putrefactive odor. Malignant œdema is chiefly confined to the domestic animals, but cases have also been reported in man. Infection takes place most readily when, as in the natural disease, other bacteria are simultaneously introduced, such as the B. proteus and the B. prodigiosus.

Animals which recover from malignant œdema are subsequently immune. Artificial immunity may be induced in guinea-pigs by the injection of filtered bouillon cultures which have been previously sterilized.

Bacillus Aërogenes Capsulatus.—Found by Welch in the blood-vessels of a patient suffering from aortic aneurism; on autopsy made in cool weather eight hours after death, the vessels were observed to be full of gas. Since then it has been found in a number of other cases. These cases, as a rule, showed marked symptoms of delirium, rapid pulse, high temperature, and the development of emphysema and discoloration of the diseased area, or of abdominal distention when the peritoneal cavity was involved.

Microscopical Appearances.—Straight or slightly curved rods, with rounded or sometimes square-cut ends, somewhat thicker than the anthrax bacilli and varying in length, occasionally growing out into long threads. In the animal body, and sometimes in cultures, the bacilli are enclosed in a transparent capsule.

Motility.—Non-motile.

Spore Formation.—Absent.

Staining Reactions.—Stains with the ordinary aniline dyes and by Gram's method.

Biological Characters.—Anaërobic, growing at room temperature, but more rapidly at 37° C. in the usual culture media in the absence of oxygen, with gas production. *Gelatin* is not liquefied, but is gradually peptonized. On *agar* grayish-white colonies are developed in the form of flattened spheres, oval or irregular masses, beset with hair-like projections. *Bouillon* is diffusely clouded, and a white sediment is formed. *Milk* is rapidly coagulated.

Pathogenesis.—Usually non-pathogenic in healthy animals, although Dunham found that the bacillus taken freshly from human infection is sometimes very virulent. When quantities up to 2.5 c.c. of fresh bouillon cultures are injected into the circulation of rabbits and the animals killed shortly afterward, the bacilli develop rapidly with abundant formation of gas in the blood-vessels and organs, especially the liver. Welch suggests that in some cases in which death has been attributed to the entrance of air into the veins the gas found at autopsy may have been produced by this or some similar micro-organism entering the circulation and developing shortly before or after death. The bacillus has been found in the dust of hospital wards.

The Anthrax Bacillus (*Bacillus Anthracis; Milzbrand Bacillus; Bactéridie du Charbon*).—This organism is always present in the blood of animals affected with anthrax or splenic fever, an acute disease very prevalent, in certain parts of Europe and Asia, among sheep and cattle. In this country it is comparatively rare. The disease also occurs in man as the result of infection, either through the skin, the intestines, or, in rare instances, through the lungs, in the form of external anthrax or malignant pustule, and internal anthrax or wool-sorter's disease. Those persons are most subject to infection who come in contact with animals, hides, wool, etc.

Owing to the fact that anthrax was the first infectious disease which was shown to be caused by a specific micro-organism, the study of this bacillus has probably contributed more to our general knowledge of bacteria than any other living organism. It was first observed by Pollender in 1849 in the blood of animals affected with anthrax. In 1863 Davaine showed by inoculation experiments that it was capable of producing the disease. Then finally in 1879, Pasteur, Koch, and others demonstrated that the bacillus could be isolated in pure cultures on artificial media, and that when susceptible animals were inoculated with portions of these cultures conditions similar to those found in the animal from which the original cultures were obtained were produced.

