- BACTERIA in DRINKING WATER. -

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Pure drinking water is a requisite of good health. Therefore the condition of our drinking water should interest us all. Although bacteria are found most everywhere in external nature, water is one of the best media for the transferance of bacteria. It is of hygienic and economic importance that we know about the condition of our drinking water.

The bacteria in drinking water are of economic importance because the health of a community depends upon the water which the people drink. Polluted water is usually the source of contaminating of such diseases as typhoid fever and Asiatic cholera. The bacteria which may be found in a certain water supply is not only of importance to the bacteriologist but is of the greatest importance to practical hygiene. There has been outbreaks of typhoid fever in recent years caused by contaminated water. One example of an outbreak of typhoid fever was at Ithaca, New York in 1902.

The methods of contamination of the water supply are many. Surface drainage is an important and very common method of contamination of our drinking water. Rivers, creeks and wells that receive surface drainage are usually more highly polluted than deep drilled wells and springs. Artesian wells are almost free from bacteria, as are also springs from chalk strata. The washing of cultivated lands carries organisms easily. A common mode of contamination of river water is sewage, while wells may become infected either from the surface or by seepage from manure piles, cess pools and privy vaults which are too frequently found in the immediate vicinity of the well. The water may become very highly infected with numerous organisms but if there is not enough organic matter in the water they are compelled to die. This, however, is very rarely the case. Water forms one of the best means for the distribution of bacteria. They may be carried by the rivers, rain, snow or springs and it might be said that ice and snow are by no means free from bacteria.

When entering upon a bacteriological analysis of water one of the most important and particular steps is the collection of the samples. Simple as it may seem it is sometimes a difficult and responsible undertaking. The sample should be chosen as near a fair representative as possible of the water which is to be examined. It is necessary to observe strict bacteriological precautions in our manipulations. It is also wise to take a history of the sample. After collecting a fair sample one should proceed immediately to make innoculations from it because of the fact that bacteria multiply very rapidly. If it is desired to determine the kinds of organisms in the sample collected first inoculate two or three tubes of liquefied agar with a loop of the water and then pour the warm inoculated agar into sterile petri dishes and allow the organisms to grow. After the colonies are well developed innoculate a tube of bouillon from each of the different colonies. From each tube of bouillon inoculate a full set of media and thus obtain cultural characteristics of each organism. If it is desired to compute the number of organisms in a given sample proceed as when isolating the organisms except use a measured amount of water to innoculate the agar plates and by counting the colonies compute the number of organisms per c.c. in a given sample. The bacteriological contents of various waters can by no means be determined by the odor, color or appearance. Because a water has a bad odor or taste is no proof that it is not pure bacteriologically. People have been very much deceived by thinking that their water supply is pure because the taste is good and appearance clear. Absolute knowledge as to the purity of water can only be determined by a scientific investigation.

There are several conditions which enter into the rate at which bacteria multiply. The temperature at which bacteria grow best, varies much. Some thrive best at blood or animal heat while others grow best at a much lower temperature. The freezing of water is no proof of its purity as some persons may imagine. For instance it has been proven that the typhoid bacillus is not only present in ice but is able to cause the disease. The freezing of the water only retards their growth, but continual freezing and thawing will kill bacteria. Another necessary requirement to the multiplication of bacteria is nourishment. Water which contains a large amount of organic matter is much more favorable to the development and growth of bacteria. Bright sunlight is detrimental to the growth of bacteria. Some bacteria grow in the presence of air or oxygen while others thrive best without oxygen. The number and vitality of bacteria in drinking water varies much at different seasons and under different climatic conditions. It is interesting to note that the number of organisms in a given sample of water which contains relatively few bacteria will increase much more rapidly than one that is more highly contaminated and that there is a limit as to the number of bacteria that certain water will support. It is also known that after water has supported the multiplication of a particular species of micro-organisms, the later, on being re-introduced into the same water will suffer rapid destruction. Thus the water which has been affected with a plague of a particular microbe acquires immunity towards further attacks of the same organism.

A number of bacteria possessing pathogenic properties of the most pronounced character, have been detected in natural waters from time to time. The common mode of isolation is one way to detect pathogenic bacteria in water. By special methods for the discovery of particular forms some of the most important advances have recently been made. Some time ago there appeared in the "Journal of Applied Microscopy" an account of a method for detecting typhoid bacillus in water. It was discovered by a German scientist. I performed the experiment which is as follows: Take a flask of sterile bouillon and a Chamberlain filter. Put the typhoid culture of water or bouillon into the filter (being careful not to get any on the outside of the filter) and set it into the flask of sterile bouillon and insert the plug immediately. Set the flask in the incubator and keep at about 37° C and within six to twelve hours the bouillon in the flask will become clouded. The principle is that the typhoid bacillus will pass through the filter more rapidly than the others. I used a bouillon culture of the typhoid bacillus when I performed the experiment and met with success. It is a question, however, that no other bacteria will pass through the porcelain filter almost as soon.

We have been speaking of the methods and sources by which our drinking water becomes infected and we will now consider the ways by which we may purify our drinking water. Rivers purify themselves as they proceed. This is an observed fact but authorities differ with regard to the mode of self-purification. The movement and pressure of the running water is believed to influence the vitality of certain microbes. The sun light no doubt is bactericidal but there is dispute as to the depths which the sun's rays will penetrate water. Most authorities agree that subsidence of impure matter and their subsequent disintegration at the bottom is a cause of self purification of water. Oxidation is another agency by which running water is purified. There are several ways of purifying water by filtration. The sand filtration is the most extensively used method of filtration. The whole London water supply is filtered by sand. The principle factors influencing the number of microbes passing through the sand are the thickness of the fine sand, rate of filtration and the renewal of filter beds. The sand bed should be at least three feet thick. It is the slimy organic layer on the surface which removes the micro-organisms. There are many commercial filters which are more or less effective. By distillation we obtain the purest water possible but the distillation of water on a large scale for common use is scarcely practicable. By thorough boiling we either kill or attenuate most all bacteria and this is a very good way to purify water for domestic purposes. There are chemical means of purification of water which are also very effective. A very recent method is by means of electricity which when passed through water in large enough quantities has a decided bactericidal effect. Whether it is an economic process yet remains to be proven.

The consideration of the cultural characteristics, with drawings of the organisms isolated during this investigation will now be taken up. It appears that the majority are micrococci with the bacilli coming next in prominence.

