ters." In the purity of its bitter taste, the promptness of its action upon the assimilating organs, and the absence of other qualities even in considerably larger than medicinal doses, it has no equal. Concerning its physiological action in a definite way—that is, as shown by experiments in laboratories—we know but little, the more striking effects of active poisons having greater fascination for physiologists. *Gentisic acid*, when taken even to the extent of several grams, has no special action. *Gentiopicrin* has not been tested, to the writer's knowledge, in a pure state; but the older *gentianins*, etc., consisting of mixtures of the above two substances, have never shown themselves poisonous. In excessive quantities gentian and its preparations disturb the stomach and bowels, and may occasion nausea and vomiting. Sometimes it appears to be slightly laxative. Gentian is employed in medicine almost exclusively for the purpose of obtaining its stimulating effect upon the appetite, gastric secretion, and assimilating functions. Under its influence the appetite improves, the feeling of weight or discomfort felt in the stomach or bowels after eating—if due to debility of those organs—disappears, more food is taken, and probably more of what is taken is assimilated. It must be borne in mind that it probably, like other bitters, has a slight inhibitory action upon the digestive process by its presence in the mass of food. The secondary effect—viz., the improved nutrition of all the organs, and their consequently better performance of their various functions—is what is known as a tonic effect. Strength, weight, color, firmness of tissue, are all improved, and better health results. This drug is, then, indicated in debility, with poor appetite, of a more or less chronic character. Of course, acute and sudden depression, such as collapse or shock, or the weakness of fevers during the stage of high temperatures, are to be treated by stimulants, and are not suitable ones for tonics alone; but, on the other hand, during the recovery from all severe illnesses gentian may be of great value. It is often of service in dyspepsia, and, in combination with iron, in simple anæmia. As an antiperiodic it has been completely superseded by quinine; as a substitute for tobacco and opium in the treatment of those habits it has no special value.

ADMINISTRATION.—Gentian, in the form of the whole root, is sometimes chewed, and the salivary extract swallowed; the method, although troublesome, is an excellent one. The dose is not particularly important, but 2 or 3 gm. will probably do as much good as a larger quantity. There are several widely used preparations, all good. The extract (*Extractum Gentianæ*, U. S. P.), an infusion evaporated to a pillular consistence, is a nearly black, pleasant-smelling, but very bitter, soft solid, scarcely firm enough to make permanent pills. Dose, a gram or less. The fluid extract (*Extractum Gentianæ Fluidum*, U. S. P.), made with diluted alcohol, is less used than the other preparations, but represents the root well. The compound infusion (*Infusum Gentianæ Compositum*, B. P.), although not now officinal here, is considerably used; its strength is 12.5 gm. to 1,000 c.c. with orange and lemon peel. Dose, a wineglassful or two. But the most commonly used of all, and probably the most perfect bitter tonic ever made, is the compound tincture (*Tinctura Gentianæ Composita*, U. S. P.), which has the following composition: Gentian, 10 parts; bitter orange peel, 4 parts; cardamom, 1 part; percolated with diluted alcohol until 100 parts of tincture are obtained. The addition of aromatics in the last two preparations greatly enhances their value. *W. P. Bolles.*

GENTIANACEÆ.—(*The Gentian Family.*) The great size and wide distribution of this family, and the singular uniformity of its species in agreeing with the general composition and properties of the drug last discussed, render it of great importance that army surgeons and travellers generally should be able to recognize them when seen. There are no poisonous plants among them. A very few are slightly or not at all bitter and their roots or leaves are edible. Several *Coutoubeas* are used as anthelmintics. With these exceptions, all the others in use, to the number of a hundred or more, have the properties of the official *Gentian* and *Chiretta*. Among these are a large number in the genera *Gentiana*, *Swertia*, *Lisianthus*, *Pleurogyne*, *Erythræa* (the "Centaurys"), *Sabattia*, *Axacum*, etc. All show a distinct tendency toward laxative properties, and in some this tendency is marked. The family contains upward of sixty genera and nearly a thousand species, Gentiana being the largest genus, with about three hundred species. The family is represented mostly in the temperate zones and in tropical mountains with a temperate climate. They may be known by the following family characteristics: They are mostly herbs, smooth, with opposite, entire, extipulate leaves, these usually nerved or ribbed. The flowers are solitary or cymose in the axils, or at the summit, the cymes often panicled. The flowers are regular, rarely a little oblique, perfect, 4-5-merous, the corolla gamopetalous. The stamens are of the same number as the corolla lobes, alternate with them and affixed to the corolla tube or throat. The disc, if any, is inconspicuous. The ovary is superior, one-celled, or rarely two-celled by the union of the two parietal placentæ. The ovules are numerous, anatropous or amphitropous. The fruit is usually a two-valved, dehiscent capsule, rarely indehiscent, still more rarely fleshy. The embryo is small, in copious albumen, the radicle, if its direction is distinct, ascending.

Henry H. Rusby.

GEOFORM, or gaiaform, prepared by the action of formaldehyde on guaiacol, is a yellow, non-irritant powder, without odor or taste. It is soluble in alcohol, ether, hot benzol, and solutions of soda or potassa, and is insoluble in water, petroleum ether, and benzin. Heated for several days it acquires an odor of vanilla. Used by Brissonet and others, it is claimed to be non-toxic, as much as 15 gm. (ʒ ss.) a day having been administered, without inconvenience, to a dog weighing 16 kgm. (35 pounds). It is given in capsule in tuberculosis, the dose being that of guaiacol.

Tanno-geoform, its compound with tannin, is preferred for intestinal tuberculosis and night sweats, and for other sweating processes, such as hyperidrosis.

W. A. Bastedo.

GERANIUM.—CRANESBILL. *Wild Geranium.* "The dried rhizome of *Geranium maculatum* L. (fam. *Geraniaceæ*)," U. S. P. This plant is exceedingly abundant in woodlands about New York, and elsewhere in eastern and central North America, and is represented farther west by other species, with similar properties. It is a perennial slender herb, a foot or two high, with palmately lobed, roundish leaves, from two to six inches in diameter, and numerous lilac-purple flowers, something over an inch in breadth. The rhizome is of horizontal growth, 5 to 10 cm. (2 to 4 in.) long and 0.5 to 1.5 cm. (¼ to ⅝ in.) thick, more or less crooked, cylindraceous but somewhat vertically flattened, brown; roughly and shortly wrinkled and strongly, rather sharply tuberculate; fracture short, purple, the bark thin, a few short and broad yellowish wood-wedges scattered near the dark cambium; inodorous; taste strongly astringent.

Besides inert *mucilage*, *resin*, *coloring matters*, etc., geranium contains from ten to twenty-five per cent. or more of tannin, to which its medicinal value is owing. It is a mild, rather pleasant, vegetable astringent, and considerably employed in diarrhœa, chronic dysentery, etc., and as a wash, gargle, or injection, in catarrhs of the pharynx, vagina, or urethra. A fluid extract is official and represents it well for internal use. Dose, 1 to 2 c.c. (ɱ xv. ad xxx.). For washes and gargles a ten-per-cent. decoction may be made in the usual way. Cranesbill is often selected, when an astringent is needed for a child, on account of its comparatively easy administration.

Geranium will probably be dropped from the next edition of the Pharmacopœia. *Henry H. Rusby.*

GERMANDER. See *Labiatæ*.

GERMAN MEASLES. See *Roetheln*.

GERMICIDES.—Modern science having established the fact that certain infectious diseases of man and of the lower animals are due to minute micro-organisms, popularly spoken of as "germs," the term *germicides* has been introduced to designate those agents which have the power of destroying the vital activity of such organisms.

Strictly speaking, a germ is the primitive reproductive element of an animal or vegetable organism. But medical authors, in advance of exact knowledge, have long been in the habit of speaking of the "germs of disease"; and since it has been shown that in certain instances these disease germs are minute vegetable organisms, belonging to the *bacteria*, a more definite idea is attached to the word germ, and the term germicide is understood as referring to an agent which has the power to destroy organisms of this class—micrococci, bacilli, and spirilla.

It is evident that an exact knowledge of the germicidal power of various substances is desirable with a view to therapeutic possibilities, and especially with reference to the destruction of disease germs external to the bodies of infected individuals—*disinfection*. As methods have been perfected by which organisms of this class—pathogenic or non-pathogenic—may be isolated and cultivated through successive generations in sterilized media—"pure cultures"—it has become possible to determine in an exact manner the germicidal power of a given agent as regards a particular germ; and in a general way to classify chemical agents with reference to their power to destroy bacterial organisms. Already much work has been done in this direction, and it is the object of the present article to place upon record the results of the determinations which have been made up to the present date.

But before referring in detail to the experimental data, it will be desirable to give an account of the methods of research, and to call attention to the various circumstances which influence the result, and which must be taken into consideration if we attempt to compare the data obtained by different experimenters.

In the case of pathogenic organisms *two methods of determination* are available: (*a*) the inoculation of germs which have been exposed to the action of a supposed germicide into a susceptible animal; (*b*) the attempt to cultivate germs exposed in the same way in suitable culture media. In the one case failure to multiply in the body of the test animal, and in the other failure to multiply under favorable conditions in a culture medium is taken as evidence of the germicidal power of the agent tested.