Microscopical Appearances.—In the blood of animals it occurs as large rods of variable size, from 1 to 1.25 μ broad and 3 to 10 μ or more long, often arranged in flexible filaments twisted and plaited together. In unstained specimens examined in the hanging drop the ends of the rods appear to be slightly rounded, while in stained preparations they seem to be square cut. Under a high magnification, especially in cultures, the ends are seen to be a trifle thicker than the body of the cell, and occasionally somewhat indented and concave, giving to the rods the appearance of joints of bamboo cane. At one time much stress was laid upon these morphological peculiarities as distinguishing marks of the anthrax bacillus; but it has been found that they are the effects of artificial cultivation, staining, etc., and not necessarily characteristic of the organism under all conditions. The bacilli, when obtained from the blood of affected animals and certain culture media (liquid blood serum), are enclosed in a capsule, which in stained preparations may be distinguished by its taking on a lighter stain than the rods themselves which it surrounds. (See Plate XII., Fig. 1.)

Motility.—Non-motile.

Spore Formation.—Forms spores under aërobic conditions at temperatures from 12° C. up to 37° C. The spores are elliptical in shape and once or twice as long as broad; they first appear as small refractile granules distributed at regular intervals, one in each rod, and as the spores develop the mother cells become less and less distinct until they finally disappear altogether, the complete oval spore being set free by its dissolution. Spores are never formed in the living animal or in unopened carcasses, owing to lack of oxygen, but in slaughtered animals, bloody dung, etc., where the conditions necessary for their production exist. This fact is practically important with regard to the disposal of the carcasses of animals dead of anthrax. In fresh culture media the germination of spores takes place in a few hours. In old cultures which have been repeatedly transplanted the power of spore formation is often spontaneously lost. Certain varieties of anthrax bacilli soon become asporogenous. All agencies which decrease the virulence of the bacilli (as, for instance, cultivation at 42° C.) act unfavorably upon the function of spore formation. (See Plate XII., Fig. 2.)

Staining Reactions.—Stains easily with the ordinary aniline colors, also by Gram's method.

Vitality.—Anthrax bacilli free from spores retain their vitality in cultures for months, probably by spore production; in water they soon die; in the soil fresh anthrax blood is rendered germ free by exposure to sunlight in twelve to twenty-four hours. According to Koch, when exposed to desiccation, anthrax bacilli retain their vitality only for five weeks; in dried blood they withstand a temperature of 92° C. for one and one-half hours, but in the presence of oxygen they are killed by exposure to light in nine hours and in a vacuum in eleven hours. Pickling fails to destroy anthrax bacilli in meat in fourteen days, but kills them after six weeks. They are rapidly destroyed by moist heat at 60° C. Exposed to cold from 1° to 24° C. the bacilli in agar cultures were destroyed for the most part in twelve days, and the few surviving organisms yielded colonies of diminished pathogenic action and power of liquefying gelatin.

Dried anthrax spores retain their vitality indefinitely; in a moist condition in water, earth, putrid spleen, etc., the spores have lived for one and one-half to two and one-half years. They also resist a comparatively high temperature. Exposed to dry heat they require a temperature of 140° C. maintained for three hours to kill them, but in moist heat they are destroyed by a temperature of 100° C. in four minutes. Anthrax spores in a desiccated condition are killed by the action of direct sunlight in four hours, by diffuse daylight in several weeks.

Biological Characters.—Aërobic and facultative anaërobic, growing best in the presence of oxygen but also in its absence. Under the latter condition, however, this bacillus no longer liquefies gelatin, and the presence of oxygen is absolutely necessary for the formation of

spores. The anthrax bacillus grows rapidly on a variety of nutrient media at a temperature from 14° to 43° C., but best at 37° C.

Growth on Gelatin.—On *gelatin plates* small, white, opaque colonies are developed on the surface at the end of twenty-four to thirty-six hours at 24° C., while the deeper colonies are of a greenish color. Under a low power the colonies exhibit a characteristic appearance, consisting of a light-gray tangled mass of threads projecting beyond the edges in curly-hair-like tufts, which have been likened to a Medusa's head. Liquefaction of the gelatin takes place in three or four days, a white pellicle floating on the surface. In *gelatin stab cultures* at the end of twelve to twenty-four hours a thick, white central thread appears along the line of puncture, from which other white threads and irregular projections radiate perpendicularly into the medium. After two days liquefaction commences on the surface and gradually extends downward.

