following are a few passages, is a devastating criticism of this new school:

"We are now to be told that . . . experience, hitherto taken to be the raw material of art, should be accepted as its finished product. . . . One of the chief reasons for the unintelligibility of modern verse is the predominance of associations that are personal to the writer. Egoism is carried so far that poems are written for the appreciation of which a complete account of their author's external and internal life is needed. . . . Those who write unintelligible poetry . . . find themselves justified by the beliefs of an increasingly popular school of thought which in effect denies the existence of the intellect. . . . To make the fullest use of the associative value both of words and of what words stand for has been the task of literature since literature was first attempted. . . . Modern writers therefore do not break new ground in paying attention to the effects of association. What is new in their writing is the result of their paying attention to association alone and exploring it so thoroughly that meaning is entirely or almost entirely superseded."

Or, as Mr. Desmond MacCarthy says, it is hopeless to reproduce in print the very texture of consciousness, such as leads Mr. James Joyce to record the jabberings of the idiot or flat-headed savage who talks unheard in the backward abyss of our minds and sometimes screams audibly in delirium.

Reason by which to Think

Mr. Sparrow has clearly defined the symptoms, but as medical men we want to go behind the symptoms and determine the causes at work, here as elsewhere. Mr. Gerald Heard, in his recent book *These Hurrying Years*, has attempted this task. He attributes them to a growth in self-consciousness, a new realization of what the mind is doing. While this development has seemed to many onlookers only "the treason of the clerks," the betrayal of reason, the blind escape into childishness, superstition, and self-comforting illusion, he does not so regard it. What we have to focus upon is the force, the cause which has produced that reaction. He thinks that we need not be unduly perturbed by the new experiments, since they are all part of a growth which, though largely blind to-day, is making for a new synthesis. He admits that this may be too optimistic, and I think it is clear that the pendulum has swung too far. I have great belief in the capacity of life to adapt itself to its environment. But of one thing I am sure—we shall never achieve a new civilization by denying reason its place. Even though we realize that it does not include the whole of life, it must have the final word. Earlier in the year I quoted a saying of Gaskell's which will bear repetition now: "The race is not to the swift, nor to the strong, but to the wise."

When I was seeking for a title to express the viewpoint to which I wished to direct your attention, I remembered an essay by that charming writer Stephen Paget, in which he said:

"Great words and phrases (may) come down in the world. For instance, I have reason to believe—a phrase of noble birth and of the utmost refinement—is at the mercy of gossip. I have reason to believe that the conductor gave me sixpence short on purpose; and so forth. Quick, let us do honour to this old phrase—for it is descended from two of the stateliest of all words."

It occurred to me to adopt that phrase, hoping thus to make a plea for the restoration of reason to its throne on the highest level of the nervous system: the last to come, the first to go, but all the more to be cherished on that account. Reason is the judge and assessor of our instincts and our emotions, which, however necessary for driving energy, if uncontrolled are but blind leaders of the blind. We have reason by which to think. . . .

THE LABORATORY TESTING OF DISINFECTANTS

BY

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Disinfection is of two principal kinds: that which is conducted outside the body, with the object of preventing the spread of infection to other persons; and that which is conducted or attempted on or in the body itself in order to avert or relieve infection in the patient so treated. The first of these uses is mainly in the hands of the nurse or the sanitary inspector; to the second the attitude of the profession varies between a faith which is often misplaced and complete scepticism. This is hardly extraordinary, because either of these attitudes, or any intermediate standpoint, could be justified from the literature of the last thirty years. This literature is profuse, contradictory, and often highly misleading. For this the complexity of the subject is in part to blame, and in part the methods of the investigator. That is to say, there are at least six important classes of disinfectant, each with perhaps twenty members, and there are a dozen important families of bacteria the many members of which may behave quite differently; but, what is worse, there is a quite unlimited variety of conditions under which the action of one on the other may be observed, and in doing this there are pitfalls which may lead to entirely erroneous conclusions.

An unfortunate result of this is that fantastic claims are often made which are no doubt answerable for a good deal of distrust in disinfectants generally. A single example will serve to illustrate this confusion. Of all disinfectant actions, that of mercury salts might be supposed to be fully and generally understood, since it has been tested *ad nauseam* and freely utilized in medicine for many years. It is almost universally believed, and endless published experiments suggest, that extremely dilute solutions of perchloride of mercury kill bacteria, even in short periods; but Shippen¹ has recently shown that a 1 in 200 solution does not kill *Staphylococcus aureus* in fifteen minutes. If we believe Watson,² a 1 in 1,000 solution of mercury biniodide acting for twenty-four hours is the perfect reagent for sterilizing catgut; according to Bulloch,³ it is quite ineffective even if allowed to act for four years, and even a solution of ten times this strength fails to sterilize catgut in 730 days.

Discrepancies of this kind are not due to chance, or to an erratic behaviour of bacteria beyond human control; they are due to differences in method. The more flattering of the results quoted were obtained by methods which are actually bad, in that they made bacteria appear to have been killed when they quite certainly had not. But enormous differences may exist between results obtained by methods involving no such fallacy on either side, the results in each case being valid for the conditions employed. Thus the phenol coefficient of potassium permanganate acting in distilled water only has been placed at 50; the addition of 1 per cent. of serum reduces it to 0.8.⁴ These figures themselves have no absolute validity, since they depend upon several conditions other than the composition of the fluid in which the tests were made. Examples such as this may appear to suggest that the results of any such tests are valueless; it may be argued that so wild a degree of irregularity betokens a proceeding in which there is some inherent fault. The answer to this is that when the conditions of a test are exactly defined and observed its results are consistent within narrow limits of exactitude; the truth is, in fact, ascertainable if the method used is correct.