Extended experiments by the method of inoculation have been made upon the anthrax bacillus (Davaine, Koch), upon the tubercle bacillus (Schill and Fischer), and upon the micrococcus of rabbit septicæmia (Davaine, Sternberg). Experiments have also been made upon the virus of glanders (Reynal, Peuch, Vallin), upon that of symptomatic anthrax (Arloing, Cornevin, and Thomas), and upon the micrococcus of fowl cholera (Salmon).

This method is very definite and satisfactory so far as the negative results are concerned—that is to say, when the agent under trial fails to exercise any germicidal power. In this case the death of the test animal, and the fact that the pathogenic organism to which this result is due is found in its blood or tissues, is sufficient evidence of the failure of the agent under trial to destroy the vitality of the germ. But the survival of the test animal cannot be taken as positive proof that the agent to the action of which the test organism was submitted has completely destroyed the vitality of this organism. This for two reasons: *first*, the inoculated animal may suffer from a modified and non-fatal attack of the infectious disease, the germ of which is used in the test; *second*, in the case of a chemical agent which has been mixed in a given amount with a pure culture of the test organism, or with blood from an infected animal containing this organism, the agent is necessarily injected into the test animal along with the germs which have been subjected to its action, and may exercise a restraining influence upon the development of these germs without destroying their vitality. This would give time for their destruction in the body of the animal by those means which have been provided by nature. The writer has elsewhere suggested that this is probably one of the functions of the white blood corpuscles, and that, when the developing power of pathogenic organisms is restrained in any way, before or after their introduction into the body of a susceptible animal, this provision of nature may suffice to prevent an attack of the disease, or at least to modify its severity.

The *second method* permits of a more accurate determination when the experiments are conducted with a due regard to the possible restraining influence of the germicide agent, which by preventing growth might lead to the mistaken inference that the vitality of the test organisms had been destroyed. This error is to be avoided by diluting the germicide agent so largely with the sterilized culture fluid into which it is introduced, along with the test organisms which have been exposed to its action, that its restraining influence is rendered *nil*. Suppose, for example, that we mix with a culture of the anthrax bacillus containing spores an equal quantity of a solution of mercuric chloride of the strength of 1 to 1,000, making the proportion of the salt in the mixture 1 to 2,000. Now, if we take one part of this mixture and add it to ten parts of sterilized *bouillon*, we shall have the mercuric chloride present in the proportion of 1 to 20,000. Experiments upon the restraining power of this salt show that anthrax spores will not grow in culture solutions containing 1 to 300,000, and that their development is retarded by solutions of 1 to 600,000. Failure to develop in this case would therefore be no proof that the growing power of the anthrax spores had been destroyed. This proof is only to be attained by adding sufficient culture fluid to dilute the mercuric chloride beyond its restraining power. The use of a comparatively large amount of the culture fluid, and of an extremely small quantity of the material containing the test organisms, permits us to exclude this source of error, for a few germs serve as well for the test as a large number. Or we may wash the test organisms in a solution which has no germicidal action but which is capable of neutralizing chemically the agent which is being tested as to its germicidal power—*e.g.*, a solution of ammonium sulphide for corrosive sublimate.

For the reason stated fluid culture media are more suitable for experiments of this nature than solids. If we bring a little of our material containing mercuric chloride in the proportion of 1 to 2,000 upon the surface of a cooked potato, or introduce it with a needle into a gelatin culture medium, the salt will not be diluted, and would exercise its restraining influence upon the germs if they had not already been destroyed by its action. On the other hand, if we add 1 part of the material to 100 parts of *bouillon* and mix thoroughly by shaking, the mercuric chloride will be diluted to 1 to 200,000; this being still within the limits of its restraining action, we may take one part of the mixture and add it to 10 parts of the sterile *bouillon*. The mercuric chloride will now be diluted to 1 to 2,000,000, a proportion quite beyond the limits of restraining action. But there will be a sufficient number of anthrax spores in the culture medium to test the question as to whether the growing power of these particular "germs" is destroyed by mercuric chloride in the proportion named.

This source of error has not been kept sufficiently in view in some of the experiments heretofore made. Again, it often happens that no development occurs for a time, but that after several days the germs which have been exposed to the action of a chemical agent commence to grow, and finally produce an abundant and vigorous progeny. In this case mistakes are likely to arise from terminating the experiment too soon. Anthrax spores, for example, develop, in a suitable culture medium, at a temperature of 80° to 100° F., within twenty-four hours, and give rise to numerous characteristic flocculi, made up of long filaments, which are readily distinguished by the naked eye. But after exposure to a germicide agent

in less amount than is necessary completely to destroy their vitality, they may fail to develop under the same circumstances in forty-eight or seventy-two hours, and yet finally produce an abundant crop of filaments.

Bearing in mind these sources of error, the germicidal value of a given agent may be determined approximately by a series of experiments, in which the quantity of the agent under trial is increased or diminished according as it fails or is successful in destroying the vitality of the test organism. But the data obtained by experiments upon a single organism can be applied only in a general way to others of the same class, for experiments which have been made show that within certain limits there are manifest differences in resisting power, and especially that there is a wide difference in this regard between organisms in active growth—micrococci, spirilla, or bacilli—and the reproductive bodies, called spores, which are developed in the interior of the bacilli at a certain period in their life history.

It will be seen from what has been said, that the germicidal power of a chemical agent can be stated in a definite manner only when reference is made to a particular germ. It is also necessary to take into account certain circumstances relating to the test organism and the medium in which it is placed, and, especially, to consider *the time* during which this has been exposed to the action of the germicide. Thus we may, by our experiments, determine how long a time will be required for the destruction of a given germ by means of a standard solution of a certain chemical agent. Or, on the other hand, we may determine the proportion in which this agent must be used in order to be effective in a given time. In Dr. Koch's elaborate experiments, published in the first volume of the "Mittheilungen aus dem Kaiserlichen Gesundheitsamte," the time is made the variable quantity. In the writer's numerous experiments a standard time was adopted—two hours in the more recent experiments—and the object in view was to determine the minimum quantity of the agent under trial which is effective in this time.

Evidently, a comparison of the results reported by different experimenters requires a consideration of this essential condition. But in addition to this we must consider the following circumstances:

(*a*) The presence or absence of spores.

(*b*) The physical condition of the test organism—whether it is dry or moist, whether suspended in fluid or embedded in masses of albuminous material, etc.

(*c*) The chemical properties and mode of action of the agent which is being tested.

(*d*) The temperature at the time the experiment is made. As a general rule the higher the temperature the more promptly the germicidal action of a chemical agent is manifested.

(*a*) As already remarked, spores are far more resistant than bacteria in active growth. Thus the spores of the anthrax bacillus require for their destruction a boiling temperature, while the bacillus itself is quickly destroyed by a temperature of 140° F. The same spores are not destroyed by being immersed for one month in a five-per-cent. solution of chloride of zinc, or for three months in absolute alcohol, or one hundred and ten days in a five-per-cent. solution of carbolic acid in oil; the last-mentioned solution, however, destroys the bacilli, in the absence of spores, in six days (Koch).

(*b*) The germicidal power of formaldehyd, sulphur dioxide, and of other gases is largely influenced by the physical condition of the test organisms—as to whether they are dry or moist, whether they are exposed in masses or in thin films, etc. And the same circumstances influence the result, to a less extent, in experiments with aqueous solutions of various agents. This is especially true as regards those agents which enter into combination with albuminous material; thus Schill and Fischer found that the tubercle bacillus was not destroyed in tuberculous sputum exposed for twenty-four hours to the action of mercuric chloride in solution in the proportion of 1 to 2,000, while dried sputum exposed to a solution of 1 to 5,000 failed to produce tuberculosis when inoculated into guinea-pigs. The difference was no doubt due to the fact that in the moist sputum the bacilli in the interior of the mass were protected from the action of the germicide agent. The result is also largely influenced in certain cases by the amount of non-living organic material associated with the germs to be destroyed. This is especially true as regards the oxidizing disinfectants. If, for example, we subject a given quantity of germs suspended in pure water to the action of potassium permanganate or of hypochlorite of lime, these agents will be effective in dilute solutions. But if the germs are suspended in a rich culture medium, or embedded in masses of organic material, this material will be quickly oxidized, and in the chemical reaction which occurs an amount of the reagent will be decomposed corresponding with the amount of organic material present in the solution; and only the excess of the oxidizing agent will be available for the destruction of such germs as may have escaped immediate destruction by reason of their resisting power, or because they were protected by being embedded in masses of material.