On *agar plates* the growth is similar to that on gelatin and is equally characteristic, but the colonies are not so compact. At the end of twenty-four hours in the incubator a grayish-white coating is formed on the surface, which spreads rapidly and consists of masses of long threads matted together.

In *bouillon* the growth is characterized by the formation of flocculent masses which sink as a sediment to the bottom of the tube, leaving the liquid clear.

Pathogenesis.—Especially pathogenic for mice, guinea-pigs, and rabbits, somewhat less for cattle and sheep (except the Algerian sheep, which are immune), and considerably less for horses; rats, cats, dogs, chicken, pigeons, and frogs are but little susceptible. Man, though subject to local infection (malignant pustule) from accidental inoculation of wounds, and occasionally to intestinal or pulmonary infection (wool-sorter's disease) as the result of inoculation through dust charged with anthrax spores and the consumption of meat from anthrax animals, is not as susceptible to this disease as the lower animals. Subcutaneous injections in susceptible animals result in death in from one to three days. Little or no change can be observed at the point of inoculation, but the subcutaneous tissue for some distance over the abdomen and thorax is found to be œdematous, with small ecchymoses scattered throughout the œdematous portion; the underlying muscles are pale in color. The intestinal viscera show no marked microscopical lesions, except the spleen, which is enlarged, soft, and dark colored. The liver may present the appearance of cloudy swelling. The lungs are red or pale red in color, while the heart is usually filled with blood. The anthrax bacillus produces in susceptible animals a true septicæmia, and after death the capillaries throughout the body always contain the bacilli in larger or smaller number. It is difficult to produce infection by the ingestion even of spores, but by inhalation it may be readily caused in animals. Infection is most promptly brought about by introduction of the bacilli directly into the circulation, but inoculation by contact with the abraded skin may also produce infection.

Many theories have been advanced to account for the occurrence of intestinal anthrax in cattle and sheep, the form of the disease which is most common in these animals. It has been thought that infection was produced mainly by the eating of food contaminated by anthrax spores derived originally from the bodies of affected animals; but, as we have seen, it is extremely difficult to cause infection in this way. By some authors it has been supposed to be a miasmatic infection and likened to malaria; and occurring as it does in the summer months and in low swampy places, there would seem to be a possible analogy in this respect between the two infections. But anthrax occurs in epidemics, being present at one time at a certain place and absent at another. Pasteur is of the opinion that the earth-worms play an important part in conveying the spores from one locality to another from the buried carcasses of affected animals; but Koch has shown this hypothesis to be untenable, as the bodies of earth-worms offer an unsuitable medium for the growth of spores, even if they were taken up and carried in this way. The most plausible explanation so far suggested for the solution of the problem is the supposition that under natural conditions unfavorable to the development of the bacilli an attenuation of their virulence takes place, and then again as the conditions become more favorable the virulence is restored—a result which can be artificially produced in cultures by chemical agents, heat, etc. Nutall has recently suggested that perhaps the disease may be conveyed in the bodies of insects, under certain conditions, as with malarial infection; but here, too, the bacilli undergo attenuation, according to the same author.

Attenuation of Virulence and Immunity.—The virulence of anthrax cultures may be artificially attenuated by the action of chemical agents and heat. Pasteur has succeeded in effecting considerable immunity against anthrax in regions where this disease is prevalent, by the inoculation of cattle and sheep with cultures attenuated by heat. Two vaccines are employed of different degrees of strength, prepared from virulent cultures reduced in virulence by cultivation at temperatures between 42° and 43° C. According to statistics collected by Chamberland from the results of twelve years' experience with this method of protective inoculation in France, out of three million sheep thus treated only one per cent. have died of anthrax since its introduction, whereas the mortality previously was over ten per cent. In cattle the mortality percentage has been reduced from five per cent. to 0.3 per cent. The method, however, is not unattended with danger, and sometimes the animals succumb to the effects of the inoculation.

