details of the differentiation of the *lame* are carefully described.

I cannot conclude this notice without referring to the admirable manner in which this valuable memoir is written, and the great clearness with which the facts and conclusions are presented.

CHARLES S. MINOT.

EXPERIMENTS TO DETERMINE THE GERMICIDE VALUE OF CERTAIN THERAPEUTIC AGENTS.

IN the *American journal of medical sciences* for April, Dr. Sternberg gives an account of his study of this important question. The objects of the author were, —

To ascertain the exact value, as germicides, of some of the agents most frequently employed in medical and surgical practice, with a view to the destruction of pathogenic micro-organisms, hypothetical or demonstrated.

To compare this value, established by laboratory experiments, with the results of clinical experience, for the purpose of ascertaining what support, if any, the germ-theory of disease receives from modern therapeutics.

Assuming that the active agent in infective material is a living micro-organism, or 'germ,' disinfection will be accomplished by those chemical agents only, which have the power of destroying the vitality of this organism. We require to know: —

a. What is the absolute germicide power of various disinfecting agents, in order to select the best with a view to economy and efficiency;

b. Are all disease-germs destroyed by these agents in the same proportion? and, if not;

c. What agents are the most available for special kinds of infective material?

In therapeutics we should know, in addition to this: —

d. What is the minimum quantity of each of these agents which will restrict the multiplication of each specific disease-germ in a suitable culture-medium? — this with reference to medication, with a view to accomplishing a like result within the body of an infected individual.

Evidently, any thing like a complete answer to these questions is quite impossible in the present state of knowledge, and we must content ourselves with such partial or approximate answers as can be obtained by laboratory experiments upon the comparatively small number of pathogenic organisms which abound in organic liquids undergoing putrefaction.

The experiments were conducted by using small sealed flasks containing bouillon free from micro-organisms. The smallest quantity of a fluid containing such organisms introduced into one of the flasks would cause it to 'break down' within twenty-four hours, it being exposed during this time to a temperature of 100° F.

To test the germicide power of a chemical reagent, living bacteria are subjected to its action in a known proportion for a given time, and are subsequently used to inoculate sterilized bouillon in one of the flasks. Failure to multiply in this fluid, when exposed for twenty-four hours or more to a temperature of 100° F., is evidence that reproductive power — vitality — has been destroyed by the reagent used. On the other hand, failure to disinfect, i.e., to destroy the vitality of the bacterial organisms used as a test, is shown by the 'breaking-down' of the culture-fluid.

Standard solutions of the reagents to be tested are prepared with distillled water. The germs are exposed, in small glass tubes, to the action of these agents for two hours. The tubes are sterilized in the flame of an alcohol-lamp immediately before each experiment; they are open, and covered by a bell-glass during the time of exposure.

At the end of the time of exposure, a small quantity of the fluid from one of the tubes is introduced into a flask containing sterilized bouillon, and this is exposed to a temperature of 100° F. for twenty-four hours.

The micro-organisms which have been used in the experiments herein reported, to test the germicide power of the reagents named, were obtained from the following sources: —

a. A micrococcus from gonorrhoeal pus.

b. A micrococcus from pus obtained from an acute abscess (whitlow) at the moment that it was opened by a deep incision. This micrococcus is morphologically identical with the preceding.

c. A pathogenic micrococcus, having distinct morphological characters obtained from the blood of a septicaemic rabbit.

d. Bacterium termo, and other bacterial organisms (micrococci and bacilli) from 'broken-down' beef-tea which had been freely exposed to the air.

In the following table, which is arranged according to the germicide value of the agents named, all experiments are given in which the micrococcus from pus was used as a test.

Mercuric bichloride (0.005 per cent), efficient in the proportion of one part in	20,000
Potassium permanganate (0.12 per cent), efficient in the proportion of one part in	833
Iodine (0.2 per cent), efficient in the proportion of one part in	500
Creosote (0.5 per cent), efficient in the proportion of one part in	200
Sulphuric acid (0.5 per cent), efficient in the proportion of one part in	200
Carbolic acid (1 per cent), efficient in the proportion of one part in	100
Hydrochloric acid (1 per cent), efficient in the proportion of one part in	100
Zinc chloride (4 per cent), efficient in the proportion of one part in	50
Tinc. ferri chloridi (4 per cent), efficient in the proportion of one part in	25
Salicylic acid dissolved by sodium borate (4 per cent), efficient in the proportion of one part in	25
Caustic potash (10 per cent), efficient in the proportion of one part in	10
Citric acid (12 per cent), efficient in the proportion of one part in	8
Chloral hydrate (20 per cent), efficient in the proportion of one part in	5

