with an abscess already formed, the indication is to evacuate the pus. *Ubi pus, ibi evacua.* If a putrefying area is associated with a purulent focus, as much as possible of the putrid material should be cut away, the surgeon being careful not to expose healthy surfaces. In such a condition it may be proper to swab out the cavity with pure carbolic acid and then immediately after to cleanse it with alcohol. All such abscess cavities should be irrigated with some antiseptic solution and thoroughly drained, at first with iodoform gauze and later by means of rubber-tube drains. In cases in which, following an operation, there develop the symptoms of toxæmia, an early inspection of the wound should be made, and if infection has taken place the sutures should be removed, the wound irrigated with some antiseptic solution, drainage established, and dressings wet with some non-irritating solution, as Thiersch's solution of boracic and salicylic acids, be applied. The wound should be dressed daily or, in the virulent cases, more often. In some cases constant irrigation is indicated. In pyæmia, where possible, the secondary foci should be opened and treated as above.

General Treatment.—The routine treatment always includes as a preliminary procedure the stimulation of all of the excretory organs. The bowels should be freely moved, the kidneys stimulated, and diaphoresis increased. The proper nourishment of the patient should be carefully looked after, easily digested food being given in small amounts, and, when the stomach is unable to retain food, rectal enemata of peptonized milk, peptonized egg, and whiskey should be given every four hours, in amounts not exceeding from four to six ounces. The hygiene of the sick-room is also of importance; every opportunity for fresh air, sunlight, and cheerful surroundings is to be favored. In no condition is careful nursing more necessary. The use of drugs is not very satisfactory. Antipyretics are contraindicated, for they often act as powerful cardiac depressants and mask the symptoms. Alcohol in the form of egg-nogs, whiskey, and brandy, is considered by many to have very beneficial effects. In fact, these patients bear large amounts of alcohol very well, and it should be given freely. The heart's action can be stimulated best by using relatively large doses of the tincture of digitalis. If the diarrhœa is troublesome, it may be controlled by opium, or by bismuth and salicylic acid in their various forms. Paresis of the gastro-intestinal tract may be treated by an hypodermic injection of atropine sulphate gr. $\frac{1}{60}$, and bisulphate of quinine gr. v., to be repeated in five hours if necessary.

The use of intravenous and subcutaneous infusions of normal salt solution acts very beneficially in these cases. It helps to maintain the circulation, protects the nervous centres, dilutes the poisons, and assists very materially in the elimination of both the micro-organisms and their toxins. The infusions may be given daily in relatively large amounts, 1,000–1,800 c.c. being given intravenously. An objection has been raised to this, the statement being made that such a regular dilution of the blood would cease, after the first day or two, to have any beneficial effect; but this is not true, for in the course of twenty-four hours the excess of the solution may be entirely excreted from the body and a new infusion be called for. With this as a basis, many experiments have been made by adding antiseptics to the solution with the hope of bringing about a direct antiseptic influence upon the micro-organisms in the circulation and tissues.

Intravascular Antisepsis.—Experiments were carried out by Maguire, of London, to ascertain the effects of introducing a solution of formaldehyde gas directly into the circulation. His experiments were carried out upon animals and upon himself, and he concluded that 50 c.c. of a 1 to 2,000 solution of formaldehyde gas, or 50 c.c. of a 1 to 800 solution of formalin, could be safely introduced into the circulation without bringing about any serious blood changes. After injecting 100 c.c. of a 1 to 2,000 solution of formaldehyde into his own circulation, the only change that was noted was the appearance of albumin in the urine. Later, he injected 263 c.c. of a 1 to 2,000 formaldehyde solution. There followed considerable cramp-like pain in the arm, where the solution was injected, and peculiar cardiac distress. Many red blood corpuscles and blood-coloring matter were noted in the urine. This disappeared the next day. A solution of 1 to 1,000 formaldehyde, of which 63 c.c. was injected, caused severe pain in the arm and faintness. Maguire's conclusions were that 50 c.c. of a 1 to 2,000 solution of formaldehyde (1 to 800 solution of formalin) was the maximum dose to be safely injected in man. That is to say, if the total quantity of blood in an adult be estimated at 5,000 c.c., the solution of formaldehyde in the blood would be 1 to 200,000, which is a very efficient germicide. Barrows, of New York, applied this principle in the successful treatment of an advanced case of puerperal sepsis, as reported in the New York *Medical Journal*, January 31st, 1903. In his case he gave an intravenous infusion of 500 c.c. of a 1 to 5,000 aqueous solution of formalin, and on the third day following a second infusion of 750 c.c. of the same solution was given. There followed a rapid, marked, and permanent improvement which resulted in recovery. As a result of his experiments and those of others he concludes that the procedure depends on its being correctly and scientifically applied. He warns the profession against its indiscriminate use where proper blood cultures have not been made. It is also suggested that normal salt solution be used in making the formalin solution, as it has been found that no change takes place in the formaldehyde in this solution. Although no harm has been done to the blood cells by the infusion of formalin in distilled water, theoretically the normal salt solution is to be preferred.

