THE ORIGIN AND HISTORY OF THE EPIDEMIC OF TYPHOID FEVER AT MT. HOLLY, N. J., DURING THE MONTHS OF JUNE, JULY AND AUGUST, 1887.

By Dr. Albert R. Leeds.

Mt. Holly is supplied with water from Rancocas Creek. The water is not taken directly from the creek, but from a mill-race, as shown in the accompanying map. When the mill runs, water flows through this race; but when, after the day's work is over, the mill stops, the flow is interrupted also. The crib of the pumping-station is located in an angle or *cul de sac* of this race, so as to stand outside of the current.

From the crib two iron conduits, one of ten inches and the other of twelve inches diameter, and 350 feet in length, with a fall of four inches in this distance, connect with the pump-well. The well is four and a half by eight feet, and four feet in depth It is not separated from the crib by any arrangement of filters or screens.

Prior to the time of my visit of inspection, but several weeks after the epidemic began, the mud which had accumulated at the bottom of the crib and pump-well was removed, and the crib was built out a distance of ten feet, so as to project its open end into the current. The sides were closed in and the open end covered with a grating having a three-eighths inch mesh.

Upon the 6th of June, Dr. Ezra Hunt, the Secretary of the State Board of Health, in company with Dr. R. Parsons, visited the village of Smithville, which is located on Rancocas Creek, about three miles above the crib of the pumping-station at Mt. Holly, and found that there had been several cases of typhoid fever. The most important of these occurred in a large boarding-house located not more than one hundred feet from the side of the creek, and emptying therein by three drains. Early in May there had been two men ill with typhoid fever, who subsequently recovered, and at the time of Dr. Hunt's visit Mrs. A. L. was convalescent of the same disease. The dejecta of all three had passed without disinfection, directly through the drains into the creek.

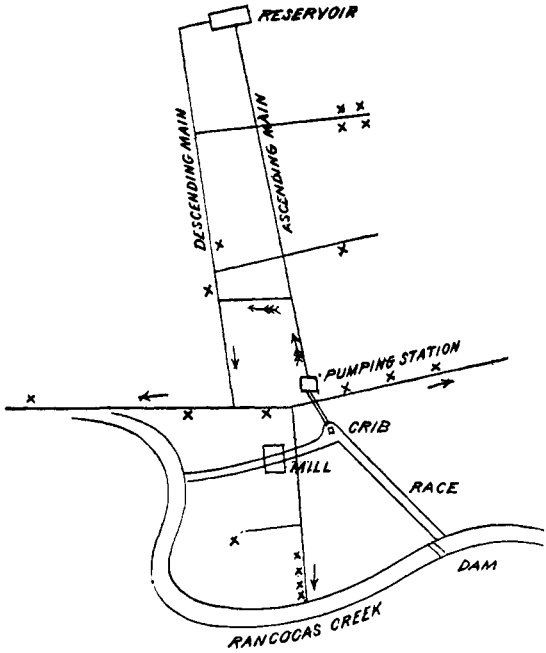
In addition to these drains, the cesspools are located on the sloping grounds of the village, and their contents eventually

wash down and are carried into the creek. Dr. Brown, the sanitary inspector of the township, reported that these cesspools had been disinfected with copperas and chloride of lime in the latter part of May, and the origin of the epidemic is more directly traceable to the discharges from the drains above alluded to.

From the 20th to the 27th of May there were heavy rains, and the epidemic broke out shortly afterward in Mt. Holly.

As will be seen by the accompanying map, the water was not pumped first through the ascending main into the reservoir, but at the time of the epidemic much of it passed directly into the distributing system.

The most striking collection of cases (indicated on the map by x) were those at contiguous houses supplied from a "dead-end" on Pine street.



At the time of my second visit to Mt. Holly, July 23d, Drs. Parsons, Parry, Barrington, Brown, and Melcher gave me the following list and details of cases up to that time :

On Pine street, Case L. P. began June 20th; still very ill. W. W. began June 25th: disease still progressing. Cases D. S. and M. G.; the last, however, being properly gastro-enteritis.

On Ridgway street there was another dead-end connected with a school. Four boys attending this school, though living in different parts of the town, were attacked with typhoid about the 2d of June, of whom one died.

On Mill street there had been four cases, beginning from the 2d to the 5th of June, of which one proved fatal, on the 20th of June, and the others had recovered or were convalescent.

On Washington street, M. C., after an illness of two and a half weeks, had died of typhoid. On Main street, L. H. was attacked June 18th and died July 10th. On Church street, L. D. was attacked June 6th. The record also includes other cases, beginning from the 1st to the 18th of June.