Plate I. Fig. 1. - B. PYOCYANEUS. The organism is a slender rod with round ends. It is quite widely distributed but is always present in the green pus of wounds. It is motile and does not form spores. It is aerobic and grows well on all ordinary media. In bouillon it causes a turbidity with a slight sediment. In gelatin the liquefaction takes place slowly with a greenish color and a white yellowish band between the solid part and that liquefied. Milk and litmus milk is coagulated and acid. On agar it causes an abundant moist growth of a green color and the media below also becoming colored. On potato the growth is a greenish brown which becomes green around the edge of the growth. Isolated from an old well.

PLATE I. Fig 2. - B. RECTICULARIS. They are slender rods and may occur in chains. The agar colonies are large, spreading and transparent. In bouillon there is a turbidity and slight sediment. Gelatin is liquefied with a good growth on the surface. On agar the growth is dry and dull. Litmus milk is colored red and is coagulated. On potato the growth is dry, dirty white and becoming crumpled. Isolated from the tap water.

PLATE II. Fig. 1. - B. CLOACAE. This bacillus is a short rod and is not very actively motile. No spores could be seen. They occur alone and in clumps but never in chains. On agar the growth is white and quite abundant. On potato the growth is slightly yellowish. Milk is coagulated after two or three weeks and becomes acid. In bouillon a pellicle is formed the liquid remaining turbid. On gelatin there are gas bubbles formed and a slow liquefaction of the shape of a turnip, with a gray colored growth on the surface. It develops gas in glucose agar. The agar colonies are white, clear and spreading. This organism I isolated from well water. It is said to be now pathogenic.

PLATE II . Fig. 2. - B. VULGARIS. This organism is a comparatively long rod. Motility is very marked. The agar colonies are small and lemon colored. On agar the growth is white, glistening and slimy. On potato the growth is glistening and yellowish. In bouillon it causes a turbidity, a sediment and a pellicle. Milk is coagulated and colored yellowish. Isolated this bacillus from well water.

PLATE III. Fig. 1. - M. FUSCUS. This is a round and comparatively small organism. The agar colonies are large and grayish white. On agar there is a white growth. In bouillon a slight pellicle is formed, the liquid remaining turbid. On potato the growth is dark brown and slimy. Gelatin is liquefied rapidly with a gray pellicle. Cultures of most all media have a fetid odor. Isolated from an old well.

PLATE III. Fig. 2. - M. LUTEUS. This is a very regular round coccus. The agar colonies are raised with greenish white centers and clear edges. On agar the growth is moist and of a red-yellow color. On potato the growth is wrinkled and salmon colored. Gelatin is slowly liquefied. Bouillon remains clear with a yellowish-red colored sediment. In milk it forms a red-yellow colored pellicle and is acid. Isolated from an old well.

PLATE IV. Fig. 1. - M. FREUDENREICHII. This organism is a large round coccus which usually occurs alone. The agar colonies are small and white colored. On agar the growth is white. Gelatin is soon liquefied, is turbid and has a flocculent pellicle. A bright yellowish brown growth on potato. In bouillon a slight turbidity and heavy sediment. Milk is acid and coagulated. Obtained this organism from water.

PLATE IV. Fig. 2. - M. OVALIS. This organism is a short oval coccus. The agar colonies are small white colonies. On agar there is a very scant growth. On potato the growth is raised and of the color of the potato. In bouillon there is a slight sediment. Milk is coagulated and very acid. Gelatin is not liquefied and scarcely no growth. Isolated this organism from the College pump water.

PLATE V. Fig. 1. - BACT. RADIATUM. This organism is a short thick rod and generally occurs singly. Gelatin is liquefied with white pellicle and turbid. On potato the growth is thick, raised and of brownish white color. On agar the growth is pure white and glistening. Milk is coagulated and acid. In bouillon is formed a pellicle and slight turbidity. Obtained this organism from an old well.

PLATE V. Fig. 2. - BACT. THERMOPHILUM. This is a very varied organism, there being several species. They are large rods and occur sometimes in filaments. The agar colonies are colorless and start from a common outgrowth. On potato there is a yellowish brown growth. On agar a dense white opaque growth. Milk is coagulated. In bouillon there is a crumpled membrane and slight sediment. Gelatin is liquefied with a heavy white sack-like growth on surface. Isolated this organism from an old well.

PLATE VI. Fig. 1. - SARC. LACTIS. This organism is a small coccus appearing in fours. They grow well at room temperature. The agar colonies are round, brownish gray colonies. On potato the growth is scant and of yellowish color. On agar the growth is bright brick yellow color and raised. Bouillon remains clear with slight sediment. Milk is not affected. Gelatin is liquefied with growth, all through the media, of a granular appearance. This organism was isolated from an old well.

PLATE VI. Fig. 2. - SARC. PULMONUM. These are round organisms appearing in tetrads or cubes . It grows slowly on most all media. The agar colonies are round pinkish red colonies. In bouillon there is a slight sediment and media clear. On agar the growth is slight on surface with good growth in depth. On potato there is scarcely no growth. Gelatin is slightly liquefied and clouded. This organism was isolated from well water.

PLATE VII. Fig. 1. - PS. PUTIDA. These are short small bacilli. The agar colonies are round brownish gray colonies. On agar there is a white glistening growth. Gelatin is not liquefied but has a white greenish growth. Onnpotato there is a grayish brown growth. Isolated from a well.

PLATE VII. FIG. 2. - STR. CITREUS. These are large cocci occuring singly and in chains. The agar colonies are large and of a reddish yellow color. On potato the growth is yellowish colored. On agar a slight yellow colored growth. Gelatin is not liquefied but there is a growth in depth of the media. Bouillon is not changed. Isolated this organism from the tap water.

PLATE VIII. Fig. 1. - NEW ORGANISM. This organism was not found in any of the manuals. It is undoubtedly a new organism. It is streptococcus appearing in long chains, the individual cocci being very small. They stain easily. One very characteristic feature of this organism is the fact that the growth on most all media produce a pink red color. On agar there is a moist pink-red colored growth on surface with spreading thread-like growths in depth. Gelatin is not liquefied but a pinkish growth appears on the surface. In bouillon there is a heavy pink sediment and media is a little turbid. Milk has a pellicle on the surface which adheres to the tube and is not coagulated. Litmus milk has about the same characteristics as milk. On potato a moist elevated pink growth. The colored growth throughout all the media is a very peculiar feature of this organism.

PLATE VIII. Fig. 2. - This organism closely resembles the M. Xanthogenicus but differs a little in growth on some media. It is a small cocci appearing in clumps, pairs and alone. The agar colonies are round and grayish white. Gelatin is liquefied with white sediment and turbid. White growth appears on agar with opaque growth in depth. On potato there is a good white growth. In bouillon there is a heavy white sediment with not much turbidity. Milk is not changed. This organism was isolated from a well.