It will be desirable to extend the experimental researches in this direction as new pathogenic organisms are discovered, and to determine in an exact manner the value of each agent which has been shown to possess germicidal power for each organism of this class. In many of the experiments which have been made test organisms have been used which are known to be non-pathogenic, but which, belonging to the same class, give valuable data for the determination in a general way of the comparative germicidal value of various chemical agents. Thus, in many of the writer's experiments the bacteria of putrefaction, as found in "broken-down" beef-tea freely exposed to the air, have served as the test. As a variety of bacterial organisms are present in such material, including one or more species of spore-bearing bacilli, this serves as a general test, and there is reason to believe that all known pathogenic organisms would be destroyed by an agent capable of destroying all germs found in such material. These experiments, therefore, furnish reliable data upon which to base practical measures of disinfection. In practice it will be best to select such agents as stand the most rigid tests, and to use them in amounts somewhat in excess of what is shown by such tests to be necessary. (See article on *Disinfectants.*)

For convenience of reference we have arranged the following summary of the experimental data in alphabetical order:

Acetone.—Anthrax spores grow freely after two days' exposure to the action of this agent; after five days the development is feeble (Koch).

Acetic Acid.—A five-per-cent. solution did not prevent the development of anthrax spores after five days' exposure (Koch). In experiments made by Abbott, glacial acetic acid in the proportion of fifty per cent. failed to destroy anthrax spores in two hours, but twenty per cent. was effective with the spores of *B. subtilis*, and with the mixed organisms in broken-down beef-tea; and micrococci were destroyed in the same time by a one-per-cent. solution.

Alcohol.—In the writer's experiments it was found that ninety-five-per-cent. alcohol did not destroy the vitality of the organisms in broken-down beef-tea in forty-eight hours. The micrococcus of pneumonia was destroyed by two hours' exposure to a twenty-four-per-cent. solution. A micrococcus obtained from gonorrhœal pus required a forty-per-cent. solution. Koch found that absolute alcohol had no effect upon the vitality of anthrax spores which were immersed in it for one hundred and ten days. When saturated with camphor, alcohol does not destroy the virus of symptomatic anthrax (Arloing, Cornevin, and Thomas). In the proportion of 1 to 1.5 it destroys the bacteria which cause the acid fermentation of milk (Molke). Schill and Fischer found that when tuberculous sputum was mixed with an equal quantity of absolute alcohol, its infecting power was not destroyed

(in twenty-four hours), but that, in the proportion of 5 parts to 1 of sputum, this agent was effective in destroying the tubercle bacillus, as proved by inoculation experiments.

Yersin reports that the tubercle bacillus in pure cultures is destroyed by absolute alcohol in five minutes. The experiments of Reinicke, Ahlfeld, Epstein, and others show that bacteria in a moist condition are quickly destroyed by a fifty-per-cent. solution of alcohol and that such a solution is more potent as a germicide than absolute alcohol, which has comparatively little germicidal power. For the disinfection of the hands a fifty-per-cent. solution is recommended by Epstein.

Solutions of mercuric chloride, carbolic acid, thymol and lysol in fifty-per-cent. alcohol were found by Epstein to be more active than aqueous solutions of the same strength. Alcoholic solutions have the advantage of dissolving oils and consequently of acting more promptly when the object in view is to disinfect the hands.

Ammonia.—The experiments of Koch show that ammonia does not destroy the spores of the anthrax bacillus; but, according to Behring, ammonia in solution in the proportion of 1 to 417 inhibits the growth of the anthrax bacillus. Gottbrecht also found that both ammonia and carbonate of ammonia have decided antiseptic properties. Rigler has proposed to use ammonia gas for the disinfection of rooms, and concluded from his experiments that it is a reliable disinfectant when used in the proportion of 1 kgm. of aqua ammonia, exposed in shallow vessels, for every one-hundred cubic feet of space. Moreno, who conducted a series of experiments in the laboratory of the University of Turin, was not able to confirm Rigler as to the value of this agent for practical use in infected apartments, and it is no doubt much inferior to formaldehyd and probably of less value than sulphur dioxid.

Ammonium Chloride.—A five-per-cent. solution failed in twenty-five days to destroy the vitality of anthrax spores (Koch).

Ammonium Sulphate.—A five-per-cent. solution was effective in five days, but failed in two days to destroy anthrax spores (Koch).

Aromatic Products of Decomposition.—Klein has tested the germicidal power of *phenyl proprionic* and of *phenyl acetic* acid. He finds that anthrax spores resist both of these acids in the proportion of 1 to 400 after two days' exposure; but anthrax bacilli, in the absence of spores, are quickly killed by a solution of this strength. Certain non-pathogenic micrococci were not killed by exposure for twenty-five minutes to a solution of 1 to 200. Exposure for ninety-six hours to these acids, in the proportion of 1 to 200, did not prevent the caseous matter of pulmonary tuberculosis from infecting guinea-pigs; 1 to 800 was effective in destroying the virulence of swine-plague virus.

Arsenious Acid.—A one-per-cent. solution destroyed the vitality of anthrax spores in ten days, but failed to do so in six days (Koch). The infective power of tuberculous sputum, as shown by inoculation into guinea-pigs, is not destroyed by twenty hours' exposure to a one-per-cent. solution.

Benzol.—Exposure for twenty days failed to destroy the vitality of anthrax spores (Koch).

Benzoic Acid.—This agent was found by De la Croix to destroy the bacteria of broken-down beef-tea in the proportion of 1 to 77, while 1 to 121 failed. A saturated aqueous solution failed to destroy anthrax spores in seventy days (Koch).

Boric Acid (boracic acid).—In the writer's experiments a saturated solution failed to destroy any of the test organisms—two species of micrococci and *B. termo.* A five-per-cent. solution failed in ten days to destroy anthrax spores (Koch). According to Arloing, Cornevin, and Thomas, the activity of the *fresh* virus of symptomatic anthrax is destroyed by 1 in 5 (twenty per cent.), the time of exposure being forty-eight hours.

The experiments of Pome and of Rideal show, also, that boric acid has no value as a germicide.

Bromine.—A two-per-cent. aqueous solution destroys the vitality of anthrax spores in twenty-four hours (Koch). Fischer and Proskauer have studied the action of bromine vapor upon various micro-organisms. They find that exposure for three hours, in a dry atmosphere, to three per cent. does not destroy the tubercle bacillus in sputum, or the spores of anthrax. But when the atmosphere is saturated with moisture 1 part in 500 is effective, and when the time of exposure is extended to twenty-four hours, 1 part in 3,500. Bromine vapor is the most active agent for the destruction of the virus of symptomatic anthrax (Arloing, Cornevin, and Thomas). It destroys the ferment of sour milk (*Bacterium lactis*) in the proportion of 1 to 348 (Molke). The bacteria of broken-down beef-tea are destroyed by 1 to 336 (De la Croix).

Butyric Acid.—Five days' immersion in this acid failed to destroy the vitality of anthrax spores (Koch).

Calcium Chloride.—A saturated solution has no destructive action on anthrax spores (Koch.)

Calcium Hydroxide.—According to Kitasato, the typhoid bacillus and the cholera spirillum, in bouillon cultures, are killed in four or five hours by the addition of 0.1 per cent. of calcium oxide. Liborius had previously reported still more favorable results, but his bouillon cultures were largely diluted with distilled water. From a practical point of view the experiments of Pfuhl are more valuable. Calcium hydrate was added to the dejections of typhoid patients. When added in the proportion of three per cent. sterilization was effected in six hours, and by six per cent. in two hours. When milk of lime containing twenty per cent. of calcium hydrate was used the results were still more favorable, the typhoid bacillus and cholera spirillum being killed in one hour by the addition of two per cent. of the disinfectant. The germicidal value of lime wash applied to walls has been determined by Jäger, silk threads soaked in cultures of various pathogenic bacteria were attached to boards and the lime wash was applied with a camel's-hair brush. Anthrax bacilli (without spores), the glanders bacillus, Staphylococcus pyogenes aureus, and several other pathogenic bacteria, were killed by a single application in twenty-four hours, but the tubercle bacillus was not killed by three successive applications. In the writer's experiments (1885) the typhoid bacillus and Staphylococcus pyogenes aureus were killed in two hours by a solution containing 1 to 40 of calcium oxide and 1 to 80 failed. Spores of the anthrax bacillus, and of several other species forming spores, were not killed by two hours' exposure to a milk of lime containing twenty per cent. of calcium oxide.

Camphor.—Alcohol saturated with camphor has no effect upon the fresh virus of symptomatic anthrax (Arloing, Cornevin, and Thomas).

Carbolic Acid.—Tested upon anthrax spores, Koch found a one-per-cent. solution to be without effect after fifteen days' exposure; a two-per-cent. solution retarded the development of spores, but did not completely destroy their vitality in seven days; a three-per-cent. solution was effective in two days. In the absence of spores, Koch found that a one-per-cent. solution quickly destroys the vitality of anthrax bacilli. The same author recommends a five-per-cent. solution for the destruction of the "comma bacillus" in the discharges of cholera patients, and a two-per-cent. solution for the disinfection of surfaces and articles soiled by such discharges. The writer has found that, in the proportion of 1 to 200 this agent destroys *B. termo* and a septic micrococcus (*M. Pasteuri*) in active growth, while 1 to 25 failed to destroy the bacteria in broken-down beef-tea. A micrococcus obtained from the pus of an acute abscess was destroyed by 0.8 per cent., while 0.5 per cent. failed. In all of these experiments the time of exposure was two hours. According to Salmon, the micrococcus of swine plague multiplies abundantly in urine containing one per cent. of carbolic acid, while the micrococcus of fowl cholera is destroyed by six hours' exposure in a solution of this strength (one-per-cent.). A two-per-cent. solution destroys the bacterium of symptomatic anthrax (dried virus)

in forty-eight hours (Arloing, Cornevin, and Thomas). The bacteria in broken-down beef-tea are not destroyed by a ten-per-cent. solution (De la Croix).