Fortesque-Brickdale, as a result of his experiments upon rabbits, published in the *Lancet*, January 10th, 1903, does not favor the use of intravascular antisepsis. He states: "That rabbits injected daily with non-toxic doses of oxycyanide of mercury, formic aldehyde, chinosol, protargol, or taurocholate of sodium are not thereby protected from the usual effects of a previous inoculation of virulent anthrax; and that chinosol and formic aldehyde in large doses (toxic) so depress rabbits infected with the pneumococcus that they die sooner than an untreated animal."

Credé has applied the theory of intravascular antisepsis in the use of colloidal silver or collargol. This he claims to be a non-irritating, strongly bactericidal agent which may be employed as an inunction or as an intravenous infusion without any detrimental effects, and which is followed by marked improvement and often by recovery from the most severe forms of septic infection. He recommends it especially in cases of general sepsis, puerperal fever, pyæmia, and septic osteomyelitis. In the less severe cases, especially where the infection is localized, he uses a fifteen-per-cent. ointment of colloidal silver, rubbing two or three grams into the skin, after mildly irritating the same and causing local hyperæmia. In the more severe cases he recommends an intravenous injection of from 5 to 20 c.c. of a one-half to one-per-cent. solution, repeated daily or every week as required. Of his more recently perfected collargol solution he uses from 2 to 10 c.c. of a two-per-cent. solution. His technique is as follows: The syringe should be cleansed, the silver solution, and no other chemical, being used for this purpose. The syringe is then partially filled with collargol solution, and the detached needle is inserted, either through the skin or, if necessary, but only after a carefully made preliminary dissection, into the vein. The syringe having been attached to the needle, some blood is withdrawn into the syringe in order to remove from it any bubbles that may be present. Finally, the fluid is slowly injected. Subcutaneous injections are not effective. Viett used the intravenous method in a series of twenty cases of sepsis, and recommends it strongly.

The experiments of Grindes and Balardzsheff, however, do not bear out the conclusions of Credé, for they reported that a one-per-cent. solution of collargol had no effect on anthrax, staphylococcus, and streptococcus infections. They report that unless the injection is given at the

point of the inoculation of the micro-organisms, no effect followed. They claim that the simple injection of collargol intravenously causes death sometimes. Baginski, Naltenius, and Kunzl-Krause report no beneficial results. However, other experimenters have met with decided success in its use, and the failures of others may be due to faulty technique.

Unguentum Credé, an ointment of metallic silver, has been used by some in the treatment of these cases. Forty-five grains are rubbed into the skin very gradually.

Antistreptococcus serum of Marmorek is limited in its usefulness to certain kinds of cases, but in these it has met with marked success. The favorable cases are those which are caused by streptococci alone, and when the infection is a mixed one, the serum acts upon the streptococcus infection alone. In many of the cases reported the disease was already far advanced, and consequently they can scarcely be considered satisfactory test cases of the usefulness of the procedure. Packard and Wilson (*American Journal of the Medical Sciences*, December, 1902, p. 1033) have collected 117 cases treated during the past two years with antistreptococcus serum, and in 114 of these cases there followed either temporary improvement or prompt recovery. After citing many other cases they make the following statement: "All of these reports tend to convince us of the fact that antistreptococcus serum will at least do no harm, and that in cases in which the streptococcus is alone involved it will eliminate that micro-organism and control the symptoms caused by its toxin unless used too late for any remedy to be of avail. When the streptococcus infection is found in combination with those of other micro-organisms we have learned that the serum has no influence except in so far as it controls the streptococcus symptomatology. Undoubtedly the attempt to obtain a polyvalent serum is one in the right direction, and, as in typhoid fever, it presents a key to new accomplishments in the line of special serum therapy."

Special forms of treatment are indicated in infections of different regions of the body. In extensive processes involving the extremities amputation may save life, but even after such a drastic measure it may be found that the infected thrombus has extended too far to be checked, or the systemic disease may be developed to such an extent that amputation is contraindicated. Klebs first suggested the idea of ligating and removing the veins in which thrombi had formed before the infected emboli should become broken off and pyæmia set up. This procedure is especially considered in involvement of the lateral and sigmoid sinuses following suppuration in the middle ear. Here thrombo-phlebitis is very likely to occur, and the internal jugular vein is also frequently involved. The first step of the operation should be in most cases the ligation of the internal jugular below the point of involvement. Then the sinus may be exposed and the purulent material scooped out or gently washed out. Sometimes an excision of a portion of the vein is indicated.

In cases in which the pyogenic focus is in the pelvis, or in which a general suppurative peritonitis exists, the entire abdominal cavity may be flushed out with hot salt solution. The head of the patient's bed may be raised, which, as Fowler suggested, will favor gravitation of the purulent material into the pelvis, from which it may be aspirated every few hours.