The following are the results of the experiments made, to determine the number of organisms in different drinking waters of

Manhattan. Where computing the number of organisms it is best to use one-tenth of a cubic centimeter for each plate. For most ordinary water this amount will not be too much.

The tap water was the first examined which contained 360 organisms per cubic centimeter.

The College pump water contained 2,980 organisms per cubic centimeter.

One old well contained 3,030 per. cubic centimeter while another old well contained 3,715 per. cubic cantimeter.

A cistern without a filter contained 16,490 per cubic centimeter.

It can now be understood that the drinking water of Manhattan does not contain any very pathogenic bacteria although the number of organisms present in most of the water is too great. The tap water seems to contain less bacteria than any of the well water. Cistern water, as a usual thing, is very highly polluted. In conclusion it may be said that the tap water is the best water hygienically.

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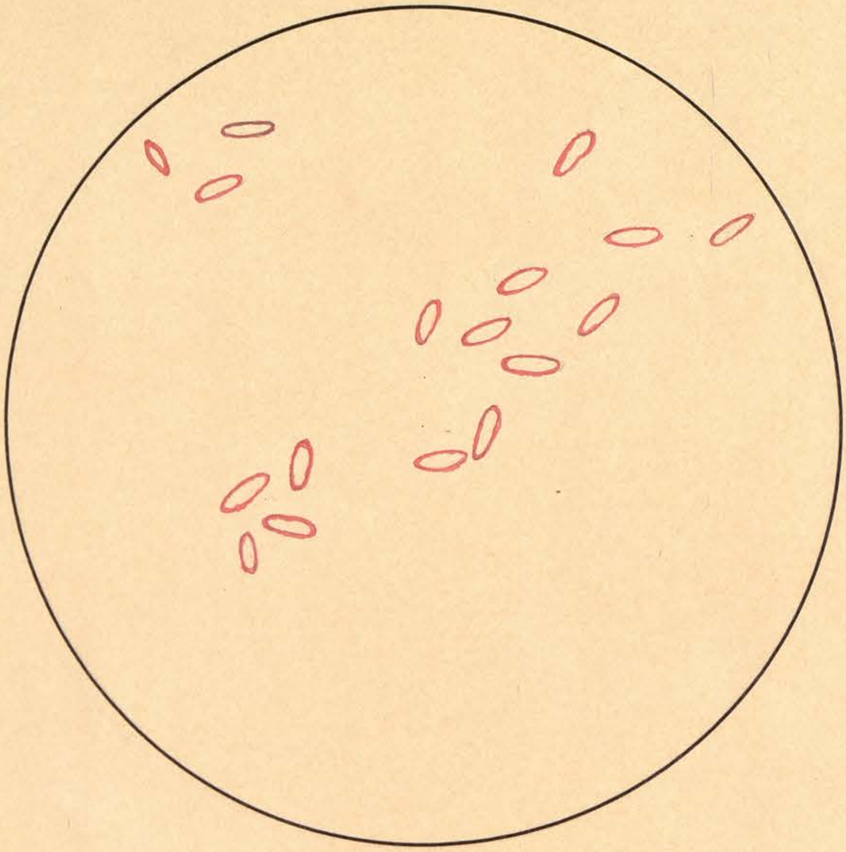
Plate I.



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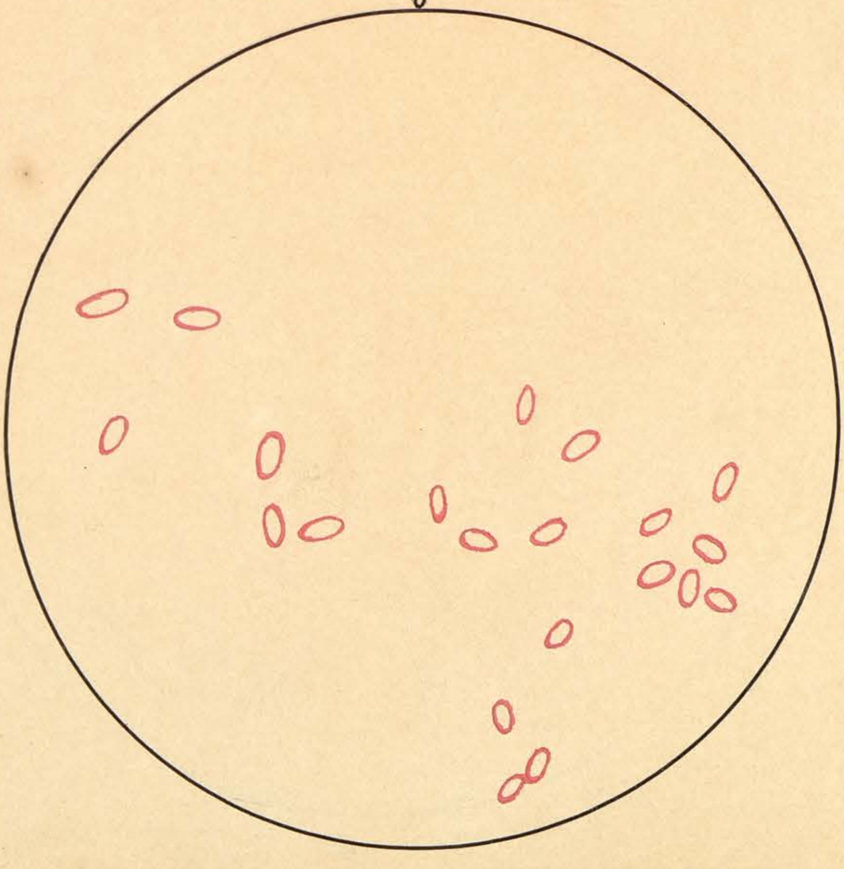