The Bacillus of Symptomatic Anthrax (*Bacillus des Rauschbrands; Bactéridie du Charbon Symptomatique*).—Like the bacilli of anthrax, of malignant œdema, and tetanus, to all of which it bears a certain resemblance, the bacillus of symptomatic anthrax is an inhabitant of the soil. It is the specific cause of the disease in animals, principally cattle and sheep, known as "black-leg," "quarter-evil," or symptomatic anthrax, which prevails in certain localities, and is characterized by a peculiar emphysematous swelling of the tissues of the leg and quarters, accompanied with the formation of gas. On section of the affected parts the muscles and cellular tissues are found saturated with bloody serum, while the tissues themselves are dark, almost black in color. The bacillus can always be found in the affected parts, in the gall and after death in the internal organs.

Microscopical Appearances.—Long rods, with rounded ends, from 0.5 to 6 μ broad and 3 to 5 μ long; mostly isolated, also occurring in pairs, joined end to end, but never growing out into long filaments, as the anthrax bacillus does in culture media and the bacillus of malignant œdema in the animal body.

Motility.—Actively motile, flagella being attached to the bodies of the cells.

Spore Formation.—Forms spores elliptical in shape, usually thicker than the bacilli, lying near the middle of the rods, but rather toward one end, giving them a spindle shape.

Staining Reactions.—Stains with the ordinary aniline dyes, but not with Gram's method or only when the staining is much prolonged.

Biological Characters.—Strictly anaërobic, growing only in the absence of oxygen, best in an atmosphere of hydrogen but not in CO_2. Develops at room temperature in the usual culture media, but best in media containing 1.5 to 2 per cent. glucose or 5 per cent. glycerin and at 37° C.

On *gelatin*, irregular, slightly lobulated colonies develop and the gelatin is soon liquefied. On *agar* the colonies are similar to those of malignant œdema but somewhat more compact, after twenty-four to forty-eight hours in the incubator. In agar stab cultures growth occurs some distance below the surface, and is accompanied by the production of gas having a peculiar, disagreeable, rancid odor.

Pathogenesis.—Pathogenic for cattle (which are immune against malignant œdema), sheep, goats, guinea-pigs, and mice; less so for horses and rats. Rabbits, pigs, cats, dogs, chickens, and pigeons are, as a rule, immune. Infection has never been produced in man.

When susceptible animals are inoculated subcutaneously with pure cultures of this organism, with spores or with bits of diseased tissue, death occurs in from twenty-four to thirty-six hours. At the autopsy a bloody serum is found in the subcutaneous tissues extending over the entire surface of the abdomen, and the muscles present a dark red or black appearance, even more intense in color than in malignant œdema, and there is considerable development of gas.

The ordinary manner of natural infection in cattle is by wounds which not only tear the skin, but penetrate the subcutaneous tissues. The disease is also produced by the ingestion of forage contaminated by the bacilli or their spores, and by the inhalation of dust containing the organisms.

Immunity.—It is well known to veterinarians that natural recovery from one attack of symptomatic anthrax protects an animal from a second attack. Artificial immunity can also be produced in various ways: by intravenous inoculation; or, in guinea-pigs, by inoculations with bouillon cultures which have been kept for a few days and have lost some of their virulence, or with cultures kept in the incubator at 42° to 43° C.; or by inoculations made into the end of the tail; or by injection of filtered cultures or cultures sterilized by heat. Arloing, Cornevin, and Thomas recommend for the production of immunity in cattle the use of a dried powder of the muscles of animals dead of the disease, which has been subjected to a temperature sufficient to attenuate its virulence. Two vaccines are prepared, as in anthrax, one by exposure of the powder to 85°–90° C. (the stronger vaccine), and the other to a temperature of 100°–104° C.; the weaker vaccine is first used, and then the stronger. The inoculation is made into the cellular tissue of the ear or on the end of the tail; fourteen days are allowed to elapse between the two inoculations. Kitt recommends a single vaccine from infected flesh heated for six hours at 100° C. and given in decigram doses. The results obtained from these methods of preventive inoculation against symptomatic anthrax would seem to have been fairly satisfactory.

