter milk. All of you must be familiar with this peculiar trouble. At certain seasons of the year, especially in the fall, milk seems to have a tendency to become extremely bitter without becoming sour. Quite naturally, this has been ascribed to some special food which the animals get hold of at this season. It is, however, a troublesome matter, for it spoils the milk and injures it for all dairy purposes.

A fermentation, not quite so common, but far more troublesome when it occurs, is that known as slimy milk. Perhaps some of you have had experience with this milk, that can be more readily sold by the yard than by the quart or gallon. The milk, after milking, rapidly becomes viscous, thickening to such an extent that the vessel in which it is placed may be inverted without spilling the milk. So slimy does it become that it can sometimes be pulled out into long threads, like molasses candy. Such milk is of course worthless. It cannot be churned, the cream will not rise on it, and it is useless for cheese-making. Of course no one wants to drink it. Up in Norway, however, the people are said to be fond of drinking, or rather eating, this slimy milk, and have learned to prepare it artificially by putting a small plant into the milk. With us, however, it is nothing but a troublesome nuisance, and the farmer who finds it in his milk usually tries every imaginable remedy to check it.

Milk not infrequently undergoes a change by which it becomes rancid. It has the smell of rancid butter, and chemical study has shown that the trouble is due to the formation of the same material which gives the taste to the rancid butter, viz., butyric acid. Such a fermentation, though very common, is not ordinarily seen in the dairy, since it is concealed by other more prominent changes, and thus escapes notice.

One of the commonest fermentations of milk is what we may call that of alkaline curdling. Under its influence the milk curdles without becoming acid. I am sometimes asked why milk sometimes becomes "loppered" without losing its sweet taste. It is due to the effect of the fermentation that we are now considering. Such a curdling seems to be similar to that produced by the action of rennet. Indeed, careful study seems to indicate that the two are almost, if not precisely, identical, and that these alkaline fermentations are produced by the formation of a ferment similar to rennet. This form of fermentation represents a class of which there are many varieties. They are accompanied by various odors and smells, and the milk seems to be undergoing decomposition. The various forms of tainted milk may be usually ascribed to the class of fermentations now considered. They are certainly very common, almost always occurring in milk which has stood for a short time, but commonly they escape notice, since the souring of the milk is so much more prominent that it entirely conceals the alkaline curdling. Experiment, however, easily isolates this fermentation.

Once in a while dairymen are troubled by a blue milk, not blue milk like that of the city restaurant, which is blue simply because the cream has been removed from it and water added, but milk which is blue from a special fermentation. Such milk appears like other milk when it is drawn, but just about the time it begins to sour, small blue patches may be seen in it. These patches increase in size, and finally, by the time the milk is quite sour, it has assumed a brilliant blue color. No one wants to drink such milk, though it is probable that it would not do any injury if it were drunk. There is no poison in it that chemists can discover, and it has been fed to small animals like rats without doing any injury. But still no one with his eyes open will drink it, and if it is known that the milk from a certain farm is subject to this fermentation it will be thoroughly avoided. Sometimes this blue milk becomes so common that it may almost be regarded as an epidemic.

Blue milk is not the only colored milk that arises as the result of fermentation. Yellow milk sometimes occurs. I have had in my laboratory milk that is just the color of a lemon; other specimens with an amber color. Red milk is occasionally found, sometimes occurring spontaneously as a troublesome infection, and easily produced artificially in the bacteriologist's laboratory. Sometimes milk assumes a green color, though never quite so brilliant as a grass green. Such milks usually have a vile odor, and are plainly undergoing a putrefactive decomposition. A violet milk is also occasionally seen.

Lastly, I may mention a series of fermentations under the head of miscellaneous. Various forms of decomposition changes occur which do not really belong under any of the above classes, and which have not been sufficiently studied to enable us to say much about them. They simply indicate that in the above list we have by no means exhausted the fermentations which are likely to occur in milk, and that future study will reveal much more in this line.

