family is at least crippled because of nursing and care required by the sick one. In this way the earning capacity of from fifty to a hundred thousand people more, for one year, is sacrificed and lost to public wealth. To the loss of time must be added the expenses incidental to sickness, which, if they averaged but fifty dollars for each sick person, would amount to five million dollars a year. It will be very apparent to every one that I have placed all my estimates too low; but even with these low estimates, the annual loss to the public wealth of the United States because of the existence of tuberculosis will reach close on to five hundred million dollars. The expenditure of one-fifth of that amount by the federal and State governments for the extermination of the disease, would completely wipe out the disease in a single generation.

I am fully aware that there are men in the medical profession, and prominent men, too, who still hold that tuberculosis is not a preventable disease, and who cry down any preventative measures on the part of the government as a useless waste of public money. If there is any doubt on the part of the government on this question, it is certainly its duty to appoint a commission to carefully examine into the question and clear up the doubt one way or another. Either tuberculosis is a preventable disease or it is not. If it is a preventable disease, the government is in duty bound to prevent it, just as much as it is bound to protect its citizens against war. The finger of science points to the fact that tuberculosis is a preventable disease. Can our government afford to wait until every skeptic in the land has been convinced that it is preventable? No; its duty begins in the very beginning, with the scientific research into the preventability of the disease, and does not end until its citizens can walk this noble land for three score and ten years, unmolested in health, life and limb by aught that can be brought under the domain and control of man.

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THE DISINFECTION OF EXCRETA.

Read in the Section on State Medicine at the Forty-second Annual Meeting of the American Medical Association, held at Washington, D. C., May, 1891.

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The Committee on Disinfectants appointed by the American Public Health Association in 1884, in its final report submitted in 1887, gives the following *general directions*:

Disinfection of Excreta, etc. The infectious character of the dejections of patients suffering from cholera and from typhoid fever is well established, and this is true of mild cases and of the earliest stages of these diseases as well as of

severe and fatal cases. It is probable that epidemic dysentery, tuberculosis, and perhaps diphtheria, yellow fever, scarlet fever, and typhus fever, may also be transmitted by means of the alvine discharges of the sick. It is, therefore, of the first importance that these should be disinfected. In cholera, diphtheria, yellow fever, and scarlet fever, all vomited material should also be looked upon as infectious. And in tuberculosis, diphtheria, scarlet fever, and infectious pneumonia, the sputa of the sick should be disinfected or destroyed by fire. It seems advisable also to treat the urine of patients sick with an infectious disease with one of the disinfecting solutions below recommended.

Chloride of lime, or bleaching powder, is perhaps entitled to the first place for disinfecting excreta, on account of the rapidity of its action.

The following standard solution is recommended:

Dissolve chloride of lime of the best quality,¹ in pure water, in the proportion of six ounces to the gallon. Use one quart of this solution for the disinfection of each discharge in cholera, typhoid fever, etc.² Mix well and leave in the vessel for at least one hour before throwing into privy vault or water closet.

The same directions apply to the disinfection of vomited matters. Infected sputum should be discharged directly into a cup half full of the solution. A five per cent. solution of carbolic acid may be used instead of the chloride of lime solution, the time of exposure to the action of the disinfectant being four hours." (Op. cit., pp. 237, 238).

The object of this paper is to inquire whether these recommendations, which were based upon the experimental data available at the time they were made, are sustained by subsequent investigations; and whether any other agents have been shown to possess superior advantages for the purpose in view.

But first we desire to call attention to another portion of the report of the Committee on Disinfectants. On page 236 the following definition of disinfection and disinfectants is given:

"The object of disinfection is to prevent the extension of infectious diseases by destroying the specific infectious material which gives rise to them. This is accomplished by the use of disinfectants. There can be no partial disinfection of such material; either its infecting power is destroyed or it is not. In the latter case there is a failure to disinfect. *Nor can there be any disinfection in the absence of infectious material.*"

¹ Good chloride of lime should contain at least 25 per cent. of available chlorine (page 92). It may be purchased by the quantity at 3½ cents per pound. The cost of the standard solution recommended is therefore but little more than a cent a gallon. A clear solution may be obtained by filtration or by decantation, but the insoluble sediment does no harm and this is an unnecessary refinement.

² For a very copious discharge use a larger quantity.