The question of the treatment of puerperal sepsis occupied the attention of the Fourth International Congress of Obstetrics and Gynæcology in Rome, September, 1902, and formed one of its chief topics for discussion. The following extracts are taken from the report by Dr. H. N. Vineberg ("American Gynæcology," January, 1903). The conclusions of H. Treub (Amsterdam) were as follows: The usual methods of treatment (curettage, intrauterine irrigations, ice bags, cold baths, turpentine injections, antistreptococcus serum, alcohol) for puerperal sepsis localized in the uterus are in most cases followed by cure. In a few exceptional cases hysterectomy will be indicated. Tuffier (Paris) said that in a given case of *septicæmia*, post partum, or post abortum, when there is no cause for the fever to be found either in the external genitals or in other organs, when the usual methods of treatment are of no avail and when the peritoneum and adnexa are intact, and the uterus is large, flabby, and is discharging fetid lochia, and if the patient's general condition warrants it, total extirpation of the uterus should be done, whether there be placental retention, a sloughing myoma, or the so-called "metritis desiccans." A. Pinard (Paris) recognized only the following indications for hysterectomy: retained putrid placental remains, sloughing myoma, and perforation of the uterus.

The *convalescent stage* calls more for careful nursing and attention to general hygienic principles than for drugs. Nourishing food, fresh air, and cheerful surroundings are the essentials. *Paul Monroe Pilcher.*

SERUM DIAGNOSIS AND SERUM THERAPY.—I. Serum Diagnosis.—Serum diagnosis and serum treatment rest upon the same fundamental principles. When a group of foreign cells enters an animal body, whether in the form of disease or of experimental infection, there results a group of changes both in the foreign cells and in one or more cell groups of the body which they invade. These changes are peculiar and specific in relation both to the invader and to the territory invaded. The blood, as the representative of all organs, undergoes specific changes which are at the basis both of serum diagnosis and of serum therapy. A few examples will make this clearer. When a human body is invaded by a group of cells of that peculiar species known as typhoid bacilli, the blood acquires a number of new and specific properties, specific in the sense of manifesting their action only in relation to the typhoid bacillus. Upon one of these new properties serum diagnosis is based. The ability to agglutinate any specimen of the race typhoid bacilli is possessed to a feeble degree by the blood of many healthy human beings. But when a person is or lately has been suffering from typhoid fever, the agglutinating power of the blood over typhoid bacilli becomes greatly increased, and the resulting reaction, first brought into clinical use by Widal in 1896, is that ordinarily known as the "Widal reaction." This reaction, like all the agglutinative reactions, is specific in a double sense. The bacilli are thus agglutinated only by the serum of patients recently or formerly infected with typhoid. On the other hand, no bacillus, except the typhoid bacillus, is clumped in high dilutions by typhoid serum. The reaction has therefore a double use. Given a group of bacilli clearly identified as typhoid, we can use them for testing the serum for diagnosis in doubtful febrile cases. Or, given some serum or blood from a case known to be typhoid, we can use this liquid either fresh or dried on blotting-paper as a means of identifying doubtful cultures of bacteria.

The agglutinative reaction has now been shown to be of use, in both the ways just exemplified, as a means of identifying a considerable variety of diseases on the one hand, and of bacterial species on the other. The diseases in which it has been found of value thus far are, first and foremost, typhoid in which its use has been firmly established since 1898. Probably the number of tests performed in this disease exceeds those performed in all of the diseases put together. Next to typhoid, Malta fever and epidemic dysentery of the type due to Shiga's bacillus are the diseases in which the agglutinative reaction between the patient's blood and the specific bacillus of the disease is most frequently performed. The reaction has also been found to be of value in the diagnosis of the bubonic plague, and it is apparently our only reliable means of diagnosis in cases of infection by the so-called paratyphoid bacillus, an organism closely allied to, but not identical with, the bacillus of Eberth.

A certain amount of agglutination has also been demonstrated in infections due to the tubercle bacillus, the pneumococcus, the pathogenic streptococci, and various others, but the reaction is not distinct enough to be clinically available. An agglutinative reaction may also be obtained with the serum of cases of glanders, whether in

animals or in human beings, but the usefulness of mallein has thus far prevented any widespread application of the agglutination test in glanders.

Technique of Serum Diagnosis in Typhoid Fever.—First of all we must have a culture of the typhoid bacillus identified as such by all known tests. Bacilli that have recently been obtained from a human body are usually preferable. From such a well-identified stock culture, which is best grown on agar-agar, a loopful is transferred to a test tube containing about an inch of sterile bouillon. At the end of twelve hours at room temperature the bouillon will be slightly cloudy owing to the presence of very actively motile bacilli. Such a culture remains fit for use for from twenty-four to thirty-six hours, at the end of which time a loopful of the bouillon culture should be transferred to another tube of sterile bouillon and so on, a new culture being started every twenty-four hours and all being kept at room temperature, not in the thermostat. In order to be fit for use the bacteria must be very actively motile and show no tendency to spontaneous agglutination, such as often occurs in cultures more than thirty-six hours old. Since such spontaneous clumping occasionally occurs even in cultures frequently transplanted, it should be an invariable rule to examine, between slide and cover glass, a drop of the culture to be used, before adding any of the suspected blood. Spontaneous clumping is the most frequent source of error in performing the Widal test, for if we have added the blood of a suspected case without previously examining the culture, and if agglutination is then found, we have no means of knowing whether it was produced by the action of the blood or had previously taken place in the culture.