Davaine showed, by inoculation experiments, that anthrax bacilli in fresh blood are destroyed by being exposed to the action of a one-per-cent. solution for one hour. Solutions in oil and in alcohol have been shown by Koch to be less effective than aqueous solutions. Thus a five-per-cent. solution in oil failed to destroy the vitality of anthrax spores in one hundred and ten days, and the same solution did not destroy the bacilli in the absence of spores in less than six days. A control experiment showed that olive oil alone was effective in the same time. A five-per-cent. solution in alcohol did not destroy anthrax spores in seventy days. Schill and Fischer found that the infecting power of tuberculous sputum, as shown by inoculation into guinea-pigs, is destroyed by twenty-four hours' exposure to a five-per-cent. solution. The same result was obtained with a three-per-cent. solution, while one and two-per-cent. solutions failed.

Behring (1890) reports that the bacillus of typhoid fever, of diphtheria, and of glanders, the spirillum of cholera and streptococci are destroyed in a few hours by a 0.5-per-cent. solution and in one minute by a 1.5-per-cent. solution. Staphylococci are more resistant and require a solution of from two to three per cent. The germicidal value of carbolic acid is increased by the addition of mineral acids to disinfecting solutions (Laplace), by sodium chloride (Scheurlen), and by heat.

Carbonic Oxide.—This gas has no effect upon bacteria, which freely develop in it (Hamlet).

Chloral Hydrate.—In the writer's experiments this agent was found to destroy micrococci in the proportion of twenty per cent., and to fail in ten-per-cent. solution, the time of exposure being two hours.

Chlorine.—Fischer and Proskauer have made an elaborate research with reference to the germicidal power of this agent, as tested by a variety of micro-organisms. In the absence of moisture these experimenters found that desiccated anthrax spores were not destroyed by exposure for an hour in an atmosphere containing 44.7 per cent. of this gas. When, however, the spores were moistened, an exposure for one hour in a *moist* atmosphere containing four per cent. of chlorine was effective, and by extending the time to three hours one per cent. sufficed to destroy the vitality of the spores. The anthrax bacillus, in the absence of spores, was killed by exposure in a moist atmosphere containing 1 part in 2,500, the time of exposure being twenty-four hours, and the same amount was effective for *Micrococcus tetragenus;* while the micrococcus of erysipelas and the micrococcus of fowl cholera were killed by 1 to 25,000 in twenty-four hours, and 1 to 2,500 in three hours. The bacillus of mouse septicæmia was destroyed in one hour by 1 to 200, and the same proportion was effective for the tubercle bacillus in sputum. In the writer's experiments, made in 1880, the bacteria present in urine which had been freely exposed to the air and had become putrid were destroyed by exposure for one hour in an atmosphere containing 1 to 400. Koch found that after immersion for twenty-four hours in chlorine water, anthrax spores do not develop in a suitable culture medium. Chlorine destroys the fresh virus of symptomatic anthrax, but is powerless against that which has been dried (Arloing, Cornevin, and Thomas). The bacteria of broken-down beef-tea are destroyed by 1 to 1,061 (De la Croix).

Chloride of Lime.—(See *Hypochlorites*).

Chloroform.—Immersion for one hundred days in chloroform does not destroy anthrax spores (Koch). This agent is without effect upon the virus of symptomatic anthrax (Arloing, Cornevin, and Thomas). One part to 1.22 failed to destroy the bacteria of broken-down beef-tea (De la Croix).

The more recent (1894) experiments of Behring show that in the absence of spores this agent quickly destroys bacilli and micrococci. He reports that in his experiments the cholera spirillum was destroyed by a one-per-cent. solution in less than a minute and the typhoid bacillus by a one-half-per-cent. solution in an hour.

Chromic Acid.—An aqueous solution of 1 to 100 does not destroy the spores of anthrax in two days (Koch).

Citric Acid.—In the writer's experiments upon micrococci from the pus of an acute abscess, twelve per cent. was effective and ten per cent. failed. Abbott reports that twenty-five per cent. failed to destroy the organisms in broken-down beef-tea, and the spores of *B. subtilis* and *B. anthracis*, but that 1.25 per cent. was active in the case of micrococci.

Creolin.—This is a mixture of the cresols emulsified with hard soap. According to Behring its germicidal value is considerably greater than that of carbolic acid, except when albumen is present in the material to be disinfected.

Creosote.—This agent was found by the writer to be fatal to micrococci in the proportion of 1 to 200. In the proportion of one per cent. it failed, after twenty hours' exposure, to destroy the tubercle bacillus in sputum (Schill and Fischer).

According to Yersin a saturated aqueous solution does not destroy the tubercle bacillus in cultures in twelve hours. Guttman in extended experiments upon various pathogenic organisms found that a solution of 1 to 300 is fatal to Bacillus pyocyaneus and to B. anthracis in one minute, and that 1 to 600 destroys the Finkler-Prior spirillum in the same time.

Cresol.—This is a coal-tar product obtained by the fractional distillation of crude carbolic acid. There are three forms, known as ortho-, meta-, and paracresol. A mixture of these is largely used for disinfecting purposes under the name of tricresol. A solution of cresol of 0.5 per cent. is said to be as efficient as a germicide as a two- or three-per-cent. solution of carbolic acid (Hammer). Neutral solutions are non-irritating. According to Gruber the germicidal value of the cresols is but little influenced by the presence of albumen. He found cresol to be three times as potent as carbolic acid for the destruction of Staphylococcus pyogenes aureus. The cresols are considerably less toxic than carbolic acid.

Cupric Sulphate.—This salt failed, in the writer's experiments, to destroy the spores of *B. anthracis* and of *B. subtilis* in two hours' time in a twenty-per-cent. solution. Arloing, Cornevin, and Thomas report that the dried virus of symptomatic anthrax is destroyed in forty-eight hours by a twenty-per-cent. solution. In Koch's experiments a five-per-cent. solution failed to destroy anthrax spores in ten days. The writer has found, however, that this salt is effective in the proportion of 1 to 200 for the destruction of micrococci, the time of exposure being two hours.

Ether.—Anthrax spores may germinate after being immersed in ether for eight days, but thirty days' exposure is effective for the destruction of these spores (Koch).

Eucalyptol.—The bacteria in broken-down beef-tea are not destroyed by 1 to 14 (De la Croix).

Ferrous Sulphate.—In the writer's experiments, reported in the *American Journal of the Medical Sciences* (April, 1883), a solution of twenty per cent. of this salt failed to destroy micrococci and the bacteria in broken-down beef-tea. In more recent experiments a ten-per-cent. solution was found to be fatal to *Micrococcus tetragenus*, but failed in the case of another micrococcus obtained from the pus of an acute abscess. Koch found that a five-per-cent. solution did not destroy anthrax spores in six days. According to Arloing, Cornevin, and Thomas, exposure to a twenty-per-cent. solution for forty-eight hours does not destroy the virus of symptomatic anthrax.

Ferri Chloridi Tinct.—In the writer's experiments a four-per-cent. solution was fatal to micrococci, and a two-per-cent. solution failed.

Ferric Chloride.—A five-per-cent. solution failed in two days to destroy anthrax spores, but was effective in six days (Koch).

Formaldehyd.—The experiments of Aronson (1892), Lehmann (1894), Philipp (1895), Rosenberg (1897), and

others have demonstrated the germicidal value of formaldehyd. A forty-per-cent. solution of this gas in water is known under the name of formalin. According to Ascoli (1895) anthrax bacilli are killed in fifteen minutes by a ten-per-cent. solution of formalin and anthrax spores in five hours by the same solution. A five-per-cent. solution destroyed the diphtheria bacillus in ten minutes and Staphylococcus aureus in thirty minutes. Formaldehyd gas in the proportion of 1 to 100 in the air of a flask was found to destroy Staphylococcus aureus in forty-five minutes, and the micrococcus of pneumonia in fifteen minutes. Wilson (1897) and others have shown that the germicidal action of formaldehyd is considerably greater at a temperature of 37° C. and above than it is at a low temperature.

Formic Acid.—This acid, of the specific gravity of 1.120, failed in two days to destroy anthrax spores, but was effective in four days.

Gallic Acid.—Abbott finds this acid to be effective for the destruction of the organisms in broken-down beef-tea in the proportion of 2.375 per cent.; tested upon the spores of the anthrax bacillus and of *B. subtilis*, it failed in this proportion, the time of exposure being two hours. Micrococci were destroyed by 0.7 per cent., while 0.4 per cent. (1 to 250) failed.