I have italicised the last sentence because I wish to call especial attention to it. I am frequently asked "what is the best disinfectant to put into a water closet." Now if a closet or privy vault is resorted to only by healthy persons and no infectious material has been thrown into it there is nothing in it to disinfect, and the recommendation of the Committee on Disinfectants does not apply to it at all. It may smell badly, and in this case the bad odor may be neutralized by the use of deodorants; or we may prevent the putrefactive decomposition of its contents and thus prevent the formation of the offensive gases given off as a result of such decomposition, by the use of antiseptics. But to accomplish this it is not necessary to sterilize the entire contents by the use of active germicide agents.

A solution of sulphate of iron or of chloride of zinc is an useful antiseptic and deodorizing agent, and the Committee on Disinfectants in making its recommendations did not intend to discourage the use of such agents. But exact experimental data showed that these agents could not be depended upon for the destruction of infectious disease germs, and the recommendations made related to disinfection in the strict and proper use of the term as above defined. This definition is now accepted by sanitarians in all parts of the world, but many practicing physicians still use the term disinfectant as synonymous with deodorant. For example, I find in a recent sanitary periodical under the heading "Medical Excerpt," an item copied from the *American Journal of Obstetrics*, to which the name of a distinguished gynecologist is attached, in which the following statement is made with reference to a much-advertised so called "disinfectant." "As a disinfectant I have used it in my house for over a year with great satisfaction." Now the agent referred to has been proved by exact experiments to have comparatively little disinfecting power, although it is a very good deodorant. According to our definition "the object of disinfection is to prevent the extension of infectious diseases by destroying the specific infectious material which gives rise to them." Are we to suppose that the distinguished gynecologist above quoted had such infectious material in his house "for over a year" at the time he was employing "with great satisfaction" the agent he recommends? If not, the term was improperly employed for "there can be no disinfection in the absence of infectious material." I wish to emphasize this point because I have reason to believe that, in the army at least, the recommendation of the Committee on Disinfectants has led to the substitution of chloride of lime for cheaper deodorants and antiseptic agents—and especially for sulphate of iron—in latrines which are frequented only by healthy persons and consequently need no disinfection. The amount of chloride of lime issued from the Medi-

cal Purveying Depot at San Francisco during the past six months for use at military posts on the Pacific Coast, is more than double the amount of sulphate of iron; but there has been no epidemic of an infectious disease, and probably comparatively little call for the use of a disinfecting agent in the sick room. We quote again from the report of the Committee on Disinfectants:

"In the sick-room we have disease germs at an advantage, for we know where to find them as well as how to kill them. Having this knowledge, not to apply it would be criminal negligence, for our efforts to restrict the extension of infectious diseases must depend largely upon the proper use of disinfectants in the sick-room." (Op. cit., p. 237).

"The injurious consequences which are likely to result from such misapprehension and misuse of the word disinfectant will be appreciated when it is known that recent researches have demonstrated that many of the agents which have been found useful as deodorizers or as antiseptics, are entirely without value for the destruction of disease germs.

"This is true, for example, as regards the sulphate of iron or copperas, a salt which has been extensively used with the idea that it is a valuable disinfectant. As a matter of fact, sulphate of iron in saturated solution does not destroy the vitality of disease germs, or the infecting power of material containing them. This salt is, nevertheless, a very valuable antiseptic, and its low price makes it one of the most available agents for the arrest of putrefactive decomposition." (Op. cit., p. 237).

Chloride of lime is also a valuable antiseptic and deodorant, and I know of no objection to substituting it for sulphate of iron other than the question of cost. The first cost of chloride of lime, by the quantity, is about double that of sulphate of iron, but practically the difference is much greater because it is necessary to preserve the chloride of lime in air-tight packages. When exposed to the air it deteriorates in value very rapidly. It is therefore necessary to pack it in air-tight receptacles, which will not be injured by the corrosive action of free chlorine, and in comparatively small quantities, so that the contents of a package may be used soon after it is opened.

We now proceed to consider the experimental data relating to the germicide value of *chloride of lime*.

The Committee on Disinfectants gave it "the first place for disinfecting excreta on account of the rapidity of its action." This recommendation was upon experimental data obtained in the pathological laboratory of the Johns Hopkins University, under the writer's direction, and is sustained by more recent experiments made in Germany.