It should never be forgotten that the reaction is a quantitative one and not a qualitative one. If enough *normal* serum is added to a culture of typhoid bacilli and they be left in contact an hour or two, some agglutination often occurs. The Widal reaction is the occurrence of agglutination in a particular dilution and within a specified time. The dilution recommended by Professor Welch of Johns Hopkins is one part of blood to fifty parts of bouillon culture of typhoid bacilli. Any agglutination which takes place in such a mixture, if accompanied by a cessation of motion within one hour, is considered a positive reaction. In my own work I prefer a dilution of 1 to 10 with a time limit of fifteen minutes. With a longer time limit this dilution often gives rise to mistakes, but among many thousands tests I have known not more than one per cent. of mistakes, provided the short time limit (fifteen minutes) is rigidly enforced.

Either the whole blood or the serum may be used, in fluid condition or dried on glass or glazed paper. The chief obstacle to using dried blood is the difficulty of securing accurate dilution. A full drop of blood should be allowed to fall upon a glass slide and dried. (In this condition it may be preserved for weeks without losing any of its properties, or may be sent by mail in case no laboratory is at hand.) To make the test the dried blood is simply scraped off into a test tube containing ten drops of a bouillon culture of typhoid bacilli. It is difficult to measure the size of the drops accurately, but in a vast majority of cases this degree of accuracy is unnecessary.

The reaction is present in about ninety-eight per cent. of all cases of typhoid fever, but in a small proportion of these the reaction does not appear until so late a period of the disease that we cannot use it for diagnosis. In about two-thirds of all cases the reaction is present by the time the patient feels sick enough to consult a physician, that is, somewhere about the end of the first week of the disease. After defervescence the reaction persists in many cases for three or four months, occasionally for years. In a case of this latter type, if the patient is seen for the first time with some febrile affection and without knowledge of his previous history, the agglutinative reaction to typhoid still persisting in the blood may give rise to an error in diagnosis. As a matter of fact, however, I have very rarely known this difficulty to arise.

Technique of Serum Diagnosis on Other Diseases.—*Plague.* Since the bacillus pestis clumps spontaneously in bouillon it has been found necessary (Klein, *Lancet*, June 8th, 1901) to make an emulsion of a small fragment of solid culture in 0.75-per-cent. solution. Cairns (*Lancet*, June 22d, 1901) has made three hundred tests in twenty-four cases by this method, and finds that in all but the mildest and the most rapidly fatal cases an agglutinative reaction appears by the end of the first week in dilution of 1 to 10. This increases until by the eighth week a dilution of 1 to 75 is often insufficient to prevent agglutination. The time limit is fifteen minutes. In hanging-drop preparations agglutination within two hours often occurs in dilutions as high as 1 to 200.

Malta Fever. The test is performed exactly as in typhoid. Agglutination is often found in dilutions of 1 to 100 or more with a one-hour time limit.

Dysentery. The serum of cases studied by Vedder and Duval (*Jour. of Exp. Med.*, February 5th, 1902) agglutinated several strains of dysentery bacillus in dilution varying from 1 to 30 up to 1 to 500 within one hour. Controls with B. coli and B. typhosus were always negative. The reaction does not always appear simultaneously with the symptoms and may disappear in convalescence with great rapidity. The clumps are usually like those in the Widal reaction. Rarely, long loose skeins of bacteria are formed.

II. Serum Therapy.—As already intimated, serum therapy depends upon the fundamental fact that a group of body cells—for example, those of the central nervous system—have a way of rising to the emergency when compelled to defend themselves against a group of foreign cells (*e.g.*, tetanus bacilli) and of producing in excess substances antagonistic to such foreign cells or to their products. Such an antagonism is known as immunity. To be immune against a given cell is to possess the power of poisoning or dissolving that cell. This is known as antibacterial immunity. When the body is attacked, not by cell groups but by cellular products, such as toxins, another type of immunity is produced by virtue of which the blood of the immunized individual is able to neutralize and render inert the toxin molecules.

Either of these forms of immunity may be "natural" or "acquired," that is to say, the blood of many individuals contains substances similar in their action to antibacterial or antitoxic substances, even when the individual has never, so far as we know, been obliged to repel the attack of foreign cells, or, in simpler language, has never had the disease against which he is thus immune. Thus negroes seem to be, for the most part, congenitally immune to malaria, in much the same way as many species of animals are immune to the typhoid bacillus.

Acquired immunity is the result (*a*) of the disease, (*b*) of inoculation with the bacterial cells or the non-cellular toxins which cause the disease, or (*c*) of the inoculation of the body with the serum of persons convalescent from the disease in question or of some animal which has previously been rendered immune to the disease. Immunity acquired as the result of infection, whether accidental or experimental, is known as "*active immunity.*" That acquired as a result of the injection of serum from a convalescent or immune animal is called "*passive immunity.*"

In the great majority of instances practical serum therapy consists in causing a patient to acquire a *passive immunity* by the means just described, but there are a few examples of serum therapy by which we endeavor to give the individual's blood antibacterial rather than antitoxic power.