The following-named reagents, as far as the experi-

ments go, are not shown to have any germicide value; viz., —

	Per cent.
Fowler's solution failed in the proportion of	40
Sodium hyposulphite failed in the proportion of	32
Sodium sulphite, exsiccata, failed in the proportion of	10
Ferric sulphate (saturated solution) failed in the proportion of	16
Potassium iodide failed in the proportion of	8
Liq. zinci chloridi failed in the proportion of	8
Boracic acid (saturated solution) failed in the proportion of	4
Zinc sulphate failed in the proportion of	20
Sodium borate (saturated solution) failed in the proportion of	4
Sodium salicylate failed in the proportion of	4

Having ascertained the germicide value of certain reagents for a single micro-organism, the question arises as to whether we are justified in assuming that other organisms of the same class, and especially pathogenic bacteria, will be destroyed by the same reagents in like proportion, or, in other words, whether we can generalize from the data obtained. It is evident, that, if each of the reagents named gives identical results with several distinct species of bacteria, we shall be justified in assuming that the value obtained will be constant for other organisms, known or unknown, of the same class; whereas, if marked differences are found as to the vital resistance of different bacterial organisms to these reagents, no generalization will be possible, and the value for each distinct organism of the class can only be fixed by experiment. To solve this question, experiments have been made as follows: —

a. Upon the micrococcus of pus.

b. Upon the micrococcus of septicaemia in the rabbit.

c. Upon bacterium termo, in its active motile stage, as found in a fresh culture.

d. Upon the bacteria in broken-down beef-tea which had been freely exposed to the air, and in which all active development had ceased.

The results show, that, in general, those reagents which destroyed the vitality of the micrococcus from pus are destructive to organisms of the same class, and that their relative value as germicides is not changed when a different micro-organism is used as the test of this value. Moreover, the reagents which were found to be practically valueless as germicides in the first series of experiments — e.g., ferric sulphate, sodium sulphite, and hyposulphite, boracic acid, etc. — proved to be equally without value when the test was extended to other micro-organisms of the same class. But the reagents found to possess decided germicide power have, in some cases, a different value for different organisms: in other words, the vital resistance of different bacterial organisms to the reagents in question is not in all cases the same.

Thus, sulphuric acid failed to destroy B. termo and the micrococcus from pus in the proportion of 0.25 %; but one-fourth of this amount (0.06 %) destroyed the vitality of the septic micrococcus.

Caustic potash destroyed the septic micrococcus in the proportion of 2 %, but failed to kill the micrococcus of pus in four times this amount (8 %). The value, as a germicide, of the solution of ferric sulphate and sulphuric acid in water, which has been extensively recommended by sanitarians as a disinfectant, evidently depends upon the sulphuric acid which the solution contains. To insure the destruction of all bacterial organisms and of the reproductive spores of those species which multiply by spores as well as by transverse fission, such a solution should be used in sufficient quantity to subject the material to be disinfected to the action of the acid in the proportion of at least five per cent for a period of two hours.

The quantity of carbolic acid used to accomplish the same result should not be less than five per cent, for it is necessary to keep on the safe side; and we do not know, at present, whether all of the pathogenic bacteria, hypothetical or demonstrated, form spores or otherwise. In the case of the anthrax bacillus and of Koch's bacillus of tuberculosis, this has been proved to be true; and we have ample experimental evidence to show that these reproductive bodies possess very great resistance to heat and to those chemical reagents which destroy bacterial organisms in their ordinary condition of rapid growth and multiplication by fission.

Evidently, therapeutic value — assuming the correctness of the germ-theory — cannot be gauged by germicide power alone, for it is possible that a reagent which possesses this power in but slight degree, or not at all, may nevertheless be capable of restricting the development of pathogenic organisms, and thus limiting their power for mischief.

The following table shows the percentage required to destroy vitality, and also that required to prevent the development of the micrococcus of pus: —

Reagent.	Percentage required to destroy vitality.	Percentage capable of preventing development.
Mercuric bichloride	0.005	0.003
Iodine	0.2	0.025
Sulphuric acid	0.25	0.12
Carbolic acid	0.8	0.2
Salicylic acid and sodium biborate	2	0.5
Alcohol	40	10
Ferric sulphate	Failed in saturated solution.	0.5
Boracic acid		0.5
Sodium biborate		0.5

An inspection of the table shows that the potent germicides in our list restrict multiplication in quantities considerably less than are required to destroy vitality. In the case of iodine the difference is eightfold; in that of carbolic acid, fourfold; in that of sulphuric acid, twofold, etc.

We also see that the agents at the bottom of the list, — ferric sulphate, boracic acid, and sodium biborate, — in the proportion of five-tenths per cent, prevent the multiplication of bacterial organisms, and are consequently antiseptic agents of value, although in saturated solution they fail to kill these organisms.

In the case of ferric sulphate, and also of zinc sulphate and zinc chloride, this power to prevent the development of micro-organisms seems to be due to

precipitation of the organic material in the nutritive medium rather than to any direct action upon the living organisms, which, as we have seen, are not killed by a far greater quantity of the reagent.

The conclusions at which Dr. Sternberg arrives, are, that the vital resistance of bacterial organisms to chemical reagents differs, within certain limits, for different species. And certain species show special susceptibility to the germicide action of particular reagents; e.g., the septic micrococcus to alcohol, and B. termo to boracic acid.