It is only within a comparatively few years that this long list of fermentations has been known. Little by little, as milk has been studied by modern scientific methods, has the number of these known fermentations increased, and nearly every year adds one or more to the list of the fermentations to which milk is known to be subject.

We will now pass on to the second division of our subject, and ask what is the cause of these fermentations. The alcoholic fermentation and that of rennet may now be omitted from discussion, for every one knows that these are produced by adding something to the milk, a yeast in the one case, and rennet in the other. Leaving aside these, then, we would naturally expect, inasmuch as the other fermentations are very varied, to find their causes varied also. In a certain sense this is true, but at the same time there is one point in which they all agree. All of the fermentations mentioned above are due to microscopic plants getting into the milk subsequent to the milking and their growing.

Before passing to a further consideration of this matter, it may be well to notice that there occurs, very rarely, a curdling of milk which is not due to micro-organisms. Once in a while milk is found to curdle almost as soon as it is drawn from the cow, and in this case the trouble is not due to micro-organisms. Such an occurrence is extremely rare, however, and it is doubtful whether any of you have ever had any experience with it. But aside from this rare occurrence, all of the fermentations are caused either by bacteria or yeasts, which get into the milk subsequent to the milking.

It has taken many years to reach this conclusion. It will be convenient for us to consider the fermentations as belonging to two classes, one of which we may call the normal fermentations, and the other the abnormal fermentations. The former class includes only the common souring and the rennet fermentations, while the abnormal class includes all of the others. Now it has been recognized from the very earliest times that the abnormal fermentations were due to something getting into the milk which did not belong there. So long ago as 1838 a microscopic study of blue milk revealed in it some micro-organisms, and these were even then suggested as the cause of the trouble. From that time, as one after another kind of fermented milk was studied, it was seen that they were all associated with some form of bacteria, and the conclusion is now very definitely proved that they are all caused by these organisms. All of the forms of fermentation mentioned above have been associated with definite species of bacteria, and all can be artificially produced by inoculating good milk with the right species of bacteria.

After it was seen that bacteria were the cause of the troubles, the next question was to account for their presence in the milk. It did not seem possible at first that they could all get into the milk after the milking. All sorts of explanations were suggested relating to conditions surrounding the cow. The cow was supposed to have caught cold, or to have been heated, or to have run too fast, or to have been eating some injurious kind of food, and for some of these reasons the milk fermented. Every thing was blamed except the carelessness of the milker. I imagine that many of you even to-day think you have very good reason for believing that certain fermentations are really caused by the food that the cow eats, and this has always been the favorite excuse. You have, perhaps, found slimy milk in your dairy, and have then remembered that recently you begun to feed your cow on a special lot of meadow hay. Thinking that this might have caused the trouble, you ceased to feed this hay and the trouble ceased. What better proof could you desire that it was the hay that the cattle ate which produced the slimy milk? In fact nothing of the sort is proved by this experiment. Do you not remember that when ensilage was first introduced, many farmers complained of it, saying that its use caused their milk to become tainted, and thus much injured its quality? And do you not also remember that as experience began to accumulate it soon appeared that it was not the ensilage which the cows ate which produced the trouble but the ensilage which the milker handled? To-day you know that you can feed ensilage to the cow with no danger provided that you exercise sufficient care in handling it, and allow no opportunity to occur for the ensilage to contaminate the milk after the milking. So it is with all other ferments. It is not the food that the cow eats that produces the fermentation, but it may be the food that is in the barn, and is being constantly stirred up so as to keep the air full of floating bacteria. These may get into the milk and produce trouble, and they will be avoided by letting the hay alone or doing the milking out of the proximity of this troublesome food. The cow may eat it with impunity. The remedy is not to change the food but the conditions of the milking-yard and the dairy.

Do not understand that I would infer that the food the cows eat has no influence on the taste of the milk. There is no question that if the cows eat a strong-tasting food like garlic, the taste is transferred to the milk. But this is a very different thing from the production of fermentation. The taste produced by such food is at its maximum as soon as the milk is drawn, while in the case of a fermentation the effect is an increasing one, being absent at first, but appearing as the bacteria have chance to grow.

