THESIS

BACTERIA IN WATER

FOR THE DEGREE OF

B.S.

School of Natural History.

ORLA A. PROCTOR.

1890.
<table>
<thead>
<tr>
<th>Plate 1</th>
<th>Plate 2</th>
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</table>

Explanation of Drawings:

Fig. 1. Represents Bacillus 1. Described on Page 12, Slide 1.

Fig. 1. Represents Bacterium 1. Described on Page 13, Slide 2.

Fig. 1. Represents Saccharomyces 2. Described on Page 27, Slide 9.

Fig. 1. Represents Micrococcus 1. Described on Page 19, Slide 14.

Fig. 1. Represents Saccharomyces 4. Described on Page 31, Slide 5.

Fig. 1. Represents Micrococcus 2. Described on Page 24, Slide 1.

Fig. 1. Represents Micrococcus 3. Described on Page 25, Slide 1.
Bacteria in Water.

Introduction:

This study and original investigation is confined wholly to bacteria and micro-organisms found in water and snow. This line of work was chosen for several reasons: First, it is a newer field. There is less written about it than many other truly bacteriological studies. Nearly all diseases in which bacteria play a prominent part, have been thoroughly studied, and carefully described by scientists with many superior means for their examinations. There is then an abundance of literature on the principal diseases caused by these germs. Second, it was more interesting than most other lines of this branch of study.
There was an interest in finding what different
growths there were in the different kinds of water.
The pleasure of finding as differences and noting it
largely repaid one for the time spent in the study.
Third: It was instructive in many ways. The situa-
tion of wells in regard to surroundings, level,
drains, etc. would naturally cause a difference in
the purity of water. The cleanliness of cistern water
would be shown partly by the number of growths.
One well may have clear water but as bad smell
another may taste bad— it may be pure at certain
times or be affected by the seasons. It is said that
persons traveling, often become sick from drinking
the different kinds of water. This is often caused
by the presence of bacteria and disease germs in the water.
It has not been the object of this study to examine one kind of water
but to get a knowledge of the number and different growths in different waters.
Importance.

Water then may be a source of disease, and at least, the purity of water is of importance to those who drink it. That water is chemically pure does not prove that it is fit to drink. Even distilled water has been found to contain bacteria and germs. Water may become impure by surface drainage when in a low spot, and so at once be infected. The soil contains many germs and bacteria which might find their way into a well.

Anthrax was found in soil many days after some water containing this bacteria was poured there. Dead animals, drains, stables, and other sources of impurity near a well have a strong tendency to render the water impure. As many diseases are attributed to bacteria, it is highly probable that these might be found in water. There are certainly many ways in which bacteria could get into water, and so there is good cause for precaution in keeping drinking water pure.
Apparatus: In this study there was used, as high power "Leitz" microscope, having three lenses—a low power magnifying 800 times, a higher one magnifying 700 times, and a high one—an immersion lens magnifying 400 times, with the other accessories of a good microscope. An incubator for hastening the growths was found to be very convenient. In order to study the bacteria there must be some way to get a growth. This is done by making an inoculation of the material containing the bacteria in a growing upon sterilized nutrient media as, Beef Broth, Agar-Agar, Gelatine, Cooked Potatoes, Bread Paste etc.

Procedure. The method of procedure was as follows. A number of small bottles holding 10 to 15 cubic centimeters were thoroughly cleansed and sterilized by heating or with corrosive sublimate, provided with corks, and then filled with water from various places and labelled. One c.c. of water of each kind was put into tubes containing
10 c.c. of sterilized beef broth, and plugged with cotton which served as a strainer to keep out all other germs, and when numbered and recorded, the tube was put in the incubator to grow. When growth appeared it was examined and described, first as it appeared in the tube and then under the microscope. In the latter case a tube 1/4 inch in diameter was heated and drawn into a fine pipette, and then thrust down by the side of the cotton plug into the growth and a little of this fluid was placed on a cover glass, dried and then stained with methyl violet, again washed and dried and placed on a slide in a drop of water. It was then examined under the microscope and a careful description of its appearance was written. For further study the growth was inoculated upon a solid culture, Agar. This is made by a pipette or needle from the beef broth. Of the slide obtained was a good one the cover glass was floated off with water, dried,
and again mounted in a little "Canada Balsam," labeled and then placed in a box to keep from injury, for future study. If the same growth is found in each culture there is good evidence of purity.

