

ing, Dec. 20, the bridge was traversed by two trains, advancing side by side from one end, and composed of twenty locomotives, and enough cars loaded with gravel to together cover both tracks completely. The independent span *CD* was occupied entirely by engines when the bridge was fully loaded. The deflection of the point *C* under the test was between six and seven inches, being an aggregate arising from the yielding of *AB*, the compression of the tower, and the deflection of *BC* itself. On the removal of this load, of double the amount which will probably ever be imposed upon the structure, the bridge completely recovered itself.

The application of the cantilever in bridge-building may be seen in several other instances in this country. Sometimes it has been used to diminish the opening to be spanned by a single truss, and more frequently it has been introduced to facilitate the erection of a bridge in places where temporary supports in mid-channel could be obtained only with great difficulty and expense. A wagon-bridge at Fort Snelling, Minn., furnishes an example of the former class; but the cantilevers are reduced to simple triangular brackets, projecting some thirty or thirty-five feet beyond the faces of two adjacent piers, and reducing the span to two hundred feet. The Cincinnati southern railway bridge, over the Kentucky River, has three spans of three hundred and seventy-five feet each. As the gorge which this structure crosses is two hundred and seventy-five feet deep, and ordinary false-works were out of the question, the spans were built out from each cliff as projecting trusses, anchored back to the rock. By the aid of one temporary timber tower on each side, and the iron piers, the bridge was thus joined in the middle. The lower chord connections were then severed at three hundred feet from each bank, leaving the middle span with a cantilever of seventy-five feet projecting from each of its ends. Here the introduction of hinges obviated the changes of strain which would otherwise be caused by the effect on the tall iron piers of changes of temperature. The Minnehaha bridge, across the Mississippi River, between St. Paul and Minneapolis, has three spans, and was erected like the Niagara bridge, — the two shore-arms on false-works, and the middle span as two cantilevers, which are connected by a hinged joint in mid-river, without any independent span.

A design for the Frazer-River bridge on the Canadian Pacific railway, by Mr. Schneider, although not yet erected, antedates the Niagara bridge, and is like it, only on a smaller scale. The design for the Blackwell's Island bridge, across the East River, New York, which was awarded the first prize in 1876, introduced cantilevers and an independent span. A similar type of bridge is in progress at St. John, N.B.; one is proposed for the new Harlem-River bridge, New York; and the great bridge for crossing the Frith of Forth, now under construction, is a bold design of this type, having two openings of seventeen hundred feet each. Others might be mentioned if space permitted.

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### THE CHOLERA BACILLUS.<sup>1</sup>

THE question, which, in my last report of Jan. 7, was left unanswered, — whether the bacilli found in the intestines affected with cholera are parasites due to cholera alone, — may be looked upon as answered.

It was at first exceedingly difficult, on account of the varying conditions under which the pathological changes took place in intestines affected by cholera, and on account of the great number of bacteria constantly present in them, to find out the bacillus proper to the disease. In most cases death occurred, not at the height of the cholera process, but during the period of reaction immediately following, in which such important changes take place in the condition of the intestines and their contents, that it is impossible, from such cases alone, to gain a clear conception of the cholera process. Only when one has had an opportunity to dissect a number of uncomplicated cases, and to compare with them the conditions exhibited in persons when first attacked, is it possible to gain a correct insight into the pathological conditions of cholera. On this account it was always kept in view, to use the greatest caution in accepting any theory as to the connection of the bacterial condition and the cholera, or as to causal connection of the bacteria with cholera, till the full proof might be obtained.

In the last report, I could already state that the peculiarities of the cholera bacteria were so well determined that they could safely be distinguished from others. Of these characteristics, the following are the most striking: the bacilli are not perfectly straight, like other bacilli, but slightly curved, like a comma. The bending may go so far that they take the form of a half-circle. In the pure cultivation from these bent rods often arise s-formed figures, and more or less long, slightly wavy lines, of which the first are made up of two, and the last of a large number, of the cholera bacilli, which, by continued increase, have remained connected. They possess powers of locomotion, which can best be seen, and in most marked degree, in a drop of cultivation-liquid suspended on a cover-glass: in such a preparation, one sees the bacilli moving with the greatest velocity in all directions through the field.

Especially characteristic is their action when cultivated in gelatine, in which they form colorless colonies, which at first are closed, and appear as if they consisted of very brilliant little glass particles. Gradually these colonies liquefy the gelatine, and spread out to a considerable extent. In gelatine cultivation they are, therefore, through this remarkable appearance, very surely distinguished from other bacteria colonies, and can easily be isolated from them. Moreover, they can pretty surely be distinguished by cultivation in hollow slides, as they always go to the edge of the drop, and in that position can be recognized by their peculiar movements,

<sup>1</sup> Sixth report of Dr. Koch of the German cholera commission, dated Calcutta, Feb. 2, 1884. Translated from the *Berliner klinische wochenschrift* for March 31. An abstract of the seventh report will be found in the Notes and news.

and, after application of aniline solution, by their comma form.