I am also in receipt of a number of valuable communications from Drs. Parry, Parsons, and Barrington, from which I shall take the liberty to quote.

Dr. Parry writes, July 20th: "I would call your attention to the part of the creek where the water was taken from, a sort of *cul de sac*, where the water never has a running current on the side or near the edge where the box is. It is virtually standing water while the mill is not running below, and hence a place where the sediment from up the stream must settle. Add to this much mud in the crib and pump-well, a dirty reservoir to pump into, and polluted water, as this was shown to be, and we find it followed by the following cases, occurring about seven to nine days after a rain had commenced. . . . . All of these cases have taken more or less hydrant water, some using it entirely, some at the places of work, and some occasionally. Two-thirds of these cases have occurred, I think, from the 30th of May to the 10th of June. . . . . In many cases there has been a very rapid pulse, with comparatively low temperature, some lower even than the above record. But in one case that proved fatal, the axillary temperature attained 106°, and registered above 104° daily for a week preceding her death, with pulse from 130 to 140 during the same time. . . . . We have had, occurring at the same time as cases quoted, children afflicted with gastro-intestinal fever,

not typhoid, but temperature, pulse, and duration of the disease the same as well-marked typhoid cases, with many cases of mild continued fever, and have had no malarial trouble in surrounding malarial districts, and these cases were not controlled by quinine, but all have had much gastric trouble, vomiting, etc. . . . . We have had in the last week or two, in addition to a few cases of typhoid fever, a dysenteric trouble with, in some instances, violent gastric disturbance."

Under the same date, July 20th, Dr. Parsons writes: "I have had under my care three cases of typhoid fever. These cases had the rose-colored spots, bleeding from the bowels and nose, and more or less stupor; temperature 102° to 104°, with a morning and evening variation of about 1°. Two of the cases used water supplied from the creek by the water company, the other used well water only when at home. I have also seen about twelve cases of fever which were remittent, but differing somewhat from the usual form by having some typhoid symptoms, and quinine seems to make no impression on them. This outbreak of fever occurred in various parts of the town almost simultaneously."

On the 23d of July I visited, in company with Dr. R. E. Barrington, the case L. P., and found it presented the well-known characters of typhoid fever. I took some of the greenish stools, and made some of the primary, secondary, and tertiary gelatine-peptone cultures from them. The predominant form was a nearly straight bacillus 0.006 of a millimetre in length, and 0.0002 of a millimetre in breadth, which in the third culture was obtained in a pure condition. The stools contained an innumerable quantity of these bacilli.

Although the data above narrated rendered the fact of this epidemic in Mt. Holly being rightly attributable to typhoid well nigh certain, yet I did not feel satisfied without the confirmatory evidence from autopsy. At my request, Drs. Parsons and Barrington kindly performed an autopsy, and under date of Aug. 8, the former writes: "You will receive by mail a section of the small intestine, and some fecal matter, taken from a patient six and a half years old. I made a post-mortem examination of this case on Saturday, August 6th. While the patient was very young, he had all the symptoms of typhoid, excepting the "spots," and died

rather suddenly from intestinal hemorrhage. On examination, I found the ileum ulcerated in about a dozen places. This being the only autopsy during the epidemic, it establishes the fact that some of the cases are *true* typhoid."

Under date of August 15th, Dr. Parsons again writes: "The case from which the specimen was taken that I sent to you, was a child six and a half years old. He had continuous high temperature that varied from 102° to 104°, some slight diarrhœa occasionally, but no other abdominal symptoms, no delirium, very slight stupor, no epistaxis, loss of strength not marked. He improved very rapidly a few days before his death, so much so that the nurse moved him into another room. This brought on hemorrhage of the bowels from which he died in about eighteen hours, after a sickness of three weeks."

"At the autopsy I found in the lower part of the small intestine about twelve or fifteen ulcers, varying in size from a pin head to one inch in length. This ulcer had nearly perforated the intestine. There were several blood-clots and some fecal matter in the bowels."

I was deeply interested to discover what additional evidence of typhoid fever would be obtained by microscopic study of the material submitted by Drs. Parsons and Barrington. My attention was particularly directed to the sides of one of these typhoid ulcers in the small intestine, and after removing small portions of the adherent matter, I made a number of stainings with methyl violet. They all yielded me great numbers of micrococci, the micrococcus being mostly single, but many in short chains. According to Eberth, a certain bacillus with rounded ends is peculiar to typhoid, and Koch is of the same opinion, regarding this bacillus of Eberth as being the only one which has a specific relation to the disease. I find it likewise stated that when these bacilli of Eberth are present in great numbers they have the appearance of masses of micrococci, but when isolated from these masses they are recognized as short thick rods having rounded ends. Unfortunately, having no authentic specimen of Eberth's bacillus with which to compare my slides, I am unable to state whether or no what I took to be micrococci, were really Eberth's bacillus. They possessed one property which is the same as that of Eberth's bacillus, in that they were not so deeply stained by methyl violet as another bacillus

present in the superficial layers of the intestine and in the fecal matter. This bacillus was a long, straight, thin rod which stained deeply, and which I took to be the bacillus typhosus of Klebs.