There is, therefore, reason for supposing that different pathogenic organisms may differ in like manner, as to susceptibility to the action of various reagents administered medicinally with a view to their destruction. Nevertheless, the comparative germicide value of the reagents tested is the same for the several test-organisms, and, allowing certain limits for specific peculiarities, it is safe to generalize from the experimental data obtained in the practical use of these reagents as disinfectants. But it must be remembered that the resisting power of reproductive spores is far greater than that of bacterial organisms in active growth (multiplication by fission), and the data obtained for the latter cannot be extended to include the former.

The antiseptic value of the reagents tested depends upon their power to prevent the multiplication of putrefactive bacteria; and this is not necessarily connected with germicide potency, for some reagents which fail to kill these micro-organisms are, nevertheless, valuable antiseptics, e.g., ferric sulphate and boracic acid.

Clinical experience has demonstrated the value of all the potent germicide reagents tested in one or more of the diseases which there is the most reason to believe are due to the presence of pathogenic micro-organisms in the *primae viae*, in the blood, or in the tissues; e.g., intermittent-fever, typhoid-fever, dysentery, erysipelas, syphilis, etc. The 'germ-theory' as to the causation of these diseases receives, therefore, very strong support from modern therapeutics; but the experiments do not justify the belief that any one of the reagents tested can be administered as a specific in germ-diseases generally. This also accords with the results of clinical experience, and makes it possible to believe that the specific, self-limited diseases are also 'germ' diseases.

LETTERS TO THE EDITOR.

The practical value of soil-analysis.

IN *Bulletin* lvi. of the New York agricultural experiment-station, Dr. Sturtevant gives the reasons for which the station declines to make soil-analyses 'for the purposes of the individual farmer;' summarizing them in the statement that such ayalyses "can offer no solution of the problem of what fertilizer, and how much, to apply."

Were this statement made in a somewhat less general and absolute manner, I should have no fault to find with it; for in the case of the long-cultivated fields of the state of New York, which have been subject to indefinitely varied culture-conditions and the use of fertilizers, the cases in which chemical analysis alone would point with any degree of certainty to the true cause of failure to produce profitable crops would be exceptional; and the station would be likely to be overrun with requests for an indefinite amount of comparatively useless routine work.

But when Dr. Sturtevant broadly adds his denial "that analyses of soils can give us definite information concerning their productiveness," he seems to go beyond the limits justified by the record, and beyond what the context following would appear to show he intended to say. If the clause above quoted were to read, instead, "while denying that analyses of *cultivated* soils can give us definite information regarding their *present* productiveness," I should agree with him so far as the great majority of cases is concerned, — so much so, that it is only exceptionally that I undertake the analysis of a cultivated soil, but usually go back to its virgin ancestor for information as to its general character; and from this, and the usually simple history of its cultivation, pretty definite inferences as to the prominent wants even of a cultivated soil can in very many cases be deduced, as is proved by the practical results. Dr. Sturtevant's own statement as to the frequency and consequent practical importance of such inquiries would seem to justify the taking of some pains to approach its solution, before proclaiming an absolute *non possumus*.

As for virgin soils, which over wide areas have been subject to uniform or uniformly variable conditions, it is *a priori* reasonably presumable, and I think experience confirms the inference, that, other things being equal, the amount of available plant-food, and therefore the durability of a given soil under the usual culture, without replacement, is sensibly proportional to the plant-food percentages shown by the usual method of analysis. Whether or not other things are really equal can only be ascertained by intelligent examination in the field as well as in the laboratory; and soil-specimens taken by non-experts rarely fulfil this condition.

While, therefore, believing that Dr. Sturtevant's action in this matter is well advised under the circumstances, I nevertheless believe that my contrary practice in regions but sparsely or recently settled is at least equally well justified, and that the importance of affording the settler at least an approximate insight into the present and ultimate durability of his soil, and its general character and adaptations, is so great as to justify a considerable public expenditure, upon a well-considered plan carefully carried out by competent persons both in the field and in the laboratory, even with our present limited knowledge of the chemistry of soils — which, I cannot but remark, is not likely to be increased very rapidly if the composition of soils serving for culture-experiments continues to be ignored, as has so largely been the case heretofore. The prime importance of the presence of a certain minimum percentage of lime, for example, is manifestly so great, that no experimenter can afford to be ignorant of the presence or absence of a proper supply of that substance in his soil; and the cases in which analysis shows the extreme scarcity or extreme abundance of lime, phosphates, or potash, in virgin soils and subsoils, are far more frequent than the contemners of soil-analysis suppose. In the former case the practical value of the indication is too obvious to be overlooked, and is amply attested by the results following the application, e.g., of phosphate fertilizers in such cases. We might not be able to detect the addition thus made to the phosphates of the soil by the most careful analysis; but the fact that the soil is naturally poor in phosphates will remain a fruitful truth forever after.