As yet, twenty-two cholera bodies and seventeen cholera patients have been subjects of investigation. All these cases were studied for the presence of the specific bacteria, as well with gelatine cultivation as also in microscopical preparations, for the most part through cultivation in hollow slides; and, without exception, the comma-shaped bacilli were found. This result, together with that obtained in Egypt, justifies the statement that this kind of bacterium is always to be found in the cholera intestine.

For corroboration, moreover, investigations were carried on in the same way on twenty-eight other bodies (of which eleven had died from dysentery); the evacuations of one case each of simple diarrhoea, dysentery, and of a convalescent from cholera; then from several well people, as well as on animals dead from ulcer in the intestine, and pneumonia; finally, also with putrid masses of impure water (various samples from city sewage, water from very impure swamps, swamp scum, and impure river-water): but in not a single instance did it happen, either in stomach or bowels of the bodies of man or beast, in evacuations, or in fluids rich in bacteria, that the cholera bacteria was found. As by arsenic-poisoning a sickness very similar to cholera can be induced, an animal was killed by arsenic, and, after death, the digestive organs examined for the comma bacillus; but with a negative result.

From these results the further conclusion may be drawn, that the comma bacillus is peculiar to cholera.

As to the connection of this bacillus with cholera, it was carefully stated in the last report, that there may be two views: 1°, that the condition of the organs of a person sick with cholera is such that this peculiar bacillus prospers; 2°, that the bacillus is the cause of the cholera, and that only when it makes its way into the bowels of man can the sickness take place. The first supposition is not allowable from the following grounds: it would be necessary to grant, that, when a man is taken sick with the cholera, this bacillus was already present in his organs, as shown by its universal presence in the considerable cases investigated in Egypt and India, two widely separated lands. This could not be the case, however; since, as has already been pointed out, the comma-shaped bacillus is never found, except in a case of cholera.

Even in cases of bowel affection, such as dysentery and bowel catarrh, to which cholera very often supervenes, they fail. It is also to be considered, that, if this bacterium were always present in man, it would surely have been observed on some occasion; which has not been the case.

As the increase of this bacterium cannot be brought about in the bowels by cholera, the second supposition, that it is the cause of cholera, only remains. That this is, in fact, the case, is shown unquestionably by other facts, and especially by its behavior during the progress of the disease. Its presence is restricted to the organ in which the disease is, — the

bowels. In vomit, they have, as yet, only been noticed in two cases; and in both, the appearance and alkaline reaction of the vomited fluids showed that the contents of the bowels, and with these the bacteria, had got into the stomach. In the bowels their history is as follows: in the first evacuations of the patient after the attack, as long as they have any form, very few cholera bacilli are present; the watery, odorless evacuations which follow, on the contrary, contain the bacilli in great numbers; while, at the same time, all other forms disappear almost entirely, so that, at this stage, the cholera bacilli are cultivated practically alone in the bowels. So soon as the cholera attack lessens, and the evacuations are again fecal, the comma bacteria disappear gradually, and are, after the convalescence, no longer to be found. The same is found to hold in cholera subjects. In the stomach no cholera bacilli were found. The bowels varied, according as death had occurred during the cholera attack or after it. In the freshest cases, the bowels showed a clear, red color; the inner lining of the intestines was still free from submucous extravasation; and the contents consisted of a colorless, odorless liquid: the cholera bacilli were present in enormous masses, and nearly pure. Their distribution corresponded exactly with the degree and spread of the inflammation of the lining-membrane, the bacilli being generally not so thick in the upper intestine, but increasing toward the lower end of the smaller intestine. When, however, death has taken place later, the intestines show signs of an important reaction. The lining is dark red in the lower part of the smaller intestine, impregnated with extravasations of blood, and often dead on the outermost layers. The contents of the bowels are, in such cases, more or less blood-colored, and, in consequence of the re-appearance of the bacteria of decomposition, putrid and fetid. The cholera bacteria at this stage begin to disappear, but continue still to be present for some time in the solitary glands and in their vicinity, — a circumstance which first called attention to the presence of this peculiar bacterium in the bowels of the Egyptian cholera subjects. They entirely fail in such cases, only when the patient has lived through the cholera, and dies from the after-weakness.

The cholera bacteria act exactly as other pathological bacteria. They occur only in their peculiar disease; their first appearance is when the illness begins; they increase in number with the severity of the attack, and gradually disappear as the illness wanes. They are found where the trouble exists; and their number, at the height of the disease, is so great, that their injurious effect on the lining of the intestines is explained.