Glycerin has no action upon the fresh virus of symptomatic anthrax (Arloing, Cornevin, and Thomas); and is inert as regards the spores of bacilli (Koch).

Heat.—(*a*) Dry heat. Werner, in 1879, found that putrefactive bacteria enveloped in dry cotton were destroyed by exposure for one hour to a temperature of 125° C. (257° F.). Wernich also experimented upon the bacteria of putrefaction, and found that exposure for five minutes to a temperature of 125° to 150° C. secured their destruction. The virulence of dried tuberculous sputum is not destroyed with certainty by exposure for one hour to 100° C. (Schill and Fischer).

Koch and Wolffhügel, as the result of an elaborate series of experiments, arrive at the following conclusions:

1. A temperature of 100° C. (212° F., dry heat), maintained for an hour and an half, will destroy organisms which do not contain spores.

2. Spores of mould fungi require for their destruction in hot air a temperature of from 110° to 115° C. (230° to 239° F.), maintained for an hour and a half.

3. Bacillus spores require for their destruction in hot air a temperature of 140° C. (284° F.), maintained for three hours.

(*b*) Moist heat. Davaine, in 1873, showed that the virulence of fresh anthrax blood which does not contain spores is destroyed by a temperature of 55° C. (131° F.), maintained for five minutes; or by 50° C. (122° F.) for ten minutes; or by 48° C. (118° F.) for fifteen minutes. The writer has fixed the thermal death point of several species of bacilli and micrococci at 60° C. (140° F.), the time of exposure being ten minutes. This temperature is also fatal to the micrococcus of swine plague, while the micrococcus of fowl cholera is destroyed by exposure for fifteen minutes to a temperature of 132° F. (Salmon). The destruction of spores is a very different matter, and requires a boiling temperature, maintained, in the case of some of these reproductive bodies, for several hours. But a temperature of 5° C. above the boiling point quickly destroys the most refractory spores. Thus the writer has found, as the result of repeated experiments, that this temperature—105° C. (221° F.)—maintained for ten minutes, is fatal to the spores of *B. subtilis*, and that the same temperature in two minutes' time destroyed the vitality of anthrax spores. Koch, Gaffky, and Loeffler also report that a temperature of 105° C. and upward, maintained for ten minutes, is fatal to all spores, as shown by their failure to develop in culture solutions. Where a temperature of 110° C. was reached, the experiment could be stopped, as no spores were capable of germinating after exposure to this temperature.

The tubercle bacillus is destroyed by a temperature of 70° C. maintained for ten minutes.

Hydrochloric Acid.—In experiments upon broken-down beef-tea, the writer found this acid to be effective in the proportion of fifteen per cent., and to fail at ten per cent. (two hours' exposure). One part in two hundred was found to destroy the virulence of septic blood (rabbit septicæmia), as proved by inoculation experiments. Anthrax spores are destroyed in ten days by a two-per-cent. solution, but not in five days (Koch).

In the experiments of Kitasato this acid in the proportion of 0.2 per cent. destroyed the typhoid bacillus in five hours. Boer found that the typhoid bacillus was destroyed by 1 to 300 in two hours, the diphtheria bacillus by 1 to 700, and the cholera spirillum by 1 to 1,350.

Hydrogen.—Bacteria may develop in an atmosphere of hydrogen (Hamlet).

Hydrogen Peroxide.—In the writer's experiments, a solution containing 3.98 per cent. of H_2O_2 was found to destroy the organisms in broken-down beef-tea in the proportion of thirty per cent. The same solution failed in twenty per cent. Tested upon a pure culture of *B. anthracis* containing spores, the same solution was effective at twenty per cent. (0.8 per cent. H_2O_2=1 to 125), and failed at ten per cent. Tested upon micrococci, ten per cent. was effective, and five per cent. failed. The solution used in these experiments contained five per cent. of sulphuric acid, and the germicidal power of this agent must be considered in estimating their value as determining the effect of H_2O_2 upon the vitality of the test organisms.

Gibier (1890) reports that solutions containing 1.5 per cent. of hydrogen peroxide destroy the anthrax bacillus, the bacillus of typhoid fever, Streptococcus pyogenes, and various other bacteria in a few minutes. Pave found that this agent in a one-per-cent. solution destroys spores in one hour and staphylococci in from ten to fifteen minutes.

Hypochlorites of Lime and of Soda.—Commercial chloride of lime contains from twenty to thirty per cent. of available chlorine, and Labarraque's solution of good quality from two to three per cent. According to Duggan, a solution containing 0.25 of one per cent. (1 to 400) of chlorine as hypochlorite is an effective germicide, even when allowed to act only one or two minutes, while 0.06 of one per cent. (6 to 10,000) will kill spores of *B. anthracis* and *B. subtilis* in two hours. These results are not in accord with those of Koch, who reports that a five-per-cent. solution of chloride of lime (value in available chlorine not given) failed in two days to destroy the vitality of anthrax spores, but was effective in five days. The development of the spores was, however, retarded by one day's exposure.

Indol.—When added to water in excess, failed in eighty days to destroy anthrax spores (Koch).

Iodine.—In the writer's experiments, iodine in aqueous solution with potassium iodide was found to be fatal to the micrococcus of rabbit septicæmia in the proportion of 1 to 1,000, and to a micrococcus obtained from the pus of an acute abscess in 1 to 500. De la Croix reports that 1 to 410 destroys the bacteria of broken-down beef-tea. Salmon found 1 to 1,000 to be fatal to the micrococcus of fowl cholera. "Iodine water" was found by Koch to destroy the vitality of anthrax spores in twenty-four hours. The same author reports that exposure for forty-eight hours to a two-per-cent. solution of iodine in alcohol failed to destroy anthrax spores, but that exposure in such a solution for five days was effective. In the experiments of Schill and Fischer, twenty hours' contact with a solution of the strength of 1 to 500 failed to destroy the virulence of tuberculous sputum, as tested by inoculation experiments.

Iodine Trichloride.—The germicidal value of this agent has been established by the experiments of Riedel (1887), of Behring (1890), and of Traugott (1893). The last-mentioned bacteriologist reports that a one-per-cent. solution will destroy in one minute the bacillus of typhoid fever and of diphtheria, the cholera spirillum, Streptococcus pyogenes and staphylococci.

Iodoform.—Dissolved in oil, in the proportion of five per cent., iodoform failed in an hour and a half to destroy

tubercle bacilli in fresh sputum. A saturated solution in water also failed after twenty-four hours' contact; as did also a five-per-cent. solution in oil of turpentine (an hour and a half's exposure). No better results were obtained in an experiment in which the material was exposed for twenty hours to dry iodoform vapor, but in the presence of moisture dried sputum was disinfected in two hours. Mixing the sputum with moistened iodoform was also effective after twenty-four hours' contact (Schill and Fischer).

Iodol.—The writer has made experiments which show that bacteria are not destroyed by adding iodol in excess to culture solutions—probably because it is quite insoluble.

Labarraque's Solution.—(See *Hypochlorites.*)

Lactic Acid.—A five-per-cent. solution failed in five days to destroy anthrax spores (Koch). Abbott reports that a twenty-per-cent. solution of concentrated lactic acid (specific gravity 1.21) was effective for the destruction of the bacteria in broken-down beef-tea and the spores of *B. subtilis*, while fifteen per cent. failed. Upon anthrax spores lactic acid of the same strength failed in the proportion of fifty per cent. Micrococci were destroyed by a one-per-cent. solution, while 0.5 per cent. failed; time of exposure in these experiments, two hours. The bacillus of typhoid fever is killed in five hours by 0.4 per cent., the cholera spirillum by 0.3 per cent. (Kitasato).

Mercuric Chloride.—Koch's experiments (1881) gave the following results: A solution of 1 to 1,000 destroys anthrax spores in a few minutes, and 1 to 10,000 is effective after a more prolonged exposure. The writer (1884) obtained similar results—1 to 10,000 destroyed the spores of Bacillus anthracis and of Bacillus subtilis in two hours. More recent experiments indicate that failure to grow in culture solutions cannot be accepted as evidence of the destruction of vitality in the case of spores exposed to the action of this agent, unless due precautions are taken to exclude the restraining influence of the small amount of mercuric chloride which remains attached to the spores. Koch had ascertained that the development of spores is restrained by the presence of 1 to 300,000 in a culture medium, and Geppert has shown that even so small an amount as 1 to 2,000,000 will prevent the development of spores, the vitality of which has been reduced by the action of a strong solution (1 to 1,000). When this restraining action is entirely neutralized by washing the spores in a solution containing ammonium sulphide it requires, according to Geppert, a solution of 1 to 1,000 acting for one hour completely to destroy the vitality of anthrax spores. Fränkel found that a solution of 1 to 1,000 was effective in half an hour. The typhoid bacillus, the bacillus of mouse septicæmia, and the cholera spirillum, in bouillon cultures and in cultures in flesh-peptone-gelatin, are destroyed in two hours by 1 to 10,000; but in a bouillon culture to which ten per cent. of dried egg albumen was added a one-per-cent. solution was required to destroy the typhoid bacillus in the same time (Bolton). According to Van Ermengem, cultures of the cholera spirillum in bouillon are sterilized in half an hour by 1 to 60,000, but cultures in blood serum require 1 to 800 to 1 to 1,000. In experiments upon tuberculous sputum, Schill and Fischer found that exposure of fresh sputum to an equal amount of a 1 to 2,000 solution for twenty-four hours failed to disinfect it, as shown by inoculation experiments in guinea-pigs. The antiseptic power of mercuric chloride is given by Miquel as 1 to 14,300. In the writer's experiments 1 to 33,000 was found to prevent the development of putrefactive bacteria in bouillon, but a minute bacillus contained in broken-down beef infusion multiplied, after several days, in 1 to 20,000. The pus cocci were restrained in their development by 1 to 30,000.