While thus it is seen that the unusual fermentations have long been ascribed to the action of bacteria or something else getting into the milk which does not belong there, this has by no means always been supposed to be true of the common souring of milk. The souring is a universal and not an occasional thing, and there seemed for a long time to be no way to prevent it. So long ago as 1844 bacteria were found in souring milk, and it was even then suggested that the souring was due to them. In 1850 again the fact was reaffirmed. Pasteur commenced his work on milk about 1860, and finding that he could prevent the souring by subjecting the milk to a high heat, and, moreover, being always able to discover in it numerous bacteria, he insisted that even this common fermentation was due to these organisms. The statement did not go unchallenged, however, and for the next ten years there were conflicting results. In 1874, and later, Lister and Hall succeeded in procuring milk directly from the cow with such precautions as to avoid chance of contamination by bacteria, and they found that such milk remained sweet indefinitely without showing any tendency to undergo even the souring fermentation. After this there could no longer be any question in regard to the matter, and we may therefore ascribe the souring of milk to the same class of causes as those producing the more unusual fermentations.

It may seem somewhat remarkable that bacteria should so universally get into milk. But the fact is that they are very abundant everywhere. They are in the air, in the milk vessels, on the hands of the milker, on the hairs of the cow, and above all they will be inside of the milk duct, extending for a short distance from its mouth. Some milk will always be left in the mouth of the duct, and in this milk the bacteria will grow and remain there ready to contaminate the next milk that comes out. The number of bacteria in milk is very great, and I can hardly believe the figures which are indicated by my own experiments. I have found in milk which has been only two or three hours drawn from the cow as many as 20,000 to 40,000 to each teaspoonful of milk. These numbers are surprising, but they are not so large as have been found by certain German experimenters. In milk that has been standing for a little while they increase wonderfully, so that by the time the milk reaches the city their number is prodigious. I suppose no one in a city ever gets milk to drink that contains a smaller number of bacteria to the teaspoonful than there are inhabitants in the United States according to the last census.

We are now ready to pass to the third head of the subject, the prevention of the fermentations. As I stated at the outset, I have no royal prevention to recommend for this, and can hope only to throw out some suggestions which each may apply to its own special troubles. We may set aside the fermentations produced by rennet, and the alcoholic fermentations, because these are always produced by adding something to the milk, and may therefore be easily prevented.

Now, if all other fermentations are due to the growth of bacteria, we have only to keep them out of the milk in order to prevent them. This is, however, entirely impracticable. The bacteria are so abundant, and they lurk in so many places, that no practical method can be adopted to prevent them from getting into the milk. Especially is this true of the souring species. We find that the souring of milk is produced by a number of species of bacteria, and these are marvellously numerous about the barn, and more particularly in the dairy. Perhaps care may lessen their number, but it cannot do away with them altogether.

This is not true, however, with regard to the bacteria which produce what I have called the abnormal or unusual fermentations. The bacteria which produce slimy milk, bitter milk, blue milk,

etc., are not common in the dairy, and they may be kept out of the milk by using sufficient care. Their home is in filth, and they are usually troublesome because of uncleanness. Go to an ordinary cow shed and look at the conditions surrounding the cows. The cows are usually covered with filth, and are practically never clean. They wander at will through the day in swamps, or any muck that they may happen to find, and have every facility for dragging their teats through the mire, or they lie in the mud, and thus insure the fouling of the bag and teats. At night they have no choice except to lie in filth. The farmer goes to the milking in a condition frequently almost as dirty as the cow, and uses vessels which are never thoroughly cleaned. What better chance could there be for filth bacteria to grow? If there are any troublesome bacteria around, they will be sure to get into the milk in some way, and the wonder is not that milk sometimes undergoes troublesome fermentations, but that we ever succeed in getting milk fit to drink. These are usually the causes of the troubles that the farmer has with his milk.