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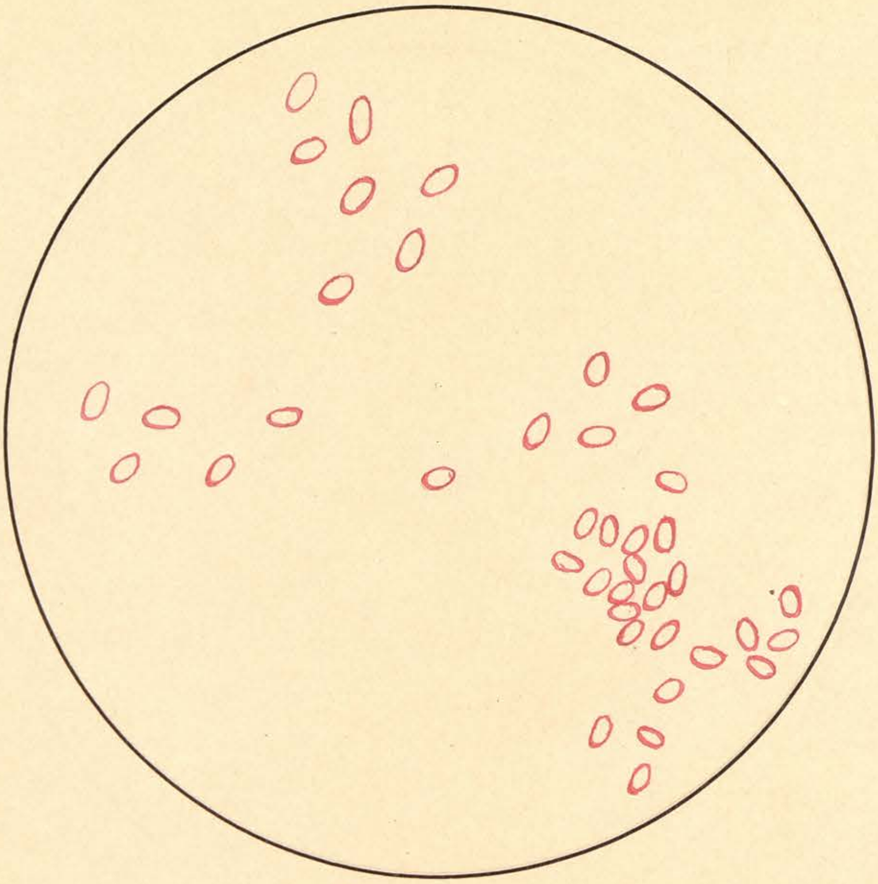

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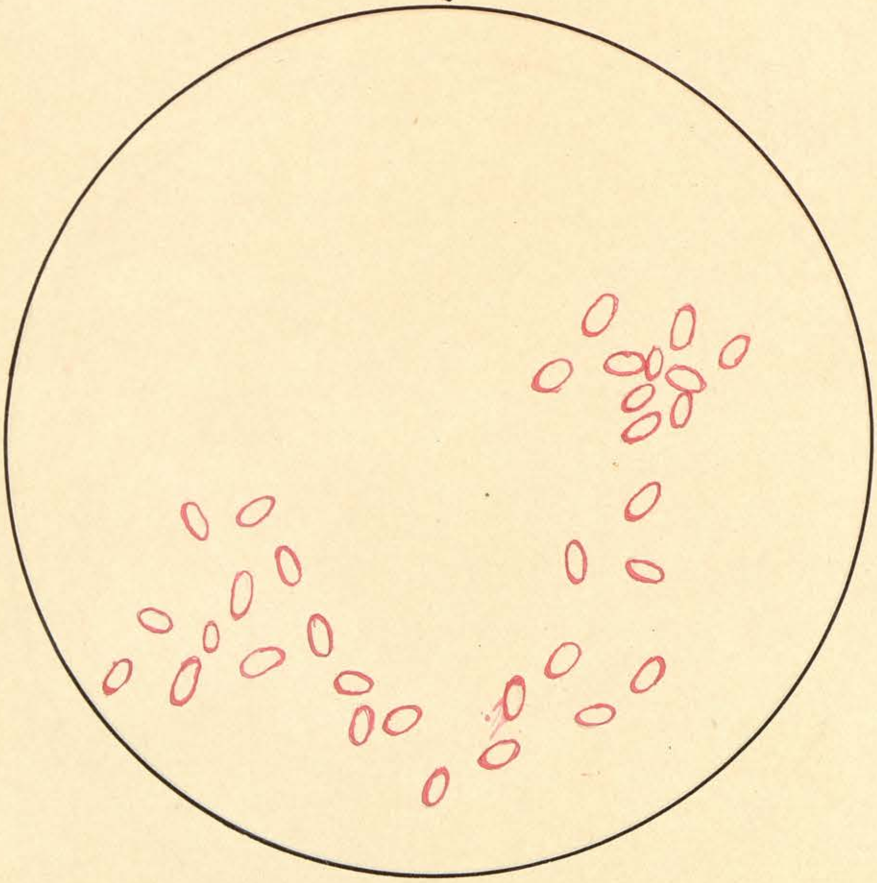

Plate III

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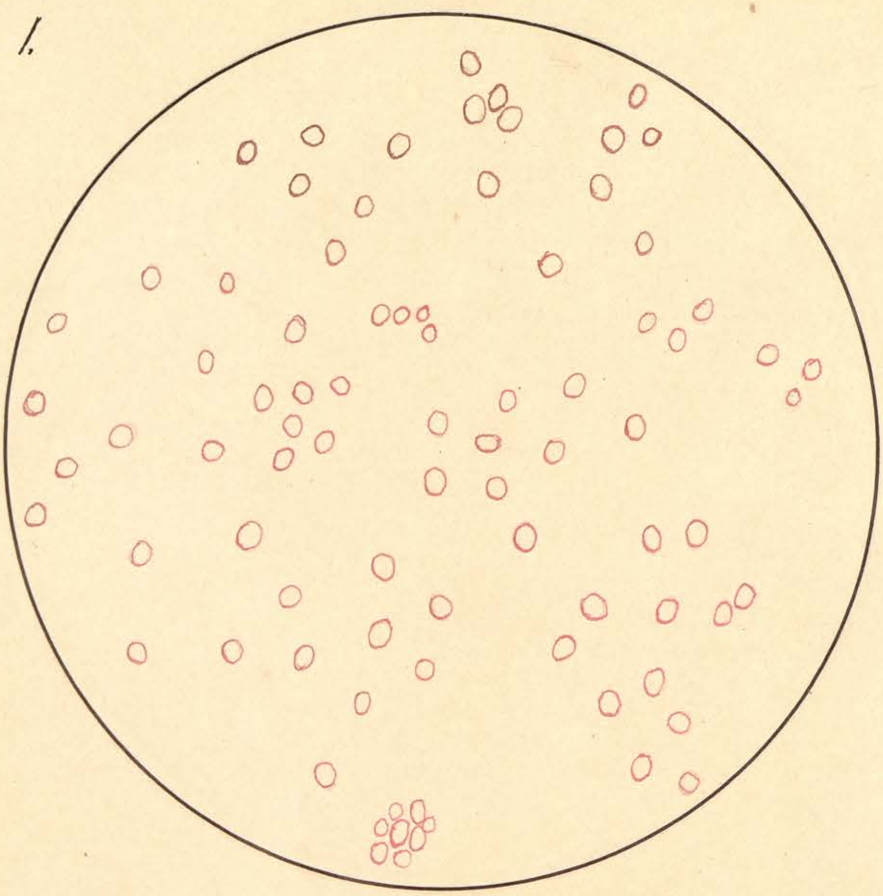