In Behring's experiments the anthrax bacillus and cholera spirillum were killed in one hour by 1 to 100,000 when the temperature was 36° C., but at a temperature of 3° C. the proportion required was 1 to 25,000. The same author states that at 22° C. Staphylococcus aureus in bouillon is not always killed in twenty-five minutes by 1 to 1,000.

Abbott (1891) has shown that a 1 to 1,000 solution does not always destroy Staphylococcus pyogenes aureus in five minutes. He says: "Frequently all the organisms would be destroyed after five minutes' exposure, but almost as often a certain few would resist for that length of time, and even longer, going in some cases to ten, twenty, and even thirty minutes."

According to Yersin, a solution of 1 to 1,000 kills the tubercle bacillus in one minute.

The albuminate of mercury, as has been shown by Lister, is soluble in an excess of albumin, and, according to Behring, is just as effective as an aqueous solution containing the same amount of sublimate when dissolved in an albuminous liquid like blood serum (?).

In practice the addition of a mineral acid to sublimate solutions, or of sodium, potassium, or ammonium chloride, is to be recommended, to prevent the precipitation of the mercuric chloride by albumin in fluids containing it. Behring recommends the addition of five parts of sodium or potassium chloride to one of the sublimate. Such a solution is more stable than a simple solution of sublimate, and no precipitate is formed by the addition of alkalies or by albumin.

The same result is obtained, according to La Place, by the addition of five parts of hydrochloric or tartaric acid to one part of sublimate in aqueous solution.

Viquerat (1889) has made a comparative study of the germicidal value of mercuric chloride and mercuric iodide. The last-mentioned salt was found to be least efficient. A solution of 1 to 1,000 of bichloride killed the anthrax bacillus and the typhoid bacillus in five minutes; the same proportion of the biniodide required fifteen minutes to destroy these bacilli.

Mercuric Cyanide, $Hg(CN)_2$, and the *oxycyanide* of mercury have been tested, with the following results: Staphylococcus aureus is destroyed in five minutes by 1 to 100, in one hour by 1 to 1,000, in two hours by 1 to 1,500 (Chibret). The development of Bacillus anthracis in culture solutions is prevented by the presence of cyanide of mercury in the proportion of 1 to 25,000, and by the oxycyanide by 1 to 16,000 (Behring).

Boer obtained the following results with the oxycyanide—cultures in bouillon, twenty-four hours in incubating oven, time of exposure two hours:

	Restrained development.	Destroyed vitality.
Anthrax bacillus	1 to 80,000	1 to 40,000
Diphtheria bacillus	1 to 80,000	1 to 40,000
Glanders bacillus	1 to 60,000	1 to 30,000
Typhoid bacillus	1 to 60,000	1 to 30,000
Cholera spirillum	1 to 90,000	1 to 60,000

Nitric Acid.—This acid, in the proportion of 1 to 400, was found by the writer to neutralize the virulence of septic blood (rabbit septicæmia). In the proportion of eight per cent. it destroys the organisms in broken-down beef-tea, but failed at five per cent.

Kitasato reports that in the proportion of 0.2 per cent. the vitality of the typhoid bacillus and of the cholera spirillum is destroyed in four or five hours.

Nitrous Acid.—Exact experiments to determine the germicide value of this agent are wanting. The writer has tested it upon vaccine virus, and found that exposure for six hours, in an atmosphere containing one per cent., destroys the virulence of this material dried upon ivory points.

Oil.—Anthrax spores germinate after having been immersed for ninety days in pure olive oil (Koch).

Oil of Cinnamon.—According to Behring, oil of cinnamon is about three times as potent a germicide as carbolic acid. Omaltschenko (1891) has made extended experiments to determine the germicidal value of essential oils and places oil of cinnamon at the head of the list.

Oil of Mustard.—According to De la Croix, 1 to 40

destroys the bacteria of broken-down beef-tea. Koch found that ten days' immersion in an aqueous solution of this oil is not fatal to anthrax spores, but that in the proportion of 1 to 33,000 it restrains their development.

Oil of Peppermint.—A five-per-cent. solution in alcohol failed in twelve days to destroy anthrax spores, but the development of these spores is restrained by 1 to 33,000 (Koch).

Oil of Turpentine destroys anthrax spores in five days, but failed to do so in one day (Koch). Turpentine has no action upon the virus of symptomatic anthrax (Arloing, Cornevin, and Thomas). Koch has shown that the development of anthrax spores is retarded by 1 to 75,000.

Oleic Acid.—A solution of five per cent. in ether does not destroy anthrax spores in five days (Koch).

Osmic Acid.—A solution of one per cent. destroys anthrax spores in one day (Koch). No report with reference to weaker solutions.

Oxalic Acid.—This acid in saturated solution destroys the virulence of the fresh virus of symptomatic anthrax, but has no effect upon dried virus (Arloing, Cornevin, and Thomas). Abbott reports that this acid in five-per-cent. solution failed, in two hours, to destroy anthrax spores. But the spores of *B. subtilis* were killed by a one-per-cent. solution, and the organisms in broken-down beef-tea by 1.5 per cent. Micrococci resisted exposure for two hours to 1 to 1,000, but were destroyed by 1 to 400.

Oxygen.—The experiments of Pasteur upon the attenuation of virus show that long exposure to the oxygen of the atmosphere reduces the reproductive activity of the micrococcus of fowl cholera and of the anthrax bacillus, and that after a time the vitality of these organisms is destroyed. The spores of the anthrax bacillus are, however, unaffected by prolonged exposure. Paul Bert has shown that oxygen under pressure is fatal to bacteria.

Ozone.—The experiments of Chappius show that atmospheric organisms, collected upon a cotton filter, are destroyed by passing through this cotton filter, placed in a tube, a current of ozonized air.

Lukaschewitsch found in his experiments that 1 gm. in a cubic metre of air failed to kill anthrax spores in twenty-four hours. The cholera spirillum in a moist state was killed by this amount in twenty-four hours, but not in fifteen hours. Sonntag, in carefully conducted experiments, found that ozonized air passed over silk threads to which various pathogenic bacteria were attached failed to destroy these bacteria in twenty-four hours when the proportion of ozone was 4.1 mgm. per litre; when the amount was increased to 13.53 mgm. per litre the anthrax bacillus and Staphylococcus pyogenes albus failed to grow after twenty-four hours' exposure.

Picric Acid.—The bacteria of broken-down beef-tea are destroyed by 1 to 100 (De la Croix).

Potassium.—In the writer's experiments, caustic potash in the proportion of two per cent. was fatal to the micrococcus of rabbit septicæmia in one experiment, and failed in a second; eight per cent. failed to kill a micrococcus from pus, while ten per cent. was successful; ten per cent. failed to destroy the bacteria in broken-down beef-tea, and twenty per cent. was successful. Exposure to the action of a ten-per-cent. solution for twenty-four hours failed to destroy the tubercle bacillus in fresh sputum (Schill and Fischer).

According to Jäger 0.18 per cent. of potassium hydroxide kills the typhoid bacillus in four or five hours. The cholera spirillum is destroyed by 0.237 per cent. added to cultures (Kitasato).

Potassium Acetate.—A saturated solution of this salt failed to destroy anthrax spores in ten days (Koch).

Potassium Arsenite (Fowler's solution of).—In the writer's experiments this solution, in the proportion of forty per cent., failed to destroy micrococci from pus.

Potassium Bichromate.—A five-per-cent. solution failed in two days to destroy anthrax spores (Koch).

Potassium Bromide is without germicidal power.

Potassium Chlorate has no germicidal power. In the writer's experiments a four-per-cent. solution failed to destroy the micrococcus of rabbit septicæmia. A five-per-cent. solution failed in six days to destroy anthrax spores (Koch).

Potassium Chromate.—A five-per-cent. solution was without effect upon anthrax spores immersed in it for two days (Koch).

Potassium Iodide.—A solution of five per cent. does not destroy anthrax spores in eighty days (Koch). In the writer's experiments, exposure for two hours to the action of a saturated solution did not prevent the subsequent development of the organisms in broken-down beef-tea.

The cholera spirillum and the typhoid bacillus are destroyed by five hours' exposure in a solution containing 9.23 per cent. (Kitasato).