I have in mind now a cheese factory which was at a certain season troubled with a badly-tainted milk, and this finally became so troublesome as to interfere with its business. A man with a pair of bright eyes was set to work to discover the cause of the trouble. He soon succeeded in tracing it to the milk of a single customer. If the milk brought by this man were kept away, the rest remained all right. Examining into the conditions of this patron's farm, he found that the cows were in the habit of wandering through a slimy swamp, and that the material from the swamp would get into their hair and teats, and hence in the milk. This was the sole cause of the trouble, for as soon as the cause was removed, the milk was good again.

I repeat, then, that the abnormal fermentations of milk can be prevented by using sufficient care. The time is coming when the farmer will be ashamed to own that he is troubled with slimy or bitter milk, for it will be regarded as indicating a lack of sufficient care and cleanliness in the arrangements of his barn. Keep your cow sheds clean, clean the cows themselves, give them clean beds to lie on, wash their teats, sand the floor, let a little of the first milk that runs out of the teat fall to the floor instead of into the milk vessel. If you want to convince yourself of the value of this last procedure, try the experiment of letting the first milk run into a separate vessel, and then see how much sooner it will sour than the rest. The first milk that comes out partly washes the milk duct, and hence contains the bacteria in great numbers. Clean your hands before you milk, and, above all, exercise more care in cleaning the vessels in which you milk. These cannot be sufficiently cleaned by a simple short scalding with hot water. Boil them once in a while for a long time on the stove, and you will find the time well spent.

These, then, are the remedies for all of the unusual fermentations, and every one must apply them for himself. It is impossible to tell beforehand where the trouble lies in your special case. It may be in the condition of the cow, or in the condition of the food, or the milker, or in the dairy itself; but, if you only look carefully for it, you will always find the mischief lies somewhere, and can be avoided by the exercise of sufficient care.

It is as important to make a careful toilet for the milking shed as for the supper table. Indeed, is it not more so? At the table a little dirt will produce no special trouble, but in the milking yard it may entail much trouble on yourself, and all using your milk in any form.

All of this will not, however, prevent the ordinary souring of milk. In spite of the greatest care, the bacteria which cause the lactic fermentation will get into the milk, and there is no practical way of avoiding them. Is there, then, any way by which the souring of milk may be prevented?

We may first ask if we cannot kill the bacteria after they get into the milk, for if this can be done, of course the milk will not sour. The simplest suggestion is to find some chemical which will kill them. It is easy enough to find such a chemical. Corrosive sublimate will poison them, and will also poison any one who may subsequently drink the milk. Of course such a violent poison will not answer. It is necessary to find something that will poison the bacteria and at the same time be harmless to man. One of the first substances ever used for this purpose was horse-radish. More than fifty years ago it was stated that horse-radish would prevent milk from souring. But when we drink milk we want it to taste like milk, and not like horse-radish. The poison used for preserving milk must, then, not give a taste of its own to the milk.

Within the last few years several chemicals have been tried for this purpose with some little success. Those most used are carbonate of soda, borax, boracic acid, salicylic acid, quick-lime, and some others not so common. In regard to these, we may summarize the results of recent experiments briefly as follows: Salicylic acid is of the most use in delaying the souring of milk. It can be used in proportions of 1–1000, about a teaspoonful to a gallon of milk. Borax comes next in value. It may be used in proportions of 3–1000, about three spoonfuls to a gallon. When used in these proportions, the two preservatives mentioned will assist the milk in keeping sweet for a short time longer than if they were not used. None of the others seem to be of any value, or at least of not enough to make it worth while to use them. Most of the preservatives sold in the market to-day are some compounds of these chemicals, and it is just as well for the farmer to buy the borax or salicylic acid pure, as to buy the patent mixture, and pay the price of the patent. At best, however, the use of chemicals for preserving milk is very limited, and it is not recommended to-day by any who have made a study of the fermentation of milk.