The experiments of Bolton, made for the Com-

mittee on Disinfectants in 1886, gave the following results: The time of exposure being two hours the typhoid bacillus and cholera spirillum in bouillon cultures were killed by a solution containing one part to 1000 parts of water (containing 0.03 per cent. of available chlorine). Anthrax spores were killed in the same time by a solution, containing 0.3 per cent. of available chlorine. Typhoid fæces were sterilized by a two per cent. solution, and in several instances by a one-half per cent. solution, but some resistant spores of non-pathogenic bacilli survived in two experiments in which a solution of 1:100 was used. In bouillon cultures to which 10 per cent. of dried egg albumen had been added, the typhoid bacillus was destroyed one-half per cent. (1:200).

Nissen, whose experiments were made in Koch's laboratory in 1890, found that anthrax spores were destroyed in thirty minutes by a 5 per cent. solution, and in 70 minutes by a 1 per cent. solution. In his experiments the typhoid bacillus and the cholera spirillum were destroyed with certainty in five minutes by a solution containing 0.12 per cent. (1:833); the anthrax bacillus in one minute by 1:1000; staphylococcus pyogenes aureus in one minute by 1:500. Experiments made by the same author on the sterilization of fæces showed that 1 per cent. could be relied upon to destroy the bacillus of typhoid fever and the spirillum of cholera in fæces in ten minutes.

Carbolic Acid.—The Committee on Disinfectants says: "A five per cent. solution of carbolic acid may be used instead of the chloride of lime solution, the time of exposure to the action of the disinfectant being four hours." This recommendation is made in view of the fact that in those diseases in which it is most important to disinfect the excreta, the specific germ does not form spores. This is now believed to be true of the typhoid bacillus, the spirillum of cholera, the bacillus of diphtheria, the bacillus of glanders, and the streptococcus of erysipelas; and it has been shown by exact experiments that all of these pathogenic bacteria are destroyed in two hours by a one per cent. solution, or less, of this agent.

Spores require for their destruction a stronger solution and a longer time. Koch found a one per cent. solution to be without effect on anthrax spores after fifteen days exposure; a two per cent. solution retarded their development, but did not destroy their vitality in seven days; a three per cent. solution was effective in two days. According to Nocht, at a temperature of 37.50 C., anthrax spores are killed by a five per cent solution in three hours.

Carbolic acid possesses the advantage of not being neutralized by the substances found in excreta, or by the presence of albumen. Thus Bolton found that the addition of 10 per cent. of dried albumen to a bouillon culture of the typhoid bacillus did not materially influence the result, the

bacillus being destroyed in two hours by a one per cent. solution.

This agent, then, is firmly established as a valuable disinfectant for excreta, but we still give the preference to the standard solution of chloride of lime of the Committee on Disinfectants for use in the sick room, "on account of the rapidity of its action," and also on account of its comparative cheapness.

At the International Sanitary Conference of Rome (1885) the writer, who was associated with Dr. Koch on the Committee on Disinfectants, presented the claims of chloride of lime, and in the recommendations of the committee it was placed beside carbolic acid with the following direction:

"Carbolic acid and chloride of lime are to be used in aqueous solution.

"Weak solutions, carbolic acid 2 per cent.; chloride of lime 1 per cent.

"Strong solutions, carbolic acid, 5 per cent.; chloride of lime, 4 per cent."

The strong solutions were to be used for the disinfection of excreta.

Creolin, a coal tar product, which is a syrupy dark brown fluid with the odor of tar, has during the past three years received much attention from the German bacteriologists. It is probably the same product which was tested under the writer's direction for the Committee on Disinfectants, in 1885, under the name of "Little's soluble phenyle." It stood at the head of the "Commercial Disinfectants" tested. The experiments made in Germany show that it is not so active for spores as carbolic acid, but that it very promptly kills known pathogenic bacteria, in the absence of spores, in solutions of 2 per cent. or less. Eisenberg found that a solution of two per cent. killed all test organisms within 15 minutes. Es-march found it especially fatal to the cholera spirillum, which was killed by solutions of 1:1000 in ten minutes. The typhoid bacillus showed much greater resisting power—a one-half per cent. solution failed after ten minutes exposure. The pus cocci were still more resistant. Behring has shown that the presence of albumen greatly diminishes its germicide power. As a deodorant it is superior to carbolic acid, and on this account is to be preferred in the sick room. A recently prepared emulsion may be used to disinfect the liquid excreta of cholera or typhoid patients, in the proportion of four per cent., two hours time being allowed for the action of the disinfectant. The experiments of Jaeger upon pure cultures of the tubercle bacillus attached to silk threads were successful in destroying the infecting power of these cultures, as tested by inoculation into the anterior chamber of the eye of a rabbit, when solutions of 2 per cent. were used.