Having established by clinical and pathological evidence the fact that the disease in Mt. Holly was typhoid fever, it becomes of great interest to ascertain the character of the water which, whatever might have been the other surroundings of the typhoid cases, was the one food they took in common.

It would have been of great importance to take the samples of water during the period when the typhoid was incubating, say at the time when Drs. Hunt and Parsons visited Smithville on the 6th of June. But the opportunity of discovering whether the specific bacillus, which was found in the intestine of the typhoid cases, was also present in the water supply during the period of incubation was lost.

The samples which I collected were taken on the 9th of July, at the time when much typhoid was prevailing in Mt. Holly, but probably subsequent to the inception of the disease in most or all of these typhoid cases.

I have made both chemical and biological analyses of the samples collected, the water on which the latter tests were made being obtained in sterilized flasks. Sample I. was from the Rancocas Creek, above the village of Smithville, some 200 yards above the point where the three drains from the large boarding house entered. Sample II. was from the water as it entered the crib of the pumping station at Mt. Holly. Between the two points on both sides of the creek are three miles of meadow and marsh lands, the soakage of which enters the stream. Both samples were dark yellow (No. 5 on my scale of water colors), of peaty taste and smell, and the Sample II. was turbid with a great quantity of floating filaments of decayed vegetation. They contained :

I.—Above Smithville.

	Parts per 100,000.	Grains per Gallon.
Free ammonia	0.002	0.0012.
Albuminoid ammonia	0.015	0.0087.
Oxygen required to oxidize organic matters	1.27	0.70.
Chlorine	0.45	0.26.
Hardness	3.10	1.80.
Total solids	6.30	3.67.
Mineral Matters	3.30	1.92.
Organic and volatile matters	3.00	1.75.

II.—Pumping Station at Mt. Holly.

	Parts per 100,000.	Grains per Gallon.
Free ammonia	0.006	0.0035.
Albuminoid ammonia	0.0155	0.009.
Oxygen required to oxydize organic matters	1.10	0.64.
Chlorine	0.55	0.32.
Hardness	2.20	1.80.
Total solids	6.20	3.60.
Mineral matters	3.30	1.92.
Organic and volatile matters	2.90	1.68.

CHEMICAL DATA.

These data are conclusive as to the polution of the creek waters by sewage at points below where sample No. I. was taken, which was *above Smithville*. It should be borne in mind that the analyses were both made on the waters after they had been allowed to stand until the suspended matters had settled, and the clear water pipetted off. The sample from above Smithville deposited very little, that from Ht. Holly much floating matter, this matter being evidently of vegetable origin. The clear waters thus obtained were both of the same deep tint of yellow color. Now it is very important to note that the gross amount of organic matters in sample I. was greater than in II. Moreover, the amount of oxygen required to oxidize the organic matters, and therefore the organic matters themselves, was greater in the Smithville than in the Mt. Holly sample. But that portion of the organic matters which was nitrogenous, was greater in the sample from Mt. Holly, the free ammonia and the albuminoid ammonia both being in excess. The free ammonia was three times more in the samples from the pumping-station. This fact, taken in connection with the corresponding increase in the amount of chlorine, is conclusive as to the entrance of sewage into the creek at or below Smithville.

Whenever the amount of peaty matter in solution is great, the amount of oxygen required to effect its oxidation is correspondingly high. This peaty matter is oxidized by contact with light and air both in reservoirs and in flowing streams, so that a stream which at its origin in cedar swamps is dark yellow in color, becomes nearly or quite colorless after flowing a number of miles. I do not think there is any ground for connecting the typhoid epidemic with this large amount of extractive peaty mat-

ter in the water supply. It was always present, and I have no reason for supposing there was any more in solution this June and July than at previous seasons. In fact the citizens of a town using cedar-swamp colored water ordinarily become advocates both of its taste and qualities. They are habituated to it, and it does not originate in them disorders of the stomach and bowels. When strangers come to the town, who are not accustomed to drinking water containing peaty matters in solution, and who do experience intestinal derangements attended with more or less diarrhœa, the citizens of the town are puzzled and indignant that these ailments should be connected with what to them is an entirely wholesome and satisfactory quality of water.