The method of milk preservation most commonly in use is that of heat. It is well known that high heat will kill all living things, and, of course, if milk be heated hot enough, the bacteria in it will be destroyed. It is found, however, that a temperature of boiling is not sufficient to kill all of the bacteria in milk. The bacteria in milk are in two different conditions. Some of them are active, perhaps swimming around in the milk, and are always rapidly growing. Others are in a dormant condition, which is known as a condition of spores. The spores correspond in a measure to seeds, and although they are dormant, each one has in itself the power to germinate and produce anew the active form of bacteria. Now it is found, that, while the temperature of boiling will kill all of the active forms, it will not kill the spores. To kill these by heat, the milk must be heated under pressure, since this renders it possible to obtain a higher temperature. A temperature of 230° F. will destroy these spores, and render the milk absolutely without life, absolutely sterile. Such milk will keep indefinitely without souring or undergoing other fermentation.

Of course it is not an easy matter to heat milk under pressure, and some other method of accomplishing the same purpose is desirable. It is found that a long continued boiling at the ordinary pressure of the air will sterilize the milk. It is also found that sterilization may be accomplished by what is called discontinuous heating. This is simply heating the milk to a temperature of boiling for a short time on several successive days. If milk be placed in a bottle and boiled a few minutes upon three successive days, it will be sterilized and remain subsequently without bacteria growth.

Based upon these facts regarding sterilization, a large number of forms of apparatus have been invented for conveniently accomplishing the heating. Several sterilizers of milk are on our markets, and still others in Europe. One of the simplest methods of sterilization is within the reach of every one. Place some milk in bottles with long necks and plug the neck with a wad of cotton wool. Then place the bottles in a common steamer, with which almost every house is provided, and steam the milk for an hour. This may not absolutely sterilize the milk, for a very few bacteria in the form of spores may be left alive. But it will so nearly accomplish the purpose that the milk will keep perfectly sweet for many days, and may be carried on a journey with impunity, provided the cotton plug is not removed. If desirable, a common cork can be put in the bottle on top of the cotton plug, to prevent the spilling of the milk.

The use of sterilized milk is rapidly becoming common. A few years ago no one ever heard of it, but now, especially in the cities, where it is impossible to get fresh milk, its use is growing rapidly. In the case of sickness affecting the digestive organs, doctors are

learning to recommend that all milk should be sterilized. Indeed, doctors have for a long time been accustomed to recommend boiled milk to patients, but formerly from a mistaken idea. It was always supposed that boiling the milk rendered it more digestible, just as cooking other food makes it more easy to digest. Within recent times, however, we have learned that boiled milk is not more easily digested than fresh milk, but, on the contrary, that it is far less easily digested. If an animal is fed with a certain quantity of boiled milk, and subsequently with an equal quantity of fresh milk, he will digest and absorb only about two-thirds as much of the boiled milk as of the fresh milk. The reason that boiled milk is better than unboiled milk for invalids is because of the presence of bacteria in the latter. In our cities, as we have seen, these are extremely abundant in all milk; and although to the ordinary healthy person they are harmless, they may be a source of irritation to one whose digestive organs are out of order, and therefore in an irritable condition. It is believed that nearly all of the cases of cholera infantum in our cities are due to the bacteria present in the milk drunk by infants. Nursing children are much less liable to have the disease, since they obtain their milk fresh and free from bacteria. It is not surprising that the doctors in our cities are learning that one of the first things to do in the case of intestinal diseases is to prevent the patient from taking in the large quantities of bacteria which he would swallow with unsterilized milk. I know of one doctor who goes further, and furnishes his patients with sterilized milk in order that he may be sure they obtain it.

There are two disadvantages in sterilizing milk by boiling. The first is that the milk is not thereby completely sterilized, and is likely to undergo some fermentation after a time. This is not a very serious matter, however, for the milk thus sterilized is pretty sure to be used before any of these fermentations occur. Milk that is sterilized is not usually intended for long preservation, but for using immediately, or, at least, within a few days. This being the case, it is not a matter of much importance if some of the spores of the resisting bacteria should be left in it in condition to set up a fermentation after a week or more.