In the following study the water is divided into six different kinds: 1) Snow Water. 2) Rain Water. 3) Running Water. 4) Still Water. 5) Cisterns. 6) Wells.

The word Tube and the number following indicates the different specimens of water, and the word Slide indicates a mounted growth from the tube having the same number, and they apply only to the divisions under which they are used. A careful description of the liquid and solid cultures, and of the bacteria is given for each different species, with drawings of the more interesting ones. The bacteria are distinguished by the genus and numbers, i.e., 367 of that genus.
Snow. On March 10 the following first specimens of snow were inoculated in beef broth, and April 1 the last 2 were treated in the same manner.


| 2 | R.W. University gate. | 7 | E.S.K. Schoolyard. |
| 3 | Main street Champaign | 8 | Top coal house. |
| 4 | 6th Springfield Av. | 9 | 2d and Uni Av. Ch. |
| 5 | Uni Ave. and Market | 10 | a front yard. |

Tube 1. In Beef Broth. There was a thin, white, granular pellicle, a narrow ring around the tube, fluid opalescent, no floating matter, a white granular sediment.

On Agar. On a melted portion there was a large thick, white, deeply wrinkled pellicle, poring, sediment or floating material.

Slide 1. The bacteria is a Bacillus No. 1, they occur in chains of 2 to 4 bacteria, are small, oval, 2 to 3 times as long as wide, Spores
central forming oval in form. The chains are mostly straight.

Tub. 2. In B. There is a thin white pellicle, which easily breaks up, leaving a narrowing, fluid turbid, white granular sediment.

On Agar. On a melted portion, a hard, wrinkled pellicle formed on solid portion, a white, smooth, upward growing colony, soon covered surface.

Slide 2. The bacteria is a Bacterium No. 1, occurring singly and in zoogloeae form in large numbers. They are short, oblong cells, have rounded ends, are 8 to 4 times as long as wide, often constricted at the middle. There are a few bacterium No. 2 as described in Tub. 1 slide 4 below.

Tub. 3. In broth. There is a very thick, heavy, white, wrinkled pellicle adhering closely to the tube. On agar the growth is same as in Tub. 2 above.

Slide 3. Bacteria are Bacterium No. 2, are large, 8 to 4 times as long as wide, rods often nearly oval, rounded ends, often polar stained, cells sometimes curved, occur single or in chains of 3 or more. They are very much larger than Bacterium 1.
Tub. 4. Growth and bacteria same as Tub. 3 above.
Tub. 5. Ditto. There are large numbers of spores present.
Tub. 6. Growth and bacteria same as in Tub. 5 Slide above.

Tub. 7. Growth same as in Tub. 6 above.
Slide 7. Contains 3 forms of bacillii: 1. *Bacillus 2.* They are narrow, small, straight rods, 3 to 5 times as long as wide, single or in chains of 2 to 4 bacteria. If long the rods are slightly curved.
2°. The bacteria are a little larger. *Bacillus 3.* Are short rods 10 to 15 times as long as broad, rounded ends, occurring singly, spores end forming, and are club or tennis racket shaped.
3°. The largest bacteria. *Bacillus 4.* Twice as large as *Bacillus 3.* And short rods 1½ to 2 times as long as wide, rounded ends, single or in chains, central spore

Tub. 8. Growths and bacteria like tubes 5 and 6 above.
Tub 9
Tube 10. In broth: Thick white wrinkled pellicle, narrowing, somewhat opaque.