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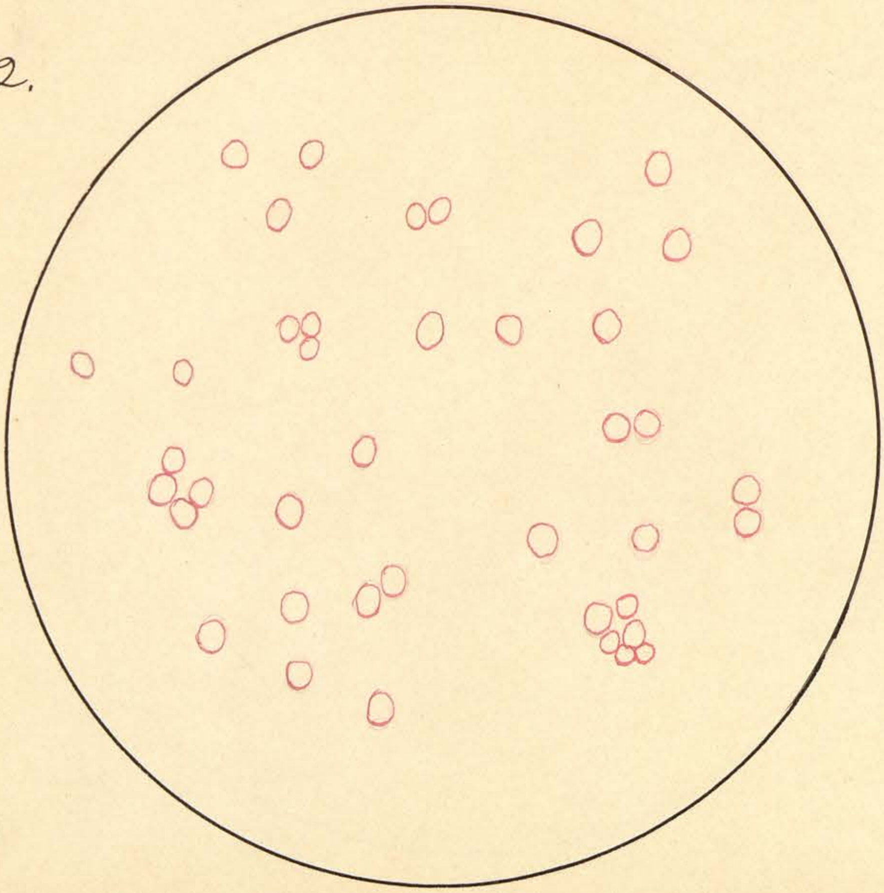

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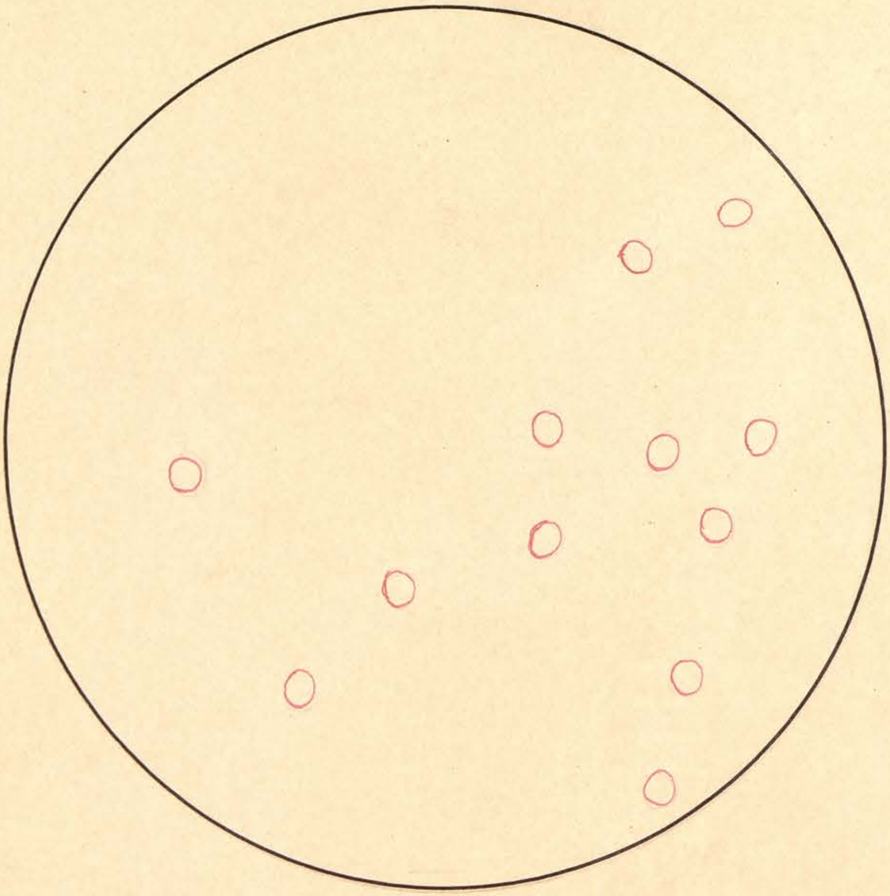