The other disadvantage is a more serious one. The milk thus sterilized has not the taste of fresh milk. Every one is acquainted with the taste of boiled milk, and we all know that it is not so pleasant as that of fresh milk. To some it is quite disagreeable, and children frequently will not touch it. Now, any sort of sterilization by boiling is sure to cause the milk to acquire this taste of boiled milk. This taste appears at about the temperature of 160° F., and, since all methods of sterilization by heat raise the temperature much above that point, the taste of boiled milk is always found accompanying such sterilization.

Now, there is a method of sterilizing milk which avoids the production of this taste, but it is long and tedious. If the milk be heated to a temperature of 155° F. for twenty minutes upon six successive days it is commonly found to be sterilized, and, since it has not been heated to 160°, its original taste will be preserved. Such a process is, of course, too long to be of any practical value, except for scientific experiment.

The fact is, that with our present knowledge, there has been devised no way of sterilizing milk without either producing the disagreeable taste of boiled milk, or being so long about the process as to render it of no value in practice.

It is, however, possible to produce, with ease, a partial sterilization. It is frequently of great value to one dealing with milk to delay the souring as long as possible, and if this fermentation can be put off for a few hours even, it may prove of great use. There has been invented in Paris a method of treating milk which accomplishes just this. It is known by the name of pasteurization. It consists simply in heating the milk for a few minutes to a temperature of about 155°, or a little higher, and then rapidly cooling it. The short heating does not indeed kill all the bacteria that are in the milk, but it does very much diminish their numbers. So much does this heating check the bacteria growth that it is found to delay the fermentation of milk from twenty-four to forty hours. Of course such a delay as this is of the greatest value in our cities. For accomplishing this pasteurization several machines have been invented, all of which enable a large amount of milk to be heated in a short time. In some the milk is caused to run over metal plates that are kept hot by steam; in others the milk is in a large vessel and the steam conducted into the vessel in a coil of pipes. All of them accomplish the same purpose, but not with equal facility.

There is one advantage arising from pasteurization which renders its practice even more valuable. It is found that nearly all, if not quite all, of the pathogenic disease germs which are likely to occur in milk, are killed by the pasteurization. It is well recognized to-day that some of our dangerous epidemics are transmitted from house to house by means of milk. Milk furnishes a good medium for their growth, and has every chance of becoming contaminated. In cities epidemics of typhoid have been repeatedly traced to the milk supply. Now, if pasteurization is sufficient to kill these disease germs, and if at the same time it delays the souring from twenty to forty hours, and if the milk thus treated retains the taste of fresh milk, and permits the cream to rise on it in the natural way, it is plain that pasteurization is a process which is highly to be recommended. It is not surprising that in Paris, and in some of the large cities of France and Germany, pasteurization of milk is becoming more and more common. In Paris it is a regular business, and pasteurized milk is sold at a trifle advance over the price of ordinary milk. People are beginning to prefer it, since it keeps so much better, and is so much safer, and withal has all of the good qualities of fresh milk. It has been suggested that pasteurization of milk in cities should be required by law. So far as I am aware the pasteurization of milk has not yet been introduced into America.

Lastly, a word in regard to the value of cold in delaying fermentation. Every one knows that milk will keep longer if it is kept cool, and it can be preserved almost indefinitely when frozen. But every one is not aware of the great value of a temporary cooling of milk. When milk is drawn from the cow it is at a high temperature, and is, indeed, at just the temperature at which the bacteria will grow the best. The bacteria which get into the milk during the milking, therefore, begin immediately to multiply with great rapidity. If, however, the milk be cooled to as low a temperature as possible, it will take several hours' exposure to the ordinary temperature of the air to bring it back again to the condition where the bacteria will grow so rapidly. Indeed, except in the very hottest summer weather, it will not again become so warm as when it left the cow, and hence will not again offer such a good chance for bacteria growth. It follows, then, that a cooling of the milk immediately after milking is of the greatest possible value in enhancing its keeping properties. Milkmen should remember that half an hour's cooling of the milk, or even less than that, immediately after milking, will save several hours in the souring time, and in hot summer weather this fact should be remembered as one of the best methods of assisting in supplying customers with good milk.