But what I desire to insist upon here is, that the typhoid epidemic was not due to the peaty vegetable matter, but to the animal matter in the nature of sewage which found its way into the stream and whose presence was made evident by the chemical data. Fortunately we are not shut up to the consideration of these chemical data only in the present instance, but I am able to adduce also the results of the biological analyses, affording, as they do, overwhelming evidence of the fact of contamination by decomposable putrescent animal matters.

Biological Data.

I prepared gelatine-peptone cultures of samples I. and II., or rather those portions of these samples which were collected at the same time, but in sterilized flasks.

A. The plate culture of the Smithville sample yielded per cubic centimetre *50 colonies of bacteria.*

B. The plate culture of the sample from the pumping station yielded *8100 colonies of bacteria.*

Another plate culture was made by dipping a sterilized platinum wire in culture A and streaking with it a plate flowed with sterilized gelatine peptone. This streaked plate yielded 15 colonies, all of which proved to be *Bacterium lineola* excepting one, which was *Bacterium termo.*

Another plate was similarly prepared from culture B. It yielded many colonies, which, on examination, proved to consist of Bacterium lineola.

Now it will be noted that I did not find in any of these cultures the bacillus of Eberth, or the bacillus of Klebs, or the micrococci of Chantemesse and Widal, which have been held by competent bacteriologists to be the specific pathogenic micro organisms of typhoid infection. What I did find were two very common species of the bacteria, which flourish vigorously wherever putrefaction is going on. They are the so-called *scavenger* bacteria, whose beneficent function in the economy of nature is to prey upon the putrescent matter. They are the sharks of the biological kingdom. They live upon offal and sewage, and by transferring oxygen to such sewage through the medium of their vital processes, they break up and destroy noxious matter and convert it into simpler and innocuous substances.

Of these scavenger bacteria there were 160 times more in the sample at the pumping station than in that from above Smithville, and I know of no other explanation of this fact than the presence of the sewage in the Mt. Holly sample, upon which they could feed and multiply.

Effect of Precipitation.

In connection with these bacteria I made the following novel experiment, and obtained therefrom a surprising result, and one of much sanitary importance. The practice of adding a minute quantity of alum to water in order to clarify it, is an old and very familiar one. But while it is successful in carrying down the dirt and coloring matters, I did not know what influence it would exert upon the bacteria. I therefore added alum, in the proportion of half a grain to the gallon, to the sample taken at the pumping station. On standing, the peaty matter was entirely precipitated in reddish-yellow flakes, and the water above became perfectly colorless and clear. On pipetting off some of this supernatant water, I found that instead of containing 8100 colonies of bacteria per cubic centimetre, as it did before precipitation with alum, it contained *only 80 colonies*. They were all the Bacterium lineola.

On filtering some of this supernatant water through a double thickness of sterilized filter paper into a sterilized tube, I found no bacteria in the filtered water. In other words, the water had been rendered by the addition of an amount of alum so minute as to be inappreciable to

taste and almost to chemical tests, *as sterile as if it had been subject to prolonged boiling*. I need not enlarge upon this demonstration, which, so far as I am aware, has not been hitherto made, of the possibility of completely removing all microbes from potable waters by the use of very minute amounts of alum followed by filtration. In case there is no organic matter in the nature of peat with which the alumina may unite, and, acting like a mordant in the operation of dyeing, may be precipitated as a lake, the alumina alone may be precipitated by the addition of lime or soda to alkaline reaction, and so carry down the bacteria. Or, in such case, a minute amount of soluble iron salt like ferric chloride may be first added, and then after precipitation with soda or lime, removed together with the bacteria by filtration.

Recommendations.

The above results, and those obtained by personal inspection of the surroundings of Mt. Holly, suggest three modes of obviating the danger of similar epidemics in the future.

I. Finding some point upon Rancocas Creek demonstrably free from sewage contamination. At present I know of none.

II. Finding a water bearing stratum in the vicinity from which, by means of driven wells, an ample supply of pure soft water, which has been submitted to a natural process of filtration, can be obtained. This may be the most economical method, and some test-wells could readily determine.

III. Previous purification of the water by means of aëration under pressure followed by filtration. In addition to the purification effected by oxidation, a minute amount of alum might be employed, but it is probable that this would not be necessary. By laboratory tests I have already determined that this particular water could thus be rendered pure, colorless, and palatable to all persons. The results of these tests are also in accord with the practical operation of purification and aëration plants already established to treat, on a large scale, water supplies of similar character as that of Mt. Holly.