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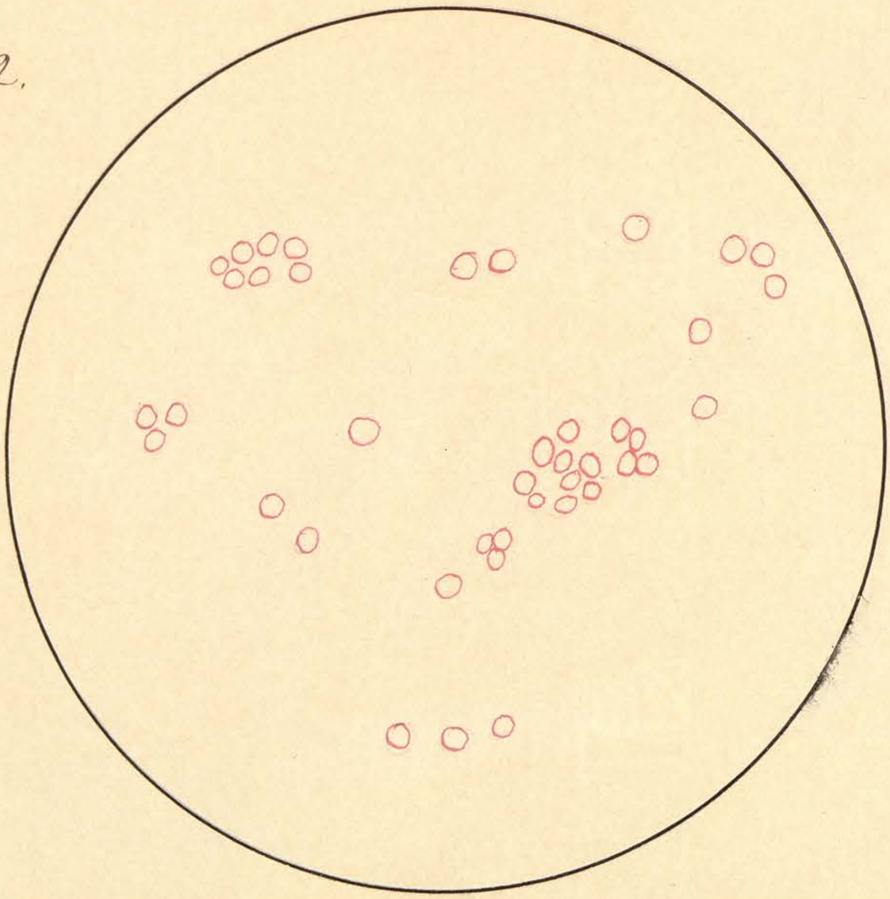

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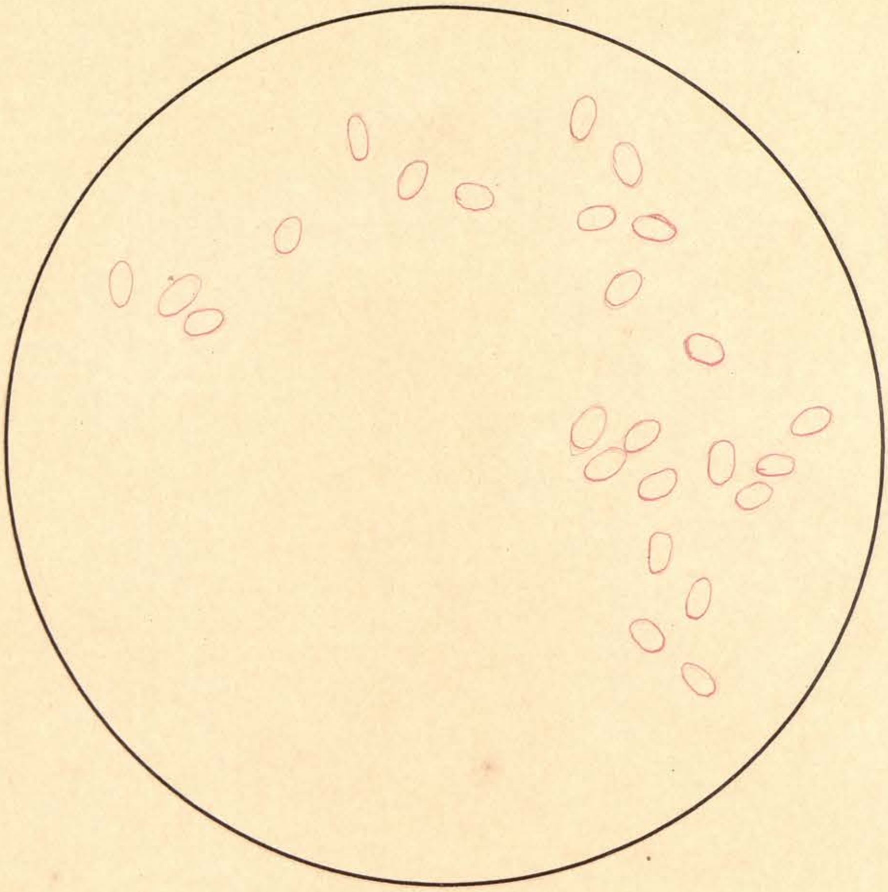

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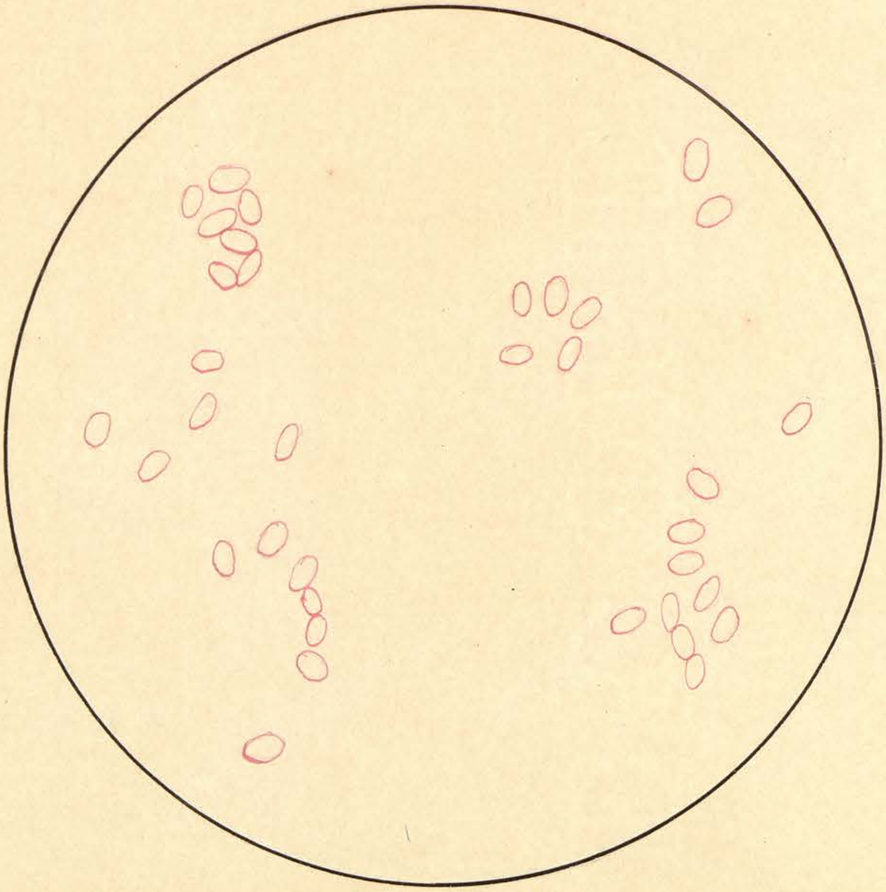