On Agar. There was a smooth, white, polished, spreading growth.

In Gelatine. There was a number of white, and a few pink growths, extending they at last settled to the bottom.

Slide 10. A few forms. Bacilli 5, are in rods, straight or slightly curved, ends rounded, 2 to 3 times as long as wide. They have two or three little light oval spots in the rods. Sperosoval and central forming. There are some bacteria of Bacilli 3. Page 14. Slide 7.

II. Rain Water.

These were next examined rains of different dates and from various places.

| Tube 1. Mar. 10 | Rain from University yard |
| Tube 2. | Rain from a front yard |
| Tube 3. | Rain from an old incan |
| Tube 5. | Streetcar track |
| Tube 6. | Drops on doorstep |
| Tube 7. | University yard |
| Tube 8. Mar. 27 | Rain from top of Uni. |
| Tube 9. | Ground by Irish pub |
| Tube 10. | Apr. 26 | Drops top of henhouse |
| Tube 11. | 26 | From roof of house |
| Tube 12. | Surface of ground |
| Tube 13. | May | Pure from sky |
| Tube 14. | 6 | " " " " " " 
Tube 1. In broth. There is a thin, white granular pellicle, a narrow ring, and granular sediment in bottom.

On Agar. There is a white, smooth, semitransparent, up spreading growth.

Slide 1. There is a new form. Bacillus 6. They are cylindrical rods, short 3-5 times as long as wide occurring singly, in chains or long slender filaments elongated, attached, increased by fission, roughened.

There is a form classified between bacillus and Bacterium, they are very small, 1-3 times as long as wide, end rounded, occurring singly. Bacteria 1. There are Bacteria of Bacterium 2. Page 13 tube 3.


Tube 3. Growth same as tube 2 above.


Tube 4. Growth same as tube 3 above.

Tube 5. Growth same as Tube 1 above.
Slide 5. There are Bacillus 6 described Page 15 Slide 1, and Bacterium 2 described Page 13 Slide 6, present.

Tube 6. Growth same as in Tube 4 above.
Slide 6. Bacteria are Bacillus 2 and 4. described Page 14 Slide 9.

Tube 7. In Broth growth same as Tube 11 above. On Agar, there are a number of small pink colonies.
Slide 7. There is a pure growth of a new form, Bacterium 3, they are numerous, nearly circular to oval in shape, 1/2 to three as long as wide, ends rounded, occur singly and starve deeply.

Tube 8. There was nothing but a pure growth of yeast Saccharomyces
They are circular or spherical, stainer deeply, occurring singly and in large masses.

Tuber 9. Same growth and bacteria as Tuber 4 above.

Tuber 10. Same as Tuber 9, with some Bacterium 3 described Page 1731.

Tuber 11 & 12. Same as Tuber 10 above.

Tuber 13. Growth like Tuber 10 above.

Slide 13. Bacteria are Bacillus 4, described Page 14 Slide 7.

Bacterium 1 in Zoogloea form described Page 13 Slide 2, and Bacterium 2, almost wholly in chains described Page 13 Slide 3.

Tuber 14. In Broth, there is a thin white, granular pellicle, moving fluid semi-transparent, a granular white sediment in bottom.

On Agar, there is a wide spreading, smooth, polished, cream colored growth covering greatest part of surface.
Slide 14. There is a new form of Bacillus. Large numbers of short straight rods rounded ends and have 20 to 15 little oval light spots in them and long curved rods, often having 100 to 15 little light spots. There is the first form of Micrococcus. They are spherical, occurring singly, in pairs, in long chains, curved or straight and in irregular masses. They are present in large numbers.

The presence of such large quantities of bacteria is worthy consideration. Snow and rain would both serve as means of distributing disease germs. In the drop or flake the bacteria would be carried long distances in various directions, and then carry them to the ground, distributing them over the surface. The air contains many germs and these would be taken up by the rain or snow and fall with them. This then would be a fair theory for the distribution of disease germs over wide areas.
Next was examined the water of running streams, drains, and running water of any kind.