The Spirillum of Asiatic Cholera (*Koch's Comma Bacillus*).—In 1883 Koch isolated from the dejecta and intestines of patients suffering from Asiatic cholera a characteristically curved organism—the so-called "comma bacillus"—and showed that these bacteria were exclusively found in cases of the genuine disease. Other observers have since described morphologically similar organisms of non-choleraic origin. Finkler and Prior, for instance, observed such organisms in the diarrhœic stools of patients with cholera nostras; Deneke found others in old cheese, Miller met with others again in carious teeth, and Metschnikov observed others in fowls. But all of these organisms differ in many respects from Koch's comma bacillus, and none of them is affected by the specific serum of animals immunized to Asiatic cholera. Though varying somewhat in different epidemics, this spirillum is now generally recognized by bacteriologists to be the chief etiological factor in the production of true Asiatic cholera.

Microscopical Appearances.—Curved rods, with rounded ends which do not lie in the same plane, from 0.8 to 2 μ in length and about 0.4 μ in breadth. The curvature of the rods may be very slight, like a comma, but sometimes it forms a half-circle, or two contact rods curved in opposite directions may form an S-shaped figure, and under unfavorable conditions of growth, as in old cultures and on the addition of chemical antiseptics, etc., they may develop into long spiral filaments consisting of numerous turns of a spiral in which it is impossible to recognize any connection between the individual elements of which they are composed. These latter, the true spirilla, are considered to be involution forms. Under favorable conditions of growth and in fresh cultures, the slightly curved or almost straight forms are commonly observed. (See Plate XII., Fig. 5.)

Motility.—Actively motile, the movements being undulatory and due to one or two flagella attached to the ends of the rods.

Spore Formation.—Absent; the arthrospores described by Hueppe have not been confirmed by other observers.

Staining Reactions.—Stains with the ordinary aniline colors, but not as readily as many other bacteria; an aqueous solution of carbol fuchsin gives the best results with the application of heat. It is decolorized by Gram's method.

Biological Characters.—Aërobic and facultative anaërobic, growing on all the usual culture media at room temperature, but best in the presence of oxygen at 37° C. There is no development below 8° C. or above 42° C. The culture media must be distinctly alkaline, as the spirillum is very sensitive to acid.

On *gelatin plate cultures* at 22° C., at the end of twenty-four hours, small, round, yellowish-white to yellow colonies may be seen in the depths of the medium, which later grow toward the surface and cause liquefaction of the gelatin, the colonies sinking to the bottom of the pockets thus formed. Examined under a low power they appear granular in structure with more or less irregular outlines, the surface looking as if covered with little fragments of glass. An ill-defined halo is first seen to surround the colonies, which has a peculiar reddish tint by transmitted light. In *gelatin stab cultures* at the end of twenty-four to thirty-six hours a small funnel-shaped depression appears on the surface of the medium, which soon spreads out in the form of an air bubble above, while below this a whitish, viscid mass is seen. The funnel now increases in depth and diameter, and in from four to six days may reach the edge of the tube; in from eight to fourteen days the upper two-thirds of the gelatin is liquefied; and in a few weeks complete liquefaction takes place.

Upon *agar plates* the growth is not so characteristic, a moist, shining, grayish-yellow coating developing on the surface in the incubator.

Blood serum is rapidly liquefied at brood temperature.

In *bouillon* the growth is rapid and abundant, the liquid being diffusely clouded, and on the surface a wrinkled membranous film is often formed.

On *potato* having an acid reaction no growth, as a rule, takes place; but if the potato be rendered alkaline with a solution of soda or cooked in a three-per-cent. solution of common salt, development takes place in the incubator as a thin, semi-transparent brown or grayish-brown layer.