The diseases in which serum therapy has been used may be divided for convenience into those in which its utility has been definitely established, those still in the experimental stage, and those in which experiment seems to have demonstrated that by our present methods immunity cannot be conferred. In the first class we may group the following diseases in which it may be considered that serum therapy has come to stay: 1. Diphtheria. 2. Tetanus. 3. Snake-bite. 4. Rabies.

I will subdivide the next class into those diseases in

which the outlook for serum therapy is very promising, and those in which it is distinctly less hopeful. Very promising have been the experiments with serum therapy in: (1) Bubonic plague; (2) acute epidemic dysentery; (3) typhoid.

Less promising, but still hopeful, is the outlook in: (1) Cholera; (2) anthrax; (3) scarlet fever.

Unpromising has been the result of our work so far in: (1) Tuberculosis; (2) pneumococcus infections; (3) streptococcus infections.

A few experiments have also been made with sera in Graves' disease (milk of thyroidless goats), epilepsy (serum of epileptics between paroxysms), syphilis, and various other diseases with results thus far inconclusive.

Diphtheria. Antidiphtheritic serum (into the details of its production I cannot here enter) is the serum of horses rendered immune to diphtheria toxin by increasing doses of the toxin administered subcutaneously. Its uses are two: (1) Prophylactic and (2) curative.

Its *prophylactic* value in communities exposed to infection (schools, hospitals, etc.) is very great. The immunity begins about twenty-four hours after the injection and lasts for from three to four weeks. For a young child two hundred and fifty units is a proper dose. For adults a proportionately larger dose is required.

Its curative properties are now established beyond reasonable doubt. By its use the mortality in large contagious hospitals has been reduced from an average of forty-five per cent. to an average of sixteen per cent. (this last figure is based on an analysis of over 200,000 cases by Bayeaux). The mortality is less the earlier the serum is given in the course of the disease. In mild cases 4,000–6,000 units are sufficient. In severe cases 80,000–100,000 units may be needed to save life. The single dose for adults is 4,000–8,000; for children 2,000–4,000, and the dose is to be repeated every four to six hours unless marked improvement shows itself after the first dose.

Urticaria occasionally results from the use of antitoxin in diphtheria and may be very troublesome, but there is no evidence that nephritis, neuritis, or any other severe complication is ever produced by the serum.

Tetanus. Less brilliant than those of antidiphtheritic serum, the results of antitetanic serum are still such as place it far ahead of all other known remedies for tetanus. The great difficulty is to get it into the system sufficiently early in the disease.

Two sera are used: (*a*) that of Behring and Roux; (*b*) that of Tizzoni. The latter has been the more successful, but there is reason to believe that the type of disease is milder in Italy. Pfeiffer* has recently collected the cases treated with Behring's serum and finds a mortality of 52.7 per cent.; in 88 cases treated with Tizzoni serum the mortality was 36.3 per cent.

The Behring serum is used in doses of 20 c.c. every five to ten hours. Of Tizzoni's product (solid) 2.25 gm. are used for the first dose and 0.6 gm. for subsequent doses.

Recently cases have been treated by subarachnoid injections of the antitoxin by means of lumbar puncture, and there is some evidence that this method is preferable. Intracerebral injections have also been employed, but without any evident advantage.

Preventive inoculations with tetanus antitoxin in cases of injury in a community in which tetanus has been prevalent, have resulted in a marked lessening of the number of tetanus cases developing.

Snake Poisoning. Calmette's antivenene, 10–20 c.c., frequently repeated, is a most useful remedy especially for the bites of cobras and colubrine serpents, less so for bites of vipers or rattlesnakes.

Antivenene appears in the serum of horses treated with increasing doses of cobra venom slightly modified by heat. Injected in patients suffering from a cobra bite it neutralizes one of the two poisons present in cobra venom—the nervous poison—and "enables the individual to devote all his vitality to overcoming the local injury" done by the other poison (the irritant) present in the venom. Since the nervous poison is the chief death-dealing agent in venoms antivenene is of great value and should be carried by all travellers likely to be exposed to snake-bite.

Rabies. Although the specific poison is as yet unknown, much has been accomplished in the prevention of rabies by injections of what is probably a toxic serum (in all essentials) obtained from the spinal cord of mad dogs. Cords preserved in dry air gradually lose their virulence, and in the treatment of mad-dog bite in the human subject injections are begun as soon as possible after the bite, first with material from cords nearly devoid of virulence and later with material of gradually increasing virulence.

The figures of the Pasteur Institute from 1886 to 1894 include 13,817 persons supposed to have been bitten by rabid animals. The mortality is 0.5 per cent. Allowing for many mistakes in diagnosis we can hardly doubt that these inoculations have been effective, since the mortality of the disease is usually estimated at from sixty to eighty per cent.

Plague. Three sera are in use: 1. The Haffkine prophylactic vaccine. 2. The Yersin "antipest" serum. 3. The Lustig "antipest" serum.

1. According to Haffkine's own reports, the difference in mortality between those inoculated and those uninoculated is from eighty to ninety per cent. As sample results he reports (Proc. Roy. Soc., vol. lxv., No. 418) an epidemic in the Umerkadi Jail: 127 uninoculated; 10 cases, 6 deaths; 147 inoculated; 3 cases, *no* deaths.