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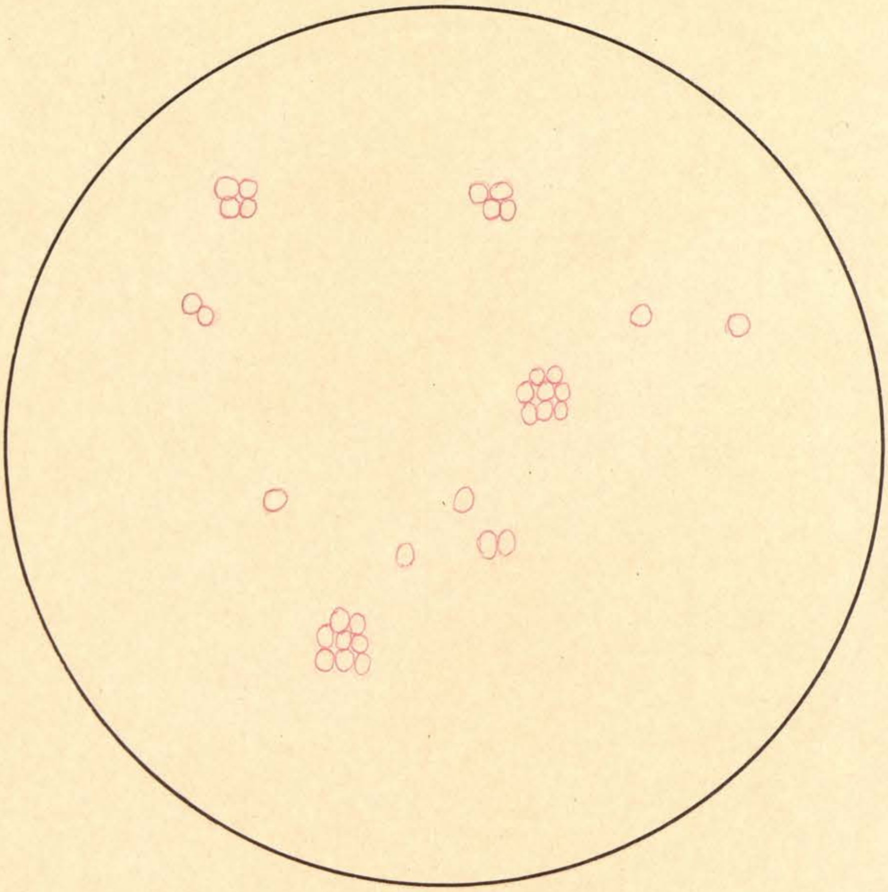

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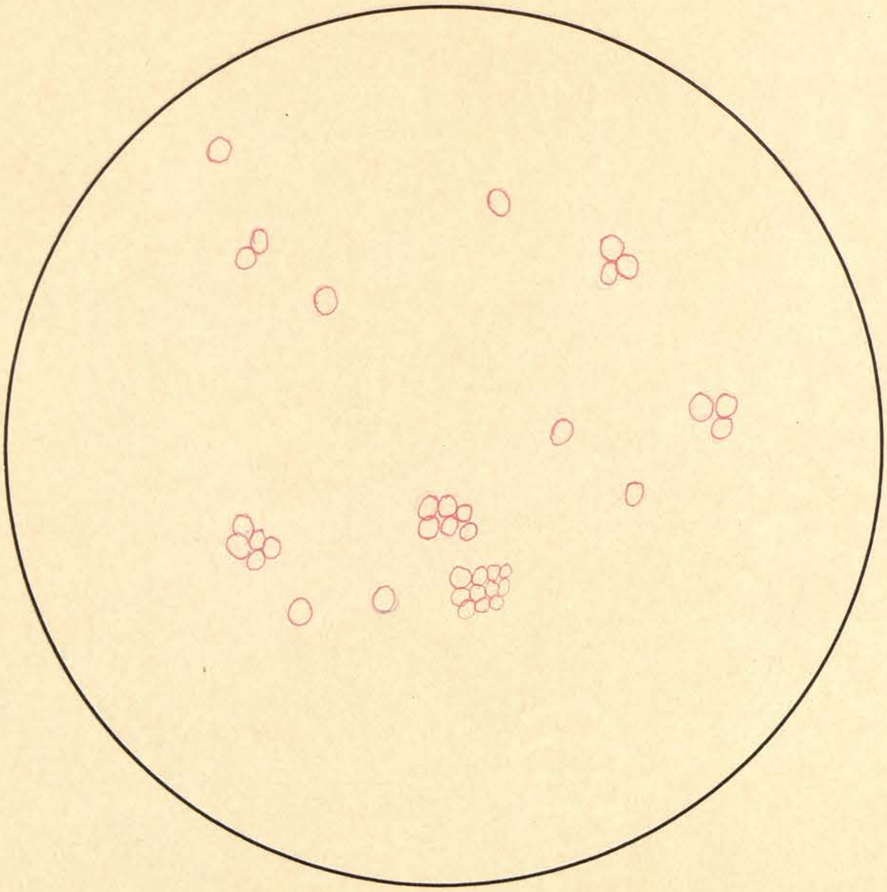