Milk is a favorable culture medium, but is not changed, as a rule, though it is coagulated by some varieties of cholera spirilla.

Vitality.—The comma bacillus does not usually exhibit much resistance to outside influences. In patients suffering from the disease the organisms have, as a rule, disappeared from the contents of the intestines in from four to eight or more rarely in from ten to fifteen days; though in a few cases living spirilla have been found after forty-seven days. They have been observed in cholera dejections from one to three, and occasionally from twenty to thirty days; in one recorded case after one hundred and twenty days. Even in cultures the spirilla of Asiatic cholera are rather short-lived. They have been found, however, to retain their vitality in pure bouillon cultures for three or four months and in agar cultures for six months or more, when protected from drying. In unsterilized water they may live for a considerable time apparently, though the observations on this vary from one day to one year. In sterile water they develop to some extent and retain their vitality for several weeks. Low temperatures, absence of light, and presence of salt in the medium would seem to favor their preservation. In well or river water they usually die in from three to eight days. In food they retain their virulence for a period varying from a few hours to a few days.

The comma bacilli are rapidly destroyed by desiccation. Exposed in cultures on a cover glass to the action of the

air at room temperature they are killed in two or three hours unless spread in a very thick layer. This fact indicates that infection is probably not usually produced through dust or other dried objects contaminated with cholera bacilli. They are destroyed by moist heat at 60° C. in ten minutes. They resist cold fairly well, withstanding repeated freezing without being killed, though their growth is inhibited. They have but little resistance to the action of chemicals, especially mineral acids, which have thus been employed for the disinfection of waterworks to which these germs have gained access. For disinfection on a small scale 0.1-per-cent. solution of bichloride of mercury or two to three per-cent. solution of carbolic acid may be used. Milk of lime is a good general disinfectant on a large scale. The wash and linen of cholera patients, floors of dwellings, etc., may be disinfected by a five-per-cent. solution of carbolic acid and soap water.

Chemical Effects.—The spirilla choleræ produce pigment in small amount only on potato. The peculiar disagreeable odor given off from cholera cultures in bouillon has been thought by some to be of diagnostic value, but it is not specific. Milk sugar is decomposed with the production of lactic acid without gas. In lactose-litmus agar the cholera spirillum forms on the surface of the medium a blue film, below this a red coloration, while lower down the medium is decolorized.

When a small quantity of chemically pure sulphuric acid is added to a twenty-four-hour-old bouillon culture of the cholera spirillum containing peptone, a reddish-violet color is produced—known as the "nitroso-indol reaction"—which is due to the production of indol and the reduction of nitrates in the culture to nitrites. Brieger separated the pigment thus formed or "cholera red." For a long time it was believed that the nitroso-indol reaction was peculiar to the cholera spirillum, and great weight was placed upon its production as a diagnostic test. But it has been shown that it is by no means specific, many other bacterial species giving the same reaction under similar conditions. The reaction, nevertheless, is a constant and characteristic property of this bacillus, and is of undoubted value in differentiating this from other similar organisms which do not give the reaction. For the test it is best to employ a culture not of bouillon, but a distinctly alkaline solution of peptone (1 per cent. peptone + 0.5 per cent. sodium chloride—Dunham's solution), from which more constant results are obtained.

Several toxins have been obtained from cholera cultures, but all of them much less poisonous than the original cultures. According to Pfeiffer these toxins are to be considered as secondary products modified by the action of the chemical reagents employed in separating them. Very much more powerful toxic products have been obtained from the bodies of the bacilli cultivated on agar and carefully killed by chloroform or heat. Three times the minimal fatal dose thus obtained from an agar culture (about 0.5 mgm.) kills a guinea-pig in from sixteen to eighteen hours, when injected into the peritoneal cavity, the effect being exactly the same as that produced by the living organisms, viz., rapidly beginning symptoms of the algid stage, muscular weakness, collapse, and death.