Allow me now to summarize the important points which have attracted our attention this afternoon:

1. The fermentations of milk are varied, although only a few are commonly recognized because the souring of milk usually obscures all other fermentations.

2. All of the fermentations except the fermentations of rennet are caused by micro-organisms getting into the milk after milking and growing there.

3. The micro-organisms are so abundant around the barn and dairy that they cannot be kept out of the milk by any amount of care.

4. The bacteria which produce the abnormal or unusual fermentations, like slimy milk, bitter milk, etc., are, however, not so common but that they may be prevented from entering the milk in sufficient quantities to produce serious trouble.

5. Filth is ordinarily their source, and cleanliness the means of avoiding them.

6. The souring of milk cannot be prevented even by the greatest cleanliness.

7. Salicylic acid in proportions of 1–1000 may be of some little value in delaying the souring, but its use is not to be recommended except in special cases.

8. Milk can be entirely deprived of bacteria by the exposure to

a temperature of fifteen to twenty degrees above boiling water, or by a long-continued boiling, or by a series of short boilings on successive days.

9. Such milk has the taste of boiled milk. This taste appears at about the temperature of 160° F. Hence has arisen the method of pasteurization of milk. By this method it is heated to a temperature of 155° F. for a short time, and then cooled. This greatly delays the fermentations, and also kills the pathogenic germs that may be present.

10. In our large cities the popularity of sterilized milk is rapidly increasing, especially in the case of milk given to patients troubled with diseases of the digestive organs.

11. A cooling of milk immediately after it is drawn from the cow is of the greatest assistance in delaying the fermentation, and is probably the most practical method which can be recommended according to the present state of our knowledge.

HEALTH MATTERS.

Sneezing One's Teeth Out.

THE report of the physician in charge of the Ningpo Missionary Hospital for the past year, says the *British and Colonial Druggist*, contains some interesting observations on tooth-drawing in China. Dr. Daly remarks that Chinese teeth are much more easily extracted than those of Europeans. The native dentists are said to possess a wonderful powder, which is rubbed on the gum over the affected tooth. After an interval of about five minutes the patient is told to sneeze, whereupon the tooth falls out. Dr. Daly has offered a reward of $100 to any one performing the operation in this way in his presence, on condition that he is allowed to choose the tooth and examine the mouth before and afterward. So far no one will consent to perform the operation on these conditions.

Alcohol and Digestion.

From experiments made on himself by Dr. Eichenberg, says the *Medical and Surgical Reporter*, some further knowledge of the effect of alcohol on digestion is obtained, which contrasts strongly with the teetotal lecturer's experiment showing how digestion in a glass vessel is retarded by alcohol. Dr. Eichenberg found that a small dose of strong alcohol — e.g., brandy — shortens the time that food in general, whether animal or vegetable, or a mixture, remains in the stomach by more than half an hour. A similar but not quite so marked an effect is produced by a dose of diluted hydrochloric acid or mustard. Pepper and condurango diminish the time the food remains in the stomach by about a quarter of an hour. Beer and an infusion of rhubarb had no effect.

LETTERS TO THE EDITOR.

**** *Correspondents are requested to be as brief as possible. The writer's name is in all cases required as proof of good faith.*

The editor will be glad to publish any queries consonant with the character of the journal.

On request, twenty copies of the number containing his communication will be furnished free to any correspondent.

American and European Meteorology.