Potassium Nitrate.—A four-per-cent. solution was found by the writer to be without effect upon the micrococcus of rabbit septicæmia in fresh blood.

Potassium Permanganate.—The writer, in experiments with this agent, found that a two-per-cent. solution was required to destroy *M. Pasteuri* in the blood of a rabbit, but that a micrococcus from pus was killed by 1 to 833—time of exposure two hours. This difference depends upon the fact that the permanganate is quickly decomposed by the large amount of organic material in the blood used in the first experiments, and not upon a difference in resisting power in the two test organisms.

Further experiments showed that, in the absence of organic matter, micrococci are destroyed in two hours by solutions containing 1 to 1,000. Equal parts of a solution of 1 to 250 and of broken-down beef infusion, proved to be without effect. Anthrax spores were not destroyed by the same solution (1 to 250) in four hours, but in another experiment, in which the time was extended to four days, they failed to germinate. The spores of *B. subtilis*, however, were destroyed in two hours by a solution of 1 to 250. According to Arloing, Cornevin, and Thomas, a five-per-cent. solution destroys the fresh virus of symptomatic anthrax, but has no effect upon the dried virus. One per cent. was found by Koch not to destroy anthrax spores in two days, but five per cent. was effective in one day.

The glanders bacillus is destroyed in two minutes by a one-per-cent. solution (Löffler). The experiments of Jäger show that a one-per-cent. solution cannot be relied upon for the destruction of various pathogenic bacteria used as a test, but a five-per-cent. solution was effective for all except the tubercle bacillus.

Quinine.—One per cent., *dissolved with muriatic acid*, destroys the spores of anthrax in ten days' time (Koch). A ten-per-cent. solution of sulphate of quinine has no action upon the bacterium of symptomatic anthrax (Arloing, Cornevin, and Thomas). The writer has found that in the proportion of 1 to 800 to 1 to 1,000 quinine prevents the development of bacilli and micrococci, but its exact germicidal power for organisms of this kind, in the absence of spores, has not been determined.

Salicylic Acid.—In the writer's experiments this reagent was dissolved by means of sodium biborate, which by itself has no germicidal power. A two-per-cent. solution was found to destroy a micrococcus from pus and *B. termo* in active growth; four per cent. failed to destroy the bacteria in broken-down beef infusion. The virus of symptomatic anthrax is destroyed by forty-eight hours' exposure to a solution of salicylic acid of 1 to 1,000, and by a saturated solution in alcohol (Arloing, Cornevin, and Thomas). Salicylic acid dissolved in oil and in alcohol, in five-per-cent. solution, does not destroy anthrax spores (Koch); 1 to 200 destroys the bacteria of sour milk (Molke); 1 to 343 destroys the bacteria in broken-down beef infusion (De la Croix).

A solution of 2.5 per cent. kills the tubercle bacillus in six hours (Yersin). In the proportion of 1 to 300 it destroys the cholera spirillum in half an hour (Van Ermengem).

Skatol in excess in water has no germicidal action as tested upon anthrax spores (Koch).

Soda.—Caustic soda destroys the fresh virus of symptomatic anthrax in the proportion of 1 to 5, but has no effect upon dried virus (Arloing, Cornevin, and Thomas). A ten-per-cent. solution destroys the tubercle bacillus in dried sputum after twenty-four hours' contact (Schill and Fischer).

The experiments of Jäger show that sodium hydroxide has about the same germicidal value as caustic potash. Boer obtained the following results, the time of exposure being two hours: anthrax bacillus 1 to 450; diphtheria bacillus 1 to 300, glanders bacillus 1 to 150, typhoid bacillus 1 to 190, cholera spirillum 1 to 150.

Sodium Biborate.—In the writer's experiments a saturated solution was found to have no germicidal power. A twenty-per-cent. solution does not destroy the virus of symptomatic anthrax, as proved by inoculation experiments (Arloing, Cornevin, and Thomas); 1 to 12 failed to kill the bacteria in broken-down beef infusion (De la Croix). A five-per-cent. solution failed in fifteen days to destroy the vitality of anthrax spores (Koch).

Sodium Chloride.—In the writer's experiments a five-per-cent. solution failed to destroy the virulence of septicæmic blood. A saturated solution failed in forty-eight hours to destroy the virus of symptomatic anthrax (Arloing, Cornevin, and Thomas). A saturated solution failed, in forty days, to destroy the vitality of anthrax spores (Koch). A saturated solution failed, in twenty hours, to destroy the tubercle bacillus in fresh sputum (Schill and Fischer).

Sodium Hyposulphite.—The writer's experiments show this salt to be without germicidal power. In saturated solution it failed, in two hours' time, to destroy any of the test organisms. Exposure for forty-eight hours to a fifty-per-cent. solution does not destroy the virus of symptomatic anthrax (Arloing, Cornevin, and Thomas).

Sodium Sulphite.—The results obtained by the writer correspond with those reported in the case of sodium hyposulphite, being entirely negative.

Stannous Chloride.—Abbott reports that this agent is active in the proportion of one per cent. and failed in 0.8 per cent., the test being the organisms in broken-down beef infusion, and time of exposure two hours.

Sulphuric Acid.—In the writer's experiments this acid was found to be fatal to micrococci in the proportion of 1 to 200; but a four-per-cent. solution failed to destroy the bacteria in broken-down beef infusion, doubtless on account of the presence of reproductive spores. An eight-per-cent. solution was, however, found to be effective (strength of acid, 1.480 gm. H_2SO_4 in each cubic centimetre). Salmon has found that a solution of 1 to 200 is fatal to the micrococcus of fowl cholera. A solution of one per cent. failed to destroy anthrax spores in forty days (Koch).

The experiments of Boer show a considerable difference in the resisting power of various pathogenic bacteria. The time of exposure being two hours, the anthrax bacillus was destroyed by 1 to 1,300, the diphtheria bacillus 1 to 500, the glanders bacillus 1 to 200, the typhoid bacillus 1 to 500, the cholera spirillum 1 to 1,300.

Sulphur Dioxide.—Wernich, in 1877, found that the bacteria of putrefaction are not destroyed by the presence of 3.3 volumes of sulphur dioxide in one hundred of air, when exposed upon strips of cotton or woollen goods saturated with putrid liquids. But four to seven per cent. was effective in six hours' time. Schotte and Gärtner, in 1880, found that strips of thick woollen goods soaked in culture liquids containing the bacteria of putrefaction were not disinfected by exposure in a chamber in which sulphur was burned in the proportion of 92 gm. per cubic metre (about six volumes per cent. of SO_2). Koch exposed various species of bacilli containing spores in a disinfection chamber for ninety-six hours, the amount of SO_2 at the outset of the experiment being 6.13 volumes per cent., and at the end of ninety-six hours 3.3 per cent. The results were entirely negative. The writer has also made numerous experiments which show that this agent is without power for the destruction of spores. Even when liquid SO_2 is poured upon the spores of anthrax or of *B. subtilis*, they germinate freely when transferred to a suitable culture medium. But this agent, especially in the presence of moisture, destroys micrococci and bacilli which do not contain spores. Thus, Koch found that the anthrax bacillus obtained from the spleen of a mouse recently dead, and exposed, while still moist, upon a silk thread, in an atmosphere containing one volume per cent. of SO_2, was destroyed in thirty minutes. In one of Koch's experiments the amount of SO_2 in the disinfection chamber was at the outset 0.84 per cent., and at the end of twenty-four hours 0.55 per cent. An exposure of one hour, in this experiment, destroyed anthrax bacilli (still moist) upon silk thread. Four hours' exposure failed to destroy the vitality of *Micrococcus prodigiosus* growing upon potato, but twenty-four hours' exposure was successful. The same result was obtained with the bacteria of blue pus. In experiments with an aqueous solution of SO_2, Koch found that five days' immersion in a solution containing 5.718 per cent. by weight was required to destroy the vitality of anthrax spores. A solution containing 11.436 per cent. by weight failed to kill anthrax spores in twenty-four hours, but was successful in forty-eight hours. According to Arloing, Cornevin, and Thomas, sulphur dioxide does not destroy the bacteria of symptomatic anthrax which contain spores. The writer's experiments show that micrococci are destroyed, even in the absence of moisture, when they are exposed for eighteen hours in a bell jar containing twenty volumes per cent. of SO_2. When the proportion was reduced to four volumes per cent. the result was not uniform, the test organisms—micrococci—were destroyed in some cases, and in others were not. In experiments with an aqueous solution of SO_2 the following results were obtained: The presence of 1 to 2,000, by weight, destroyed a micrococcus obtained from the blood of a patient with vaccinal erysipelas, and 1 to 4,000 failed; the same result was obtained with micrococci obtained from a vaccine vesicle, and with another species obtained from the blood of a patient having puerperal septicæmia.

Thoinot (1890) as a result of numerous experiments arrives at the conclusion that the bacillus of tuberculosis, of glanders, of diphtheria, of typhoid fever, and the spirillum of cholera are all destroyed by exposure for twenty-four hours in an atmosphere containing SO_2 developed by the combustion of sixty grains of sulphur per cubic metre of air space.