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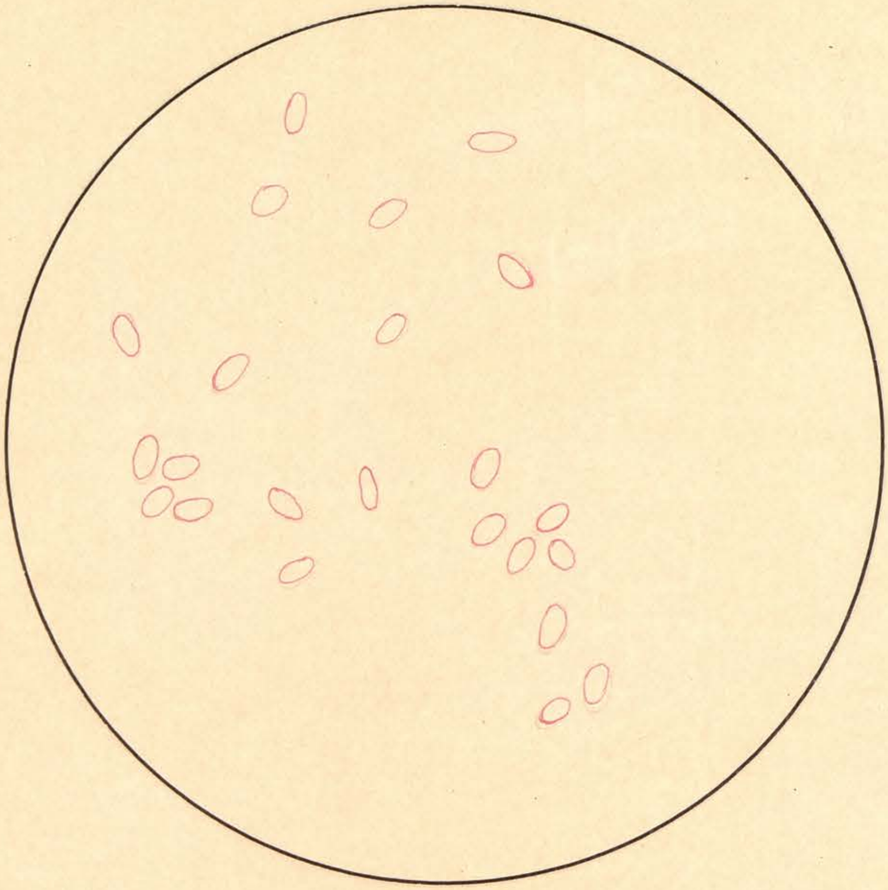

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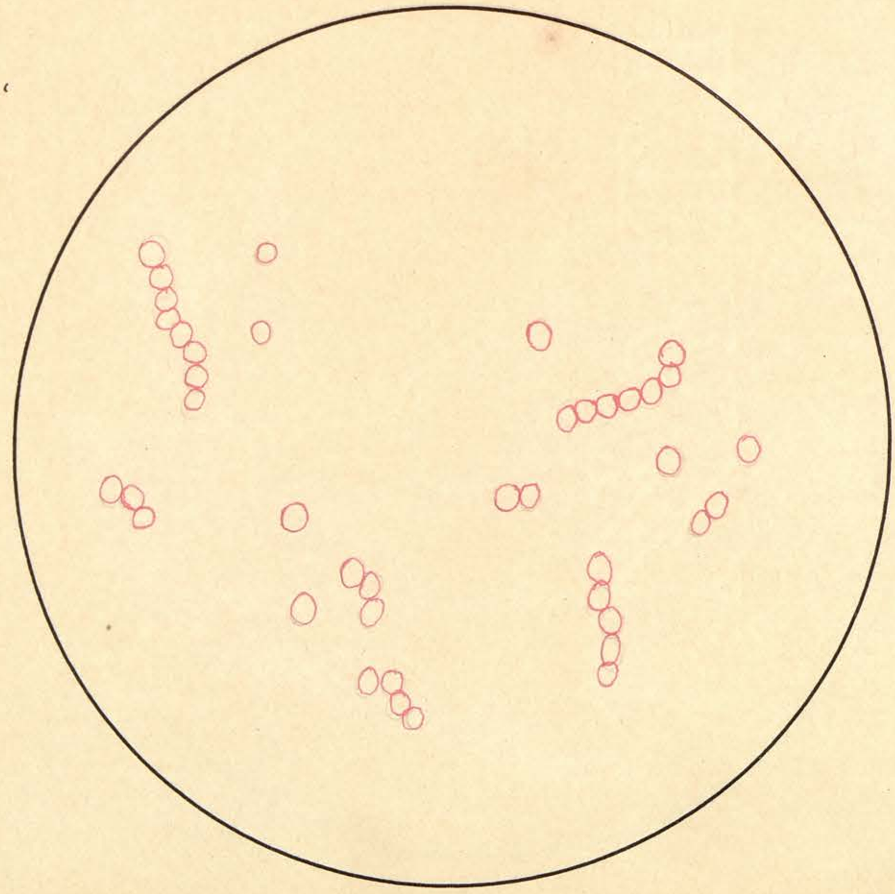

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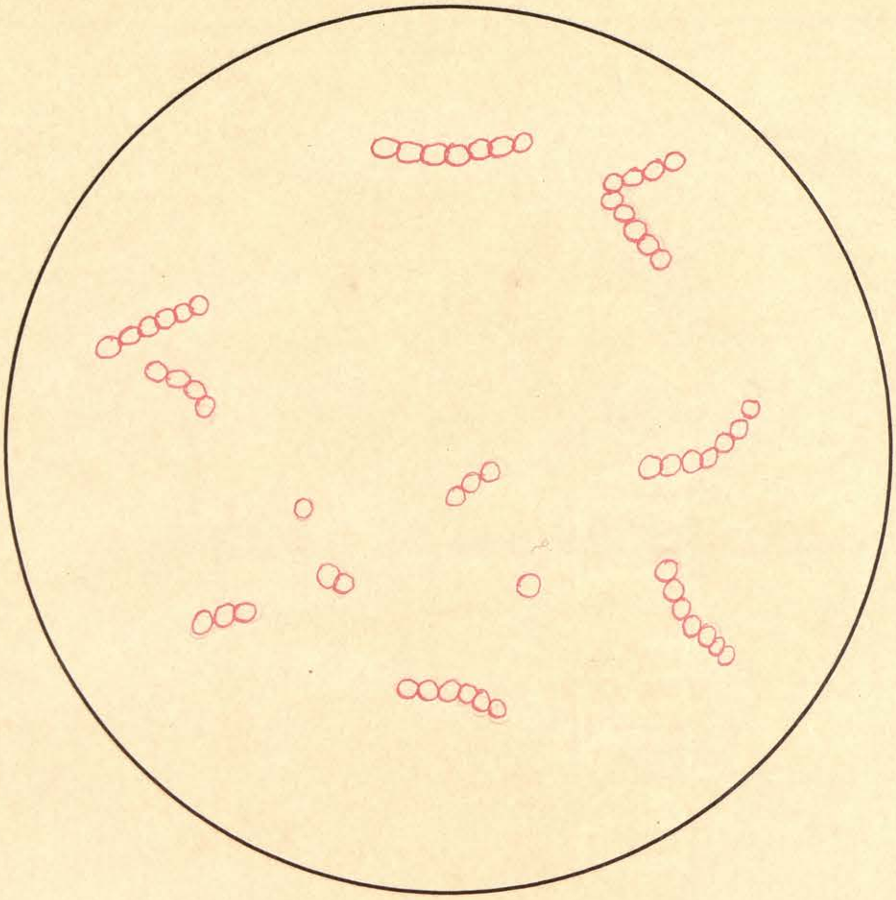

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