FROM time to time discussions have appeared in foreign journals comparing weather conditions and laws of storms in Europe with those in America. These have often shown a remarkable difference between the results announced abroad and those found in this country, and it has been a matter of great difficulty to determine the exact cause of the discrepancies. In the matter of the recent animated discussion as to the temperature at some height in the atmosphere in high areas and storms, it has been suggested already that most of the differences are due to the fact that in Europe the ordinary paths of storms are far to the north-west, over Iceland; and in consequence none of the conditions experienced in this country, on the passage of a storm over a mountain, could be studied in the south-east quadrant of storms in Europe (see this journal, June 6, 1890, p. 346). A very interesting illustration of this point has just appeared in *Meteorologische Zeitschrift* for April. Dr. Hann reviews a paper by Professor Russel, "Prediction of Cold-Waves," originally published in the *American Journal of Science* for December, 1890, and closes with the following words:—

"Of the fact, that the principal cause of cold in winter is local heat-radiation at the earth's surface, the author has no foreboding (*Ahnung:* there seems to be no exact English equivalent), which indeed can scarcely be believed, since his own discussion sets it forth with such certainty. This discussion has only a negative value in that it shows how one, in setting up a rational system of weather forecasting, should not go too far in its seeming certainties." It is not my purpose, nor is it necessary, to defend Professor Russel in his position; but Dr. Hann's view is founded on so faulty a process of reasoning from known conditions in Europe to those which are supposed to exist in this country, that it should not be allowed to pass without comment.

I have already given in this journal (Feb. 27, 1891, p. 121) a statement of the conditions accompanying cold-waves in this country, and it seemed wise to make a partial study of cold-waves in Europe. To this end I first selected out all the cases during December, January, February, and March, in the years 1881–89, which showed a fall of 10° C. (18° F.) in twenty-four hours at Vienna, Austria. It should be noted that the cold-wave discussed by Professor Russel was a fall of at least 20° F. in twenty-four hours, and a temperature reaching 36° or below over an area of at least 50,000 square miles. Dr. Hann says he does not understand this 36°, and suggests that it may mean 36° below zero! This is most extraordinary, and shows how extremely deficient is the knowledge on this subject in this case. No cold-wave of this character has occurred in this country in the last ten years. Dr. Hann probably has in mind the cold of a Siberian winter, where temperatures of —70° are often experienced. The following comprise all the temperature-falls of 18° F. at Vienna: (1) Jan. 14, 1881, from 25° F. to 7°; (2) Dec. 29, 1882, from 48° to 30°; (3) Jan. 31, 1884, from 50° to 32°; (4) Feb. 28, 1886, from 26° to 7°; (5) March 3, 1888, from 33° to 15°; (6) Feb. 12, 1889. On examining the weather-maps for these dates, it was very quickly found that there is absolutely no comparison between the temperature-falls in Europe and those in this country. In most of the six cases there was a high area to the south, and almost a calm; the conditions were favorable for radiation from the earth; but in no single case was there a cold-wave. In (4) there was a high area to the north; but here only one other station, out of fifty-eight all over Europe, reported a fall of 18° F. In not one of these cases was there a fall of temperature over a large region, but it was almost entirely confined to single localities in a very large region, and was manifestly due, as Dr. Hann suggests, to radiation from the earth. In this connection it will be an interesting contrast to give a summary of cold-waves in this country found by Professor Russel between the years 1880 and 1889, statistics of which have been published in the "Annual Report of the Chief Signal Officer for 1891." The total number counted is 619, or an average of 62 in each year. Five of these cold-waves had a fall of 20° F., extending over a region more than 1,000,000 square miles in extent, and in eighty-seven cases the same fall occurred over more than 500,000 square miles.

It is well known that our cold-waves are due to the rather rapid passage across the country of a storm which is followed by a high area. Wherever the cold air may come from, only a very small proportion of it is due to heat-radiation, the principal cause suggested by Dr. Hann. It seemed advisable to study the storms and high areas passing over Europe. I took out all the cases in which these conditions were near Sonnblick during all the months 1887–89. There were fourteen storms and twenty-six high areas. Of these, only one storm, on Oct. 22, 1889, had any thing like the characteristics of storms in this country. In all the three years there was not a single high area that was similar to those experienced here. The evidence furnished by this study was most remarkable, and showed that no comparison whatever can be instituted between these conditions and their accompaniments in the two countries.

In 1884 there was established a high-level observatory at Ben Nevis, in Scotland, over 4,000 feet in height. A great deal has been expected from this observatory, lying as it does almost in the pathway of depressions unheard of in any other part of the