**Tube 1. Water from Hydrant in Bot. Lab.**

1. " " Boneyard when low.
2. " " Boneyard high.
3. " " Boneyard after lavatory.
4. " " Drill Hall Drain.
5. " " Drill Hall Drain.
6. " " Boneyard in Urbana.
7. " " Boneyard in Urbana.
10. " " Green St. Creek.
11. " " Boneyard Drain.
12. " " Drill Hall.
15. " " Spring in Urbana.

**Tube 2. On Earth.**

There is a thin white granular pellicle which soon breaks up and falls to bottom as a granular sediment, there is a narrow ring and milky fluid.

**On Agar.**

There are a number of small, circular, smooth, polished, white growths, which soon spread and unite to form one large growth.
Slide 1. There is a new form, Micrococcus 2. They are very small, occur in groups in large numbers.

Tube 2. In Broth. Fluid became turbid, no ring, a thick, heavy pellicle, which afterwards settled to the bottom.

On Agar. The agar was heated, 1 c.c. of water was then put in and mixed up and the whole cooled around the inside of tube. In a few days there were 27 small white spots varying in size from a dot to 1/4 of an inch in diameter.

Slide 2. There were several kinds of bacteria. 1st Bacterium described on Page 17 Slide 7. They form in short chains and groups.

2nd Bacterium 1 described on Page 13 Tube 2. 3rd Bacillus 6 - Page 16 Slide. Slide from solid culture gave an almost pure growth of Micrococcus 2 described on Page 21 Slide 1.

Tubes 3, 4 and 5. Same in growth as bacteria as tube 2 above.

Tube 6. In Broth. Fluid turned milky, no ring, no pellicle, as
white granular sediment, which looks like a pellicle.
On Agar. Growth pure and plentiful in form of small white, circular, sticky appearing colonies.
Slide 6. Bacteria a new form Bacillus T., numerous small truly cylindrical rods, 1/2 to 2 times as long as wide, occurring singly.
Tube 7. Growth like tube 7 Page 17.
Slide 7. Bacteria are mostly Bacterium 3 described Page 17 Slide 7.
With a few Bacillus 4 Page 14 Slide 7 and Bacilli described Page 16 Slide 1.
Tube 8. Same as Tube 7 above.
Tube 9. Growth similar to tube 8 above.
Tube 10. Same as tube 8 above in growth and bacteria.
Tube 11. Same in growth and bacteria as tube 7 above.

Tube 12. Growth same as tube 8 above.
Slide 12. Bacteria same as slide 8 with some Bacillus. Page 147.


The following samples of still water were next examined:

Tube 1. Water from Aquarium in Bot. Lab.
Tube 2. Water from burned jar.
Tube 3. Clear water from an old jar of Ant. 2.
Tube 4. Water from surface of pond.
Tube 5. Water from urban water trough.
Tube 7. Water from common pond.
Tube 8. Clear part of same.
Tube 9. Water from where horses drink.

Tube 1. In Broth. A heavy, white, deeply wrinkled, pellicle, fluid turbid, sediment granular.

On Agar. There were 22 small white colonies. The growth commenced from a center and spread. One became yellow.

Slide 1. There were 2 slides mounted from this tube and other inoculations from it. The 1st gave a pure growth of Bacterium 2. Page 13, Slide 3. Dec. Obtained from solid culture.


Slide 1d. Same as slide 1b. This is from liquid culture.
Slide 1e. From a later culture. Large numbers of Micrococcus 1, in groups and singly. Dec. Pg. 19 Sl. 14. 2nd. Chains of Bacillus 6 made up of short rods, Dec. Pg. 16 Sl. 1.
Slide 1f. Another incubulation. A new form Micrococcus 3. They are quite large and occur only in chains of 3 to 5 bacteria long, they look like a string of beads.