Sulphureted Hydrogen.—Bacteria develop readily in the presence of sulphureted hydrogen (Hamlet).

Sulpho-carbolates.—In experiments upon anthrax spores, Koch found that a five-per-cent. solution of sulpho-carbolate of zinc was effective in five days, while sulpho-carbolate of soda failed in five-per-cent. solution to destroy these spores after ten days' contact.

Tannic Acid.—The writer found, in his experiments, that a solution of one per cent. in half an hour is fatal to *M. Pasteuri* in the blood of a rabbit. A twenty-per-cent. solution has no effect upon the virus of symptomatic anthrax (Arloing, Cornevin, and Thomas). A five-per-cent. solution failed in ten days to destroy anthrax spores (Koch). A twenty-per-cent. solution failed in two hours to destroy the spores of *B. anthracis* or of *B. subtilis*, but was effective upon the organisms in broken-down beef-tea. Micrococci are destroyed by 1 to 400, while 1 to 800 failed (Abbott).

Tartaric Acid.—A twenty-per-cent. solution was found by Abbott to be effective, in two hours, for the destruction of organisms in broken-down beef infusion, but the same proportion failed with anthrax spores and with those of *B. subtilis*. Micrococci did not multiply in culture solutions, after exposure to 0.25 per cent., but one-half this amount (1 to 800) failed.

Thymol.—An alcoholic solution of 1 to 400 was found by the writer to destroy *M. Pasteuri* in fresh blood. One part in twenty is fatal to the bacteria in broken-down beef infusion (De la Croix). A five-per-cent. solution in alcohol does not destroy anthrax spores in fifteen days,

but the development of these spores is retarded by a solution of 1 to 80,000 (Koch).

The tubercle bacillus is destroyed by contact with thymol for three hours (Yersin). Thymol has about four times less germicidal power than carbolic acid (Behring).

Valerianic Acid.—A five-per-cent. a solution in ether failed in five days to destroy anthrax spores (Koch).

Zinc Chloride.—In the writer's experiments, *M. Pasteuri* failed to develop after exposure for two hours to 1 to 200, while a micrococcus obtained from gonorrhœal pus required for its destruction a solution of two per cent. The spores of *B. anthracis* are not destroyed by two hours' exposure in a ten-per-cent. solution. A five-per-cent. solution was, however, found to be effective in the same time in the case of *B. subtilis* spores, and upon the organisms in putrid beef-peptone solution. Koch's experiments are in accord with the above, in showing the superior resisting power of anthrax spores. He found that after being immersed in a five-per-cent. solution for thirty days, these spores still germinated freely. The development of *M. prodigiosus* was found by the same author to be only slightly retarded by exposure for more than sixteen hours to the action of a one-per-cent. solution.

Zinc Sulphate.—In the writer's first experiments with this agent, a solution of twenty per cent. failed in two hours to destroy micrococci obtained from the pus of an acute abscess. In later experiments a micrococcus from the same source resisted exposure for the same time to a ten-per-cent. solution, while *M. tetragenus* was destroyed by a 1 to 10 solution. Broken-down beef infusion, mixed with an equal quantity of a forty-per-cent. solution, was not sterilized after two hours' contact. In Koch's experiments anthrax spores were found to germinate after having been immersed for ten days in a five-per-cent. solution.

George M. Sternberg.

GERM LAYERS.—It has long been known that the bodies of embryos consist of distinct layers, which in many cases are separable from one another, so as to be recognized in gross as discrete membranes. It is now known that all such layers may be reduced to three primitive ones, named the ectoderm, mesoderm, and entoderm (by certain writers, epiblast, mesoblast, and hypoblast). The ectoderm is a layer of epithelium; so also is the entoderm; the mesoderm is more complex. In the lower animals, the mesoderm is less developed than in the higher forms; in the hydroids the body is constituted mainly by the two epithelial layers, the ectoderm covering the outside of the body, and the entoderm lining the digestive cavity; there is very little space between them, the space being occupied by the slightly developed mesoderm. As we ascend the scale the mesoderm increases gradually, constantly acquiring a greater predominance, until in mammals nearly the whole bulk consists of mesoderm. But, in spite of this change, the three layers are preserved throughout, and their essential relations are not altered, so that we are able to assert the unity of organization throughout the whole series of multicellular animals, without which it would be impossible to accept the doctrine of evolution. The demonstration, therefore, of the homologies of the germ layers, is the most important morphological generalization since the establishment of the cell doctrine. As these homologies have already been discussed under *Gastrula*, and also the metamorphoses of the layers under *Fœtus*, it only remains for us to review, with precision and brevity, the rôle of the layers in the construction of the human body.

The ectoderm covers the external surface of the body, and persists in adult life as the stratified epithelium (epidermis) of the skin; it forms, of course, all the so-called epidermal structures—hairs, nails, sebaceous and sweat glands, lens, cornea, etc. It also lines part of the buccal cavity; and the buccal portion gives rise to the hypophysis cerebri, to the enamel organs of teeth, and probably to all the salivary glands. It forms a small invagination to meet the rectum, so that it also lines the anus. It gives rise to the entire nervous system by producing the medullary canal, which makes the central nervous system, and from which grow out all the nerves, and probably all the peripheral ganglia, and from which also grows out the evagination which makes the optic nerve, the retina, the choroid, and the epithelial portions of the iris. It forms the epithelium of the olfactory and nasal cavities, and the epithelium of the auditory labyrinth.

The entoderm [also spelled "endoderm"] forms the epithelium which lines the digestive tract, including the surface of the tongue; also the epithelium of the trachea and lungs, and of all the glands appended to the respiratory passages, and to the digestive tract, including the thyroid, pancreas, and liver. The liver cells, it should be remembered, constitute a true though much modified epithelium. The notochord is developed from the entoderm.

The mesoderm may be conveniently divided into three portions—the mesenchyma, the mesamœboids, and the mesothelium (*cf. Cœlom*). 1. The *mesenchyma* produces all the connective tissues of the body, and includes therefore the cutis, the non-epithelial walls of the alimentary tract, etc.; tendons, cartilage, and bone, the marrow of bones, lymph glands, and spleen; it produces also the blood-vessels and blood, the entire lymphatic system proper, and the heart. Pigment cells, fat cells, and smooth muscles are derived from the mesenchyma also. 2. The *mesamœboids* include the leucocytes and wandering cells, and perhaps the embryonic red blood cells, and the marrow cells. 3. The *mesothelium* is the epithelium of the cœlom; it produces the peritoneal and pleural epithelia, the striated muscles (myotomes), except those of the heart, and all the non-mesenchymal tissues of the entire urogenital apparatus, except, of course, the external genitalia. (Spee traces the Wolffian duct to the ectoderm.)

Now, in classifying organs, it is best to rank them as belonging to that layer from which their functionally essential and characteristic part is derived. Thus, although the pancreas, ovary, and spinal cord all contain connective tissue, we do not call them mesodermal, but respectively entodermal, mesothelial, and ectodermal. The gland cells of the pancreas come from the entoderm; the ova and the Graafian follicles come from the mesothelium; the ganglion cells and nerve fibres (axis cylinders) from the ectoderm. Adopting this principle, we may classify the organs of the human body as follows:

Ectodermal.	Mesodermal.	Entodermal.
Skin (epidermis).	1. Mesenchyma:	Epithelium (of digestive tract):
Epidermal structures:	Connective tissue:	Thyroid,
Hair,	Cutis, etc.,	Trachea and lungs,
Nails,	Tendons,	Œsophagus,
Glands:	Cartilage,	Stomach,
Sebaceous,	Bone,	Liver,
Sudorific,	Marrow,	Pancreas,
(Salivary ?),	Lymph glands,	Intestine,
(Thymus ?).	Spleen,	Yolk sac,
Corneal epithelium,	Blood-vessels:	Cœcum,
Lens of eye.	blood (in part).	Vermix,
Central nervous system:	Lymphatic system,	Colon,
Nerves,	Fat cells,	Rectum,
Ganglia.	Smooth muscle.	Allantois:
Eye, optic vesicle:	2. Mesamœboids:	(Bladder).
Optic nerve,	Leucocytes,	Notochord.
Retina, etc.	Embryonic red blood cells,	
Olfactory organ.	(Marrow cells ?).	
Auditory organ.	3. Mesothelium:	
Lining of mouth:	Peritoneum,	
Teeth,	Pleuræ,	
Hypophysis.	Urogenitals:	
Anus.	Wolffian body,	
Chorion:	Kidney,	
Placenta.	Testis,	
Amnion:	Ovary,	
(Wolffian duct ?).	Oviduct:	
	Uterus,	
	Vagina.	
	Striated muscles.	

The human body may be defined as two tubes of epithelium, one inside the other; the outer tube, epidermal or ectodermal, is very irregular in its form; the inner tube, entodermal, is much smaller in diameter, but much longer than the outer, and has a number of branches (lung, pancreas, etc.), and is placed within the ectodermal tube. Between these two tubes is the very bulky méso-