The value of this agent as a disinfectant is then fully established; as to its cost in compar-

ison with the agents heretofore mentioned I am not informed.

Quick Lime.—Experiments made in Koch's laboratory in 1887 by Liboriws led him to place a high value upon recently burned quick lime as a disinfectant. More recent experiments by Jaeger, Kitisato, Pfuhl, and others have shown that this agent has considerable germicide power, in the absence of spores, and that the value which has long been placed upon it for the treatment of excrementitious material in latrines, etc., and as a wash for exposed surfaces, is justified by the results of exact experiments made upon known pathogenic bacteria. The germicide power of lime is not interfered with by the presence of albuminous material, but is neutralized by phosphates, carbonates and other bases, and by carbonic acid.

In the writer's experiments a saturated aqueous solution of calcium oxide failed to kill typhoid bacilli; but when suspended in water in the proportion of 1:40 by weight this bacillus was killed at the end of two hours. Anthrax spores were not killed in the same time by a lime wash containing 20 per cent. by weight of pure calcium oxide. According to Kitisato the typhoid bacillus and the cholera spirillum in bouillon cultures are destroyed by the addition of 0.1 per cent. of calcium oxide. Pfuhl experimented upon sterilized fæces to which pure cultures of the typhoid bacillus, or cholera spirillum were added. The liquid discharges of patients with typhoid fever or diarrhoea were used for the purpose. He found that sterilization was effected at the end of two hours by adding fragments of calcium hydrate in the proportion of 6 per cent., and that 3 per cent. was effective in six hours. When a milk of lime was used which could be thoroughly mixed with the dejecta the result was still more favorable. A standard preparation of milk of lime containing 20 per cent. of calcium hydrate killed the typhoid bacillus and the cholera spirillum in one hour when added to liquid fæces in the proportion of 2 per cent.

The experiments with this agent show that time is an important factor and that much longer exposures, as well as stronger solutions, are required to destroy pathogenic bacteria, than is the case with chloride of lime. For this reason we still give the last named agent the preference for the disinfection of excreta in the sick room. But in latrines the time required to accomplish disinfection is of less importance, and we are disposed to give recently burned quick lime the first place for the disinfection of excreta in privy vaults, or on the surface of the ground. It may be applied in the form of milk of lime, prepared by adding gradually eight parts, by weight, of water to one part of calcium hydrate. This must be freshly prepared, or protected from the air to prevent the formation of the inactive carbonate of lime.

According to Behring lime has about the same germicide value as the other caustic alkalies, and destroys the cholera spirillum and the bacillus of typhoid fever, of diphtheria, and of glanders, after several hours exposure, in the proportion of 50 cc. *normal-bauge* per litre. Wood ashes of lye of the same alkaline strength may therefore be substituted for quick lime.

Finally, it must not be forgotten that we have a ready means of disinfecting excreta in the sick-room, or its vicinity, by the application of heat. Exact experiments made by the writer and others show that the thermal death-point of the following pathogenic bacteria, and of the kinds of virus mentioned is below 60° C. (140° F.): Spirillum of cholera, bacillus of anthrax, bacillus of typhoid fever, bacillus of diphtheria, bacillus of glanders, diplococcus of pneumonia (M. Pasteuri), streptococcus of erysipelas, staphylococci of pus, micrococcus of gonorrhoea, vaccine virus, sheep pox virus, hydrophobia virus. Ten minutes exposure to the temperature mentioned may be relied upon for the disinfection of material containing any of these pathogenic organisms—except the anthrax bacillus when in the stage of spore formation. The use, therefore, of *boiling water in the proportion of three or four parts to one part of the material to be disinfected* may be safely recommended for such material. Or better still, a 10 per cent. solution of sulphate of iron or of chloride of zinc, at the boiling point, may be used in the same way (three parts to one). This will have a higher boiling point than water, and will serve at the same time as a deodorant. During an epidemic of cholera or typhoid fever such a solution might be kept boiling in a proper receptacle in the vicinity of the hospital wards containing patients, and would serve to conveniently, promptly, and cheaply disinfect all excreta.