It might well be wished that it were possible, with these bacteria, to engender in animals a disease akin to cholera, that their causal relation to the sickness might be made the more clear. This has, as yet, not been done: whether it will ever be done may well be questioned, as animals do not appear to be subject to cholera infection. If any kind of animal could take the cholera, then such a case would have been observed in Bengal, where, during the whole year, and

over the whole country, cholera infection is spread. But all reported cases have, as yet, failed of corroboration. Nevertheless, the evidence of the facts produced cannot be weakened by the failure of the experiments on animals. With other infectious diseases, the same observation has been made; for example, in the case of typhoid fever and leprosy, — two diseases for which specific bacteria are known, without, as yet, its being possible to communicate them to animals; and yet the manner of the occurrence of the bacteria in these diseases is such, that, without doubt, they must be looked upon as the cause of the disease. The same holds true for the cholera bacteria. Moreover, the further study of the cholera bacteria has made known many of their peculiarities, which all agree with that which is known of cholera etiology, as well as further evidence of the correctness of the assumption of the bacteria as the cause of the disease.

In this connection it is well to state the often observed fact, that in the linen of cholera patients the bacteria increase in a most remarkable manner, when the clothes have been soiled with the evacuations, and then, for twenty-four hours, have been kept in a moist condition. This explains the known fact, that the people having to do with such affected linen are often attacked. On account of this, further experiments were instituted; and cholera evacuations, or the contents of the intestines of the dead, were spread on cotton, on paper, and especially on the damp surface of the ground. After twenty-four hours, the thin sheet of slime invariably changed into a thick mass of cholera bacilli.

Another peculiarity of the cholera bacteria is, that they die, upon drying, much more quickly than most others. Commonly all life is extinct after three hours' drying.

It has also been noticed that their development only takes place well in substances having an alkaline reaction. A very small amount of free acid, which would have little or no effect on other bacteria, puts a marked check on their growth.

In a healthy stomach they are destroyed, which is shown by the fact that neither in the stomach nor the intestines of animals which had been constantly fed on cholera bacilli, and then killed, were any found. This last peculiarity, together with the impossibility of their withstanding drying, gives an explanation of the every-day observation, that infection so seldom occurs from constant intercourse with cholera patients. Evidently, that the bacilli may be in condition to pass the stomach, and bring about the cholera in the intestines, peculiar conditions must be present. Perhaps, when the digestion is imperfect, the bacilli might be able to pass the stomach; and the fact observed in all cholera epidemics and in India, that those suffering from indigestion are especially subject to cholera, may bear out this view. Perhaps a peculiar condition, analogous to the period of inaction of other bacteria, would enable them to pass the stomach uninjured.

It is, on the whole, not probable that this change in the production of inactive spores exists: then such

spores, by observation, are known to remain months, or even years, capable of life, while the cholera poison remains active not longer than from three to four weeks. Nevertheless, it is conceivable that some other form of inactivity exists, in which the bacilli can retain their life in a dry state some weeks, and in which they withstand the destroying influence of the stomach.

The conversion into such a condition would correspond with that which Pettenkofer has designated as ripening of the 'cholera-infection material.' As yet, such an inactivity of cholera bacilli has not been discovered.

### THE EXPLORING VOYAGE OF THE CHALLENGER.

(First notice.)

THE Challenger was a British man-of-war, a corvette of twenty-three hundred tons, equipped at the public expense with every appliance for the scientific study of the sea and of marine life, and carrying a faculty of six civilian specialists chosen by the Royal society, in addition to a staff of naval officers selected with reference to their scientific attainments.

This floating laboratory was sent out in 1872 upon a voyage of discovery around the world, and, during an absence of three years and a half, visited every accessible sea and ocean, traversing a distance of nearly sixty-nine thousand miles. Three hundred and sixty-two observing-stations were established at sea, and over five hundred deep-sea soundings made, — a wonderful record of industry, when it is remembered how many weeks were necessarily spent at coaling-stations, and when we take into account the fact that the present methods of rapid work by means of thin-wire dredge-ropes had not then come into use, and that a dredge-haul from a depth of two thousand to twenty-five hundred fathoms, which the Blake or the Albatross now easily completes in four or five hours, took an entire day of the Challenger's time.

The collections, when finally assembled at Sheerness, after the return of the ship, were contained in 2,270 jars, 1,749 bottles, 1,860 glass tubes, and 176 tin cases of alcoholics, with 22 casks of specimens in brine, and 180 tin cases of dried specimens, besides large quantities of material already sent home from Bermuda, Halifax, Capetown, Sydney, Hong Kong, and Japan.

The Challenger long ago resumed her barbaric function as an engine of war. Her trawls and dredges, battered and torn, hang upon the stair-rails in the Museum of naval architecture in South Kensington. Their share in the work