Tubes. In Broth. A thin white gauze like pellicle, a narrow ring, fluid milky, granular sediment.

On Agar. There was a few white spots, which grew to about 1/2 of an inch in diameter, and then spread over the whole surface. Slide 2. There are a number of large, square-ended, cylindrical shaped spores, usually in chains. The Bacteria are Bacterium 3, Dec. Page 17 slide 7. Bacillus 6, Pg. 14, Dec. Pg. 14 Sl. 7.

Tube 3. Same ingrowth and bacteria as tube 2 above.
Tube 4. Same as tube 2 in growth and Bacteria with a few Bacillus.

Tube 5. Same in growth and Bacteria as tube 4.

Tube 6. Same as tube 4. 


Slide 8. In Broth. Thin pellicle, narrow ring, fluid milky white, fine granular, sediment.

Out agar. There are a number of small, separate white, polished colonies.

Slide 8. There is a new species. Bacillus 9. They are long rods 5-8 times as long as wide, have an enlarged portion like the head of a nail at one end, and resemble spines, the head is round and 1/3 to 2 times as wide as the rod, they occur singly.

Tube 9. In Broth. The fluid is clear, a pink ring, thin pellicle
and much, pink granular sediment.

On Agar. There are many, large, smooth, polished, pink colonies, made up of small colonies.


2. They are nearly circular, but vary to oval, usually single, sometimes in chains, vary much in size, smallest about as 1 to 4 compared with the largest. Just in focus, they appear deeply stained, and solid, but when a little out of focus there is a darker central portion and a lighter ring about it.

The following kinds of cistern water were next examined:

Tube 1. Water from Cistern outdoors covered.

Tube 2. " " " in closed pot.

3. " " " in lawn loose cover.

4. " " " loose but and cover.

5. Water from cistern tightly boxed in kettle.

6. " " " covered bleuwell.

7. " " " rain barrel.

8. " " " cistern closely covered.

Tube 2. Growth and Bacteria same as Tube 1. Page 16.

Tube 3. In Broth same as Tube 2; above.

On Agar. Anumber of small, shiny colonies, soon spread over whole slide. 3. There is a new form of Bacillus 10, are the smallest bacteria found and occur in large numbers, singly, are irregular in shape, varying from a short slender rod to a little dash. There are also Bacillus 4. Dec. Page 15 Slide 7. Bacillus 5. Dec. Page 15. Slide 10 and Bacillus 6. Dec. Page 16 Slide 1.

Tube 4. In Broth. A thin white pellicle, no ring, fluid milky white granular sediment.

On Agar. Small circular, white, shiny, colonies raised so as to form a hollow sphere or o shaped colony. Slide 4. There is a new form Bacterium 4, are from 2 to 3 times as long as wide, have rounded ends, and form in long chains.
There are other bacteria as Bacillus 2, 3, and 4 Dec. Page 14. Slide 7.
Tub. 5. Growth same as Tub. 14 Page 18.
Tub. 6. Growth same as Tub. 5 above.
Dow Agar, small, separate, circular, polished colonies, look like a veil.
Slide 8. Bacteria are a new species. Micrococci are large, widely scattered and separated from each other.

**VI**

The following specimens of well water were examined:

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<th>Tub.</th>
<th>Water from</th>
<th>Well removal</th>
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<tr>
<td>2</td>
<td>&quot;</td>
<td>well under covered dock</td>
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<tr>
<td>3</td>
<td>&quot;</td>
<td>25 yds from barn stable</td>
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<td>4</td>
<td>&quot;</td>
<td>at W. Work. 150 deep</td>
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<td>5</td>
<td>&quot;</td>
<td>Urban Jail</td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>&quot;</td>
<td>on Main Street Urban</td>
<td></td>
</tr>
<tr>
<td>7</td>
<td>&quot;</td>
<td>at File Factory</td>
<td></td>
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<td>8</td>
<td>&quot;</td>
<td>under open porch</td>
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<th>Tub.</th>
<th>Water from</th>
<th>Well removal</th>
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<tr>
<td>10</td>
<td>&quot;</td>
<td>&quot; in rising place</td>
<td></td>
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<td>11</td>
<td>&quot;</td>
<td>&quot; low place</td>
<td></td>
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<td>12</td>
<td>&quot;</td>
<td>&quot; yard</td>
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<td>13</td>
<td>&quot;</td>
<td>open near house</td>
<td></td>
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<tr>
<td>14</td>
<td>&quot;</td>
<td>near house</td>
<td></td>
</tr>
<tr>
<td>15</td>
<td>&quot;</td>
<td>at James Hall open</td>
<td></td>
</tr>
<tr>
<td>16</td>
<td>&quot;</td>
<td>30 feet from house</td>
<td></td>
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Tubes in Broth. There is first a thin white pellicle, but soon gets thick and wrinkled. On Agar. Growth is white and spreading. The Saccharomyces form large, deep, puffed, polished, smooth colonies.
Slide 1. Bacteria are Bacilli 6. Dec Page 16. Sl. 1. There is a new species of yeast, Saccharomyces, occurring singly and in groups.

Tube 1. Growth is same as tube 5. Page 27.


Tubes 7. Growth same as Tube 10 Page 15
Slide 7. Bacteria are Bacillus 4 Dec. Pg. 14 Sl. 7. Bacillus 5 Dec. Page 15
Slide 10 2nd Bacillus 7 Page 16 Sl. 8 Dec.
Tubes 8, 9 Growth and Bacteria same as Tube 7 above.
Tube 10 Same as Tube 7 with addition of Micrococcus 1 Dec. Pg. 19 Sl. 4.
Tube 11. Growth same as Tube 7 above.
Tube 12-13-14 Same in growth and bacteria as Tube 11 above.
Tube 15 Same as Tube 12 Bacillus 1 Dec. 12 Sl. 1 Bacillus 8 Dec. Pg. 15 Sl. 10.
Tube 16. Growth heavy like Tube 12 above.
Slide 16. Bacillus same as Tube 15 - Bacterium 1 Dec. 13 Sl. 23 - Micrococcus 1 Pg. 19 Sl. 14.
Summary. In snow the growth was slow to take place. 10 to
3 species in a tube. In 10 samples of snow there were 7
different colonies found. In rain growths occurred soonest and
more species and heavier growth, several species in 1 tube.
By running water the growths were almost like
those of rain.
In still water growths were heavier and occurred
sooner in each case, and there were the most different
species of bacteria found in sample of water.
The growths from eister were usually large but
only of one kind of bacteria especially where eister
was closed.
In the well water the growths were always slower to come,
was very slight and rarely but one species
was found in a specimen of water.
The following table shows the whole number of growths of the whole number of species in each class of water examined—the number of different kinds of bacteria found in each class—and the percent of each as compared with the number of samples of each class of water examined.

<table>
<thead>
<tr>
<th>Class of Water</th>
<th>Whole number of growths</th>
<th>Different species found</th>
<th>% of growths for each sample</th>
<th>% of different species for each</th>
<th>Whole No. of Samples Examin.</th>
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<tr>
<td>Snow.</td>
<td>19</td>
<td>11</td>
<td>7.6</td>
<td>1.90</td>
<td>1.57</td>
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<td>Rain.</td>
<td>28</td>
<td>12</td>
<td>10.8</td>
<td>2.00</td>
<td>1.71</td>
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<td>Running.</td>
<td>51</td>
<td>20</td>
<td>15.6</td>
<td>3.20</td>
<td>2.85</td>
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<td>Still.</td>
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<td>15.11</td>
<td>2.18</td>
<td>2.28</td>
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