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THE SANITARY AND UNSANITARY RELATIONS OF UNDERGROUND WATERS.

Read in the Section of State Medicine, at the Forty-second Annual Meeting of the American Medical Association, held at Washington, D. C., May, 1891.

BY S. H. BRYCE, M.D.,
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Gentlemen:—It is not my intention to deal at any length with this subject, but rather to present some of the principles to be observed in the selection of drinking waters.

Much has been said with regard to the dangers of drinking water from wells; but it has not been until recently that the differentiation has been made as regards wells that are dangerous and those that are healthy.

As a general principle, it may be said that practically all *really* underground waters are sanitarily good; but it must be clearly understood what is meant by an underground water. For instance:

1. A water lying in a shallow dug out in prairie or bog land, down only to the impervious clay or rock below, cannot fairly be called underground water.

2. Neither can a well down even into a true water-bearing stratum of sand or gravel, be called an underground water, if the water of the upper organic soil layer is allowed to percolate toward the well laterally, without really moving downward through the underlying beds of clay loam, sand or gravel, which serve to sterilize the waters in their passage downward.

3. Neither can a well be called underground if, as is commonly the case, the well is covered with loose boards, or a wooden framework, thereby allowing the filth washings from the surface of the boards to be carried down through cracks into the water of the well.

Carl Fraenkel and others have carefully examined into the water of pit-wells, and such have by Pflügge been called "hygienic monsters."

Clearly, then, underground waters mean those which have primarily fallen upon the surface, have there been contaminated with soil microbes, but which have, in their passage downward, through percolation to the water-bearing zone situated on some impervious stratum, been purified by the several natural agencies which are at work.

Of these, doubtless, the one of greatest importance is the mechanical retention in the upper layers, of the grosser organic matters, for instance those of sewage on a sewage farm.

I have found that at a sewage farm, the upper circle or two of the bed of sand has retained practically all suspended organic matters, and that even soluble organic matters are gradually abstracted by capillary adhesion from waters as they pass downward.

In addition, however, to this cleansing action of capillarity, we have at work, under favoring conditions, the destructive action of bacteria. With various kinds of organic matters, putrefaction bacteria deal largely, but their work, while purifying to the soil, may result in emanations of an extremely injurious character. In order that this decomposition may go on rapidly and without pernicious results, intermittency of deposit of organic matter on the surface and the penetration of air with its oxygen into the soil is required, in order that the nitrifying germ, proper, may carry on its beneficent work.

Manifestly, therefore, we have in towns conditions where, with the permanent presence of masses of organic matter in back-yards and in privies, waters may move laterally or from the surface, carrying to the largest extent their solubility admits of, organic materials to underground strata, which, appearing in wells, and there coming into contact with oxygen, supply conditions for the free multiplication of germs borne in from the surface or the air, and hence waters that have been sterile as underground streams, and loaded with soluble organic matters, become culture media for certain pathogenic bacteria in those seasons of the year when the water temperature makes their development abundant. Every one is familiar with wells dangerous only in the later summer months when deep, or from spring or early summer, when their water reaches a higher temperature.

Much interest has for many years attached to the experiments of Pettenkofer with regard to the rising and falling of underground waters, in their bearing upon the increase in the mortality from filth diseases, notably of typhoid fever. It has been assumed that he was correct in saying that after a summer lowering of the ground water, and then a rise with autumn rains, typhoid invariably increased.

Now, with regard to this, as with so many other conditions, individual local circumstances will decide whether or not he is correct. For instance, Buck and Franklin have laid special stress on *wetness of soil* in general, and the effect of highness or lowness of the *subsoil water*, as increasing *cholera infantum*. Hirsch, on the other hand, examined the relationship between the number of cases of cholera infantum and the level of the subsoil water at Berlin, from 1877 to 1882, and concluded that the height of the subsoil water in Berlin gives no measure of the rate of mortality. Now if we look closely into the facts there, his conclusions are as we would expect. The city is