The vaccine has no effect on cases in which the disease is incubating at the time of inoculation. The dose is 2.5 c.c. The duration of immunity is not well determined.

In a Russian village Tchistowitch (*Annales de l'Institut Pasteur*, March, 1900) succeeded in stamping out an alarming epidemic by the prophylactic use of Haffkine's vaccine. Its effects are very unpleasant, far more so than those of—

2. *Yersin's serum*, which is used as a curative in cases of plague actually under way. Daily injections of 20–40 c.c. subcutaneously or intravenously have reduced the mortality from thirty-three to thirteen per cent. in Calmette's hands. The serum also conveys a brief prophylactic immunity (twenty-five to thirty days).

Lignière has used 40–60 c.c. at a dose (*Annales de l'Institut Pasteur*, October, 1901) with ninety per cent. of recoveries in cases in which the serum was employed early.

Dysentery. Since Shiga's discovery of the bacillus of acute dysentery in the tropics, Flexner's identification of the same organism in the acute dysenteries of this country, and the discovery of the same organism in the summer diarrhœa of infancy by Vedder and Duval, work upon an antidysenteric serum has been pushed with eagerness. So far, the most definite results are those obtained in Japan and in Manila with Japanese serum from Kitasato's laboratory, but enough work has been done in this country to make it evident that the outlook is not at all unpromising.

Typhoid. The serum used in the vast majority of cases has been an antibacterial rather than an antitoxic serum, and has been administered as a prophylactic, not as a cure.

Wright (*Brit. Med. Jour.*, 1901, No. 2105) reports that among 2,669 uninoculated and 720 inoculated soldiers (Cyprus and Egypt, 1900) 68 of the former and only 1 of the latter contracted typhoid. Birt (*Brit. Med Jour.*, January 11th, 1902) noted at Harrismith (1900–01) the following data: Among 947 cases of typhoid in those not previously inoculated the mortality was 14.25 per cent. Among 203 cases of typhoid in men inoculated six to eighteen months before, the mortality was 6.8 per cent. and the type of disease milder.

Sterilized cultures of typhoid bacilli are the material used for inoculation.

Anthrax. Sclavo (*Berl. klin. Woch.*, 1901, pp. 480, 520) succeeded in obtaining from sheep, subjected to progressive inoculation of anthrax bacilli, a serum efficient

* Pfeiffer: Zeit. f. Heilkunde, xxiii., 2, 1902.

against the disease in sheep and apparently also in human beings. He refers to about twenty cases of human anthrax treated with this serum in various parts of Italy, and states that most of the patients recover.

Cholera. Working in the epidemic of 1894 at Calcutta, Haffkine inoculated with an emulsion of living cholera vibrios some 40,000 of the inhabitants. In one town, of 340 uninoculated, 45 got cholera and 39 died; of 181 inoculated, 4 got cholera and 4 died. Among 18 people living in one house, 11 were inoculated and no cholera occurred in any of them. Seven were not inoculated, 4 of them took the cholera, and 3 died. The inoculations cause a rise of 1° to 2° C., lasting with some constitutional symptoms for twenty-four hours.

Scarlet Fever. That the serum of patients convalescent from scarlet fever seems to exercise a favorable influence on the course of active cases has been noted by many observers (*e.g.*, Huber and Blumenthal, *Berl. klin. Woch.*, 1897, No. 31, and Leyden, *Münch. med. Woch.*, January 18th, 1902).

More recently sera prepared from streptococci isolated from the organs of scarlet fever cases have been used especially by Baginsky (using Aronson's serum) and by Moser, using a serum of his own manufacture. Each reports good results. *Richard C. Cabot.*

SEVEN SPRINGS.—Washington County, Virginia. These springs are located two miles from the Glade Springs. Depôt, on the Norfolk and Western Railroad. They have been known for many years, but no accommodations have as yet been provided for visitors. The waters are used commercially in the form of Seven Springs Iron and Alum Mass, an evaporated residue. An analysis of this mass by Prof. J. W. Mallet, of the University of Virginia, showed the presence of a large proportion of aluminum sulphate and iron persulphate, besides a considerable quantity of magnesium and calcium sulphate, and numerous other ingredients in smaller proportion. This substance is highly recommended as a general tonic and reconstructive, and is said to possess special merits in such affections as cholera morbus and dysentery, and in various hepatic and intestinal disorders. *James K. Crook.*