Pathogenesis.—None of the lower animals being naturally subject to Asiatic cholera, there is little reason to expect that inoculations of pure cultures of the spirillum should give rise to typical cholera infection. It has been shown, moreover, that the comma bacillus is extremely sensitive to the action of acids, being quickly destroyed in the stomach by the acids of the gastric juice. Nevertheless, numerous attempts have been made to produce cholera in test animals by inoculation of pure cultures of the organism, usually with negative or unsatisfactory results. Koch, however, has succeeded in producing an approximation, at least, to the symptoms of cholera in man by the infection of guinea-pigs by the following method: First, 5 c.c. of a five-per-cent. solution of sodium carbonate are injected into the stomach by means of a pharyngeal catheter, in order to neutralize the gastric contents; and then, after a while, 10 c.c. of a liquid containing one or two drops of a bouillon culture of the bacillus is administered in a similar manner, and at the same time the animal receives 1 c.c. of laudanum intraperitoneally, per 200 gm. weight, to control the peristaltic movements. As the result of this treatment the animals are narcotized for about half an hour, but recover without showing any ill effects from the opium. In about twenty-four hours the temperature begins to fall, weakness and paralysis set in, and, as a rule, death occurs within forty-eight hours. On autopsy the intestines are found to be congested and filled with watery fluid containing large numbers of spirilla. Unfortunately, however, other morphologically similar spirilla (the spirilla of Finkler-Prior, Deneke, and Miller) act very much in the same way, though somewhat less powerfully. Intraperitoneal injections of large quantities of cholera cultures also often produce death in rabbits and mice with similar symptoms.

With regard to the pathogenic properties of the cholera spirillum for man, there are quite a number of cases on record of accidental infection by pure cultures, which furnish the most satisfactory evidence of its being capable to produce the disease. In 1884 a student in Koch's laboratory in Berlin became ill with a severe attack of true Asiatic cholera while working with cholera cultures at a time when there was no cholera in Germany. In 1892 Pettenkofer and Emmerich experimented on themselves by swallowing small quantities of fresh cholera cultures, with the result that both of them were taken sick with typical cholera, one with mild and the other with severe symptoms. Since then other similar experiments have been reported, most of the persons taking the cultures having neutralized the acidity of the stomach previously by means of soda solution; and several fatal cases have occurred from accidental infection. At the same time, however, some negative results from experiments on the human subject have also been recorded—which only goes to show that in cholera, like other infectious diseases, an individual susceptibility is required, in addition to the presence of the germs, to produce infection.

According to Pfeiffer, cholera in man is an infective process due to the destruction of the epithelial layers of the intestines by the spirilla and the products of their growth, whereby intoxication results from absorption of the poisonous substances. The larger the surface of the mucous membrane affected, the more abundant will be the development of bacilli and the production of toxins, and the more pronounced, in consequence, will be the intoxication.

The cholera spirilla have recently been reported to have been frequently found in water (wells, water pipes, rivers, harbors, etc.) which has become contaminated with the evacuations of cholera patients. But to prove their presence beyond question in water is by no means easy, as there are so many other water bacteria simulating cholera bacilli from which they must be differentiated; hence some of the reported findings may not have been genuine cholera spirilla. The comma bacillus has been quite often observed in the fæces of healthy persons without producing, apparently, any pathogenic symptoms whatever. Abel and Claussen found thus cholera spirilla present in the stools, for days at a time, of fourteen out of seventeen healthy persons in the families of seven cholera patients. In Hamburg, during the last epidemic of cholera in Germany, twenty-eight such cases were observed in which the stools were absolutely normal.

The cholera spirillum, however, has been found in no other disease than true Asiatic cholera, occurring in this affection chiefly in the contents of the intestinal canal and especially in the mucous flakes of so-called "rice-water" stools, existing in pure culture frequently, and usually present in greatest numbers at the height of the attack. The spirilla are not, as a rule, found in the interior organs in recent cholera cases, except perhaps occasionally in the intestinal glands. In rare instances,