SEWERAGE AND SEWAGE DISPOSAL.—A system of sewerage is the network of pipes, conduits, etc., constructed for the purpose of collecting and carrying away from a city, town or village, the wastes of human life other than that portion of the wastes which are known collectively under the term garbage. The wastes entering the sewers may come from houses, stores, stables, factories, etc., and, if the sewerage system is constructed upon the so-called combined plan, the sewers will also carry street wash. If the system is constructed upon the so-called separate plan, street wash will be excluded, to be cared for by means of drains built for that purpose. The volume of sewage flowing in the sewers of a town or city of a given population depends mainly upon three things: (1) The consumption of water; (2) the tightness of the sewers, that is, their ability to prevent the entrance of ground water; and (3) whether the sewers are on the so-called separate or on the combined system. In England and upon the Continent, where the consumption of water does not average much more than thirty gallons per capita per day, the average volume of sewage produced by a given population must necessarily be less than in America, where the consumption of water in our largest cities and towns varies from seventy-five to two hundred and fifty gallons per capita per day. Upon the tightness of the joints of the pipes of the sewer system rests a great deal of responsibility in regard to the volume of liquid entering these sewers. By careful construction of the sewers and in some soils the ground water may be almost entirely excluded, but faulty construction in porous soils will often allow the entrance of a volume of ground water sometimes fully as great or greater than the volume of true sewage. In the combined system of sewage the volume of sewage flowing in the sewers is very much augmented at times of storm by the addition of street wash.

After collection in sewers some satisfactory method for the disposal of sewage is necessary. Formerly it was considered sufficient to empty this sewage into some body of water or flowing stream, which would either dilute it sufficiently to prevent visible nuisance, or carry it away from the vicinity of the town or city producing it. This method can still be carried out without offence by fortunately located cities and in sparsely settled countries with large rivers, lakes, and streams. As a country becomes more thickly settled, however, it is not sufficient simply to pass the sewage from its source to a point where it will not cause a nuisance to those producing it, but it must also be cared for in such a way as to prevent it from becoming a nuisance or a source of danger to other communities. On this account and coincidently with the great increase of urban life in civilized countries during the past twenty-five years, the question of sewage disposal has become a most pressing one. So general had the nuisance caused by sewage entering streams become in England as early as 1876, that the Rivers Pollution Prevention Act was passed—a law providing that no rivers or streams should be polluted because of the admission of crude sewage. In the twenty-seven years elapsing since that time there has been a constant agitation in England upon the subject, with an idea to bettering the condition of the rivers and streams, but even now the Act is very imperfectly carried out.

Practically the first agitation of this question in America was in the State of Massachusetts. The report of the State Board of Health for 1876 contained an article by the then secretary of the board, in regard to sewage disposal systems in England and on the Continent, and the same volume contained a report by an engineer of an examination in regard to the condition, on account of sewage pollution, of certain rivers and streams of Massachusetts. Since that date more important investigations upon sewage disposal and purification have been accomplished than during any previous period. An outline of this work, however, with descriptions of the most important methods, is all that can be given here. It is also well to state at this place that in this article little mention can be made of methods of dry disposal of wastes. These methods do not properly come under the head of sewage disposal, but they are methods in vogue in towns, dwellings, public buildings, etc., by means of which the wastes are collected in such manner as to render them more or less valuable for fertilizing purposes; that is, either without having been diluted or mixed with water, or only to a very slight extent. Besides the common middens, privies, etc., many patent processes for the accomplishment of the same result are in vogue in different places, and many processes by which by some means the solid matter of these wastes is, even when mixed with water, separated more or less efficiently from it before the main body of liquid enters the sewers

The demands made upon modern engineering in complex and difficult sewerage construction are very great, and as a result methods of construction are constantly improving. Sewerage works are increasing enormously, in number, in the area covered by a single system, and in the volume of sewage collected at a single point. The volume of sewage thus collected for disposal by a single city or metropolitan district now often reaches into the hundreds of millions of gallons daily.

Direct Disposal into Bodies of Water, or Disposal by Dilution.—Fortunately located cities and towns can satisfactorily discharge their sewage unpurified into large bodies of water. Where such communities are in close proximity to the seacoast or upon a very large river, the discharge of unpurified sewage into tidal waters or swift currents is still resorted to successfully. The method is practically without expense after the sewerage system is once complete, other than that, in some instances, of pumping. It is efficient if the tidal or other currents are strong and the sewage is prevented in this manner from reaching adjoining shores, and if the volume of water

into which the sewage is discharged is large compared with the volume of entering sewage. In some instances, however, even in such locations, some attempt at partial purification is made by collecting the sewage in basins and allowing sedimentation to occur before the discharge of the supernatant liquid; this sedimentation often being aided by the use of chemical precipitants.

Beginning in 1852 the straggling sewers of the city of London were given more definite form, and the sewage of this city was collected and carried by means of sewers to Barking Creek and Crossness, twelve miles below London Bridge. This enormous work was made necessary by the polluted condition of the Thames River. Before this date the sewage was discharged through many sewers directly into the Thames, as the river passed through the city. The greater part of the new works emptying at Barking Creek were completed in 1864, and in 1865 works on the opposite side of the river at Crossness were also completed. Ten years after the opening of these works it became necessary, on account of sewage carried up the river from these outfalls, to build large settling tanks in which the sewage was collected and chemicals were added for the purpose of precipitating the solid matter before discharging the clarified sewage into the tidal estuary. The solid matter resulting from this precipitation is taken out to sea in sludge boats, and the sewage is discharged between high and the middle of ebb tide. During 1901 and 1902 the average volume of sewage discharged daily amounted to 234,508,000 gallons and 47,673 tons of sludge were carried to sea each week. Twenty-two thousand tons of protosulphate of iron and five thousand tons of lime were used during the year.

Boston, Mass., together with the cities and towns surrounding it and composing a metropolitan district, with a population of 1,200,000 and having an area of 187 square miles, collects its sewage into three main systems, all of which discharge into strong tidal currents in the outer parts of Boston harbor. With two of these systems the discharge is continuous, while in the other the sewage is collected in large storage tanks and allowed to pass out on the ebb tide. Two of these points of discharge have been in operation for many years, and, notwithstanding the volume of the sewage, amounting at the present time to about 120,000,000 gallons daily, so efficient is the disposal because of dilution, sedimentation, and the rapid carrying away by swift tidal currents, that well-patronized summer resorts exist within short distances of the points of discharge.

The sewage of Greater New York all empties into New York harbor by means of many sewers, and is so diluted and dissipated by the swift and deep tidal currents that it is well cared for and practically unnoticeable. The sewage of Buffalo enters the Niagara River between Lakes Erie and Ontario. The sewage of St. Louis enters the Mississippi River, as does now the main portion of the sewage of Chicago through the Chicago drainage canal and the Illinois River, and in each instance, on account of the large volume of water flowing in the river, the disposal from some points of view is adequate.

Sewage Farms.—Berlin, Germany, passes its sewage to immense sewage farms, which have been in operation for many years, and are eleven thousand acres in extent; Paris, a portion of its sewage to farms at Gennevilliers and other places, where it is adequately cared for. Many other cities and towns, both in Great Britain and upon the Continent, follow the same method of disposal satisfactorily. This method can be carried out successfully, however, and at a profit to the farm only where the sewage is comparatively rich in organic matter, that is, where the volume of water is small compared with the population producing the sewage. It is with considerable difficulty even then that these farms can be made to return a profit above the cost of operation. It goes without saying that American sewage cannot be disposed of satisfactorily in this manner, being altogether too dilute; and any attempt so to utilize it means generally the use of only that portion valuable for irrigation, with the direct discharge of the remainder, unpurified by filtration through the soil, into the most convenient body of water. Sewage irrigation or farming, however, was the first attempt properly to purify sewage upon land, but having, sometimes at least, for its main object the utilization of the sewage rather than its purification; a profit from the farm being deemed of more importance than purification.

Continual agitation upon the subject of the prevention of the pollution of streams by sewage making a widefelt demand for a thorough understanding of proper and efficient purification, scientific studies upon this subject were begun practically about eighteen years ago. It had been observed that the passage of sewage through soil not only caused the removal of the suspended matters, but that the matters in solution were also changed or destroyed, that is, they did not appear in the effluent unless in an unrecognized form. The knowledge of germ life and the science of bacteriology having practically its beginning at about this period, it was believed that these changes occurring in sewage were caused by bacterial life in the soil. These first investigations were made by Schloessing and Muntz in France, and Warrington and Frankland in England. Their experiments were upon a laboratory scale and, without attempting to show that bacterial life was present by means of observation, they did demonstrate that, if germicides were added to the filter or to the sewage, purification in the filter did not occur. They also observed that their small tube filters, containing the earth, marbles, and other media experimented with, not only purified the sewage, but the filters themselves remained fairly clean, and organic matter accumulated very slowly within them. These investigations were very meagre and not long continued.

Toward the end of 1887, however, the State Board of Health of Massachusetts established an experiment station for investigations upon the subject of sewage purification, and accomplished and published the results of the most important scientific studies that had ever been made upon this subject. This experiment station is still continued. During the past eight or ten years much work along the same lines, but upon a larger scale, has been done in England, practically all of this work being based upon the Lawrence data, with such additions in construction of filters and methods of application of sewage as local needs have suggested. Many of these English studies have been largely carried on by cities and towns with the intention of applying the results directly to their own problem of sewage disposal, and thus have a practical and in some cases limited bearing only, and are without such thorough investigation of the science of the subject as has been aimed at in the long-continued Massachusetts experiments.

Sewage farming having caused the recognition of the fact that it could not be successful except with comparatively small volumes of strong sewage and where land was plentiful and cheap, nearly all the scientific investigations at the Lawrence experiment station have centred upon evolving processes of sewage purification by means of which the largest possible volume of sewage can be efficiently purified upon the smallest possible area and at a minimum cost. These studies have nearly all been upon bacterial methods of purification, that is, the oxidation or purification of the organic matter in sewage by means of the bacteria which establish themselves sooner or later in sewage filters of all kinds. With these studies others have been made in regard to methods for the treatment of sewage preliminary to filtration, which would result in allowing larger volumes to be efficiently purified upon given areas than is possible with untreated sewage.

Theory of the Bacterial Purification of Sewage.—In the purification of sewage by the action of bacteria the process is about as follows: The bacteria in the sewage, in the presence of oxygen, first attack the carbonaceous matters, carbonic acid being formed, nitrogen and hydrogen are set free and unite to form ammonia, this in turn uniting with the carbonic acid, forming ammonium carbonate, which goes into solution. The next step is the oxidation of the nitrogen of the free ammonia, first to