It is therefore necessary to inquire what are the conditions governing disinfectant action. These conditions apply equally to the laboratory test and to the sphere of practical disinfection, and, although it is customary to deride laboratory conditions as too far removed from those of practice to afford significant results, the truth is that practical conditions can be imitated closely and in almost every particular. The virtue of a test may in fact be held to depend very largely on how far it achieves this, and the whole art of devising it consists in securing the necessary conditions without sacrifice of uniformity.

Conditions Governing Disinfectant Action

Concentration of Disinfectant.—Of this self-evident factor it is only necessary to say that the usual object of a test is to determine what concentration is required in order to destroy bacteria under the further conditions which follow.

Time of Application.—The destruction of bacteria by chemical means is not a sudden process but progressive, the more susceptible being destroyed first and the more resistant surviving considerably longer. By an elaborate technique this process can be studied in detail, but routine methods serve only to demonstrate whether or no the whole of the bacteria introduced have been destroyed in a given time. A single arbitrary time period has this disadvantage—that some disinfectants act rapidly and others equally or more serviceable act slowly; examples of these classes respectively are hypochlorites and dyes. A fair comparison between such totally different reagents can only be secured by making observations at varying periods of time. A valuable alternative is to study bacteriostatic as well as bactericidal action—that is, the concentration required to prevent growth as well as that required to kill in a short period of time. For many disinfectants the ratio between these concentrations is about 1:10; for substances whose action is only exerted slowly, such as antiseptic dyes and the class of compound represented by acriflavine, the ratio may be of the order of 1:1000.

Temperature.—An increase in temperature within any range accelerates the process of disinfection. The degree of this effect varies; it is very marked in the case of phenol and coal-tar disinfectants (Chick).⁵ This factor therefore requires control. In a laboratory maintained at a reasonably constant temperature the errors arising from its neglect may not be considerable, but its accurate regulation, secured by the use of a water-bath, is required for the performance of any standard test.

Number of Bacteria.—There is a greater difference than would be expected in the conditions required for killing small and large numbers of bacteria, even though these be contained in the same volume of fluid. That this difference is not due only to more obvious causes is shown by the fact that it obtains even for disinfection by heat (Lange).⁶ It is therefore necessary to regulate this number, and it appears preferable that it should be large, at least some millions of living cells. Fantastic results are claimed from time to time in experiments with extreme dilutions of a culture as inoculum—for example, Birkhaug.⁷

Nature of Bacteria.—It cannot be emphasized too strongly that the susceptibility of different bacteria to a single disinfectant may vary greatly. This is not merely a question of general resistance depending on structural peculiarity as in sporing bacteria or tubercle bacilli, but a much more complex type of variation, which in the main is quite unexplained. Examples are the extreme susceptibility of staphylococci to the action of violet dyes and of pneumococci to that of optochin. The same bacteria may be highly resistant to disinfectants of another type; an example is the resistance of staphylococci to certain

metallic salts (Eisenberg).⁸ It is even possible for different strains of the same micro-organism to exhibit varying degrees of resistance. It has been suggested on this account that the proper evaluation of a disinfectant must involve tests with a range of different bacteria.⁹ How far this is necessary will depend on the type of use for which it is intended. The most important group of intestinal bacteria is well represented by *B. typhosus*, and bacteria responsible for surgical infections by *Streptococcus pyogenes* and *Staphylococcus aureus*, and tests conducted with these micro-organisms should, broadly speaking, be valid in the respective spheres; but the data in one are not transferable to the other, nor are either necessarily relevant to special purposes of other kinds.

Presence of Other Material.—A chemical reaction with the proteins or other constituents of the bacterial cell is the basis of all disinfectant action, and the presence of other material with which the disinfectant will react similarly may therefore prevent the destruction of all the bacteria unless the disinfectant is available in excess. Such other material almost invariably occurs where disinfectants are employed, and an appropriate practical test must therefore introduce it. It is here, in the most essential feature of a test, and that by which it stands or falls as a replica of working conditions, that uniformity of practice almost entirely ceases. It here becomes necessary also to distinguish between disinfectants applied on or in the human body and those used outside it, for which appropriate testing methods clearly must differ, especially in the nature of this added material, or "organic matter." These two classes may conveniently be termed "excremental" and "surgical," and will be considered separately. But there is also a type of test, very generally in use, which ignores this last factor altogether.

Simple Comparative Tests

The method introduced by Rideal and Walker in 1903¹⁰ consisted of adding a small quantity of *B. typhosus* culture to solutions, both of the disinfectant and of phenol, and cultivating the mixtures at intervals during a short period of time, the result, or coefficient, being an expression of the activity of the disinfectant in comparison with that of phenol. This test has since been modified¹¹ only in details making for greater accuracy, and the technique for it which was last year adopted as a British standard¹² is substantially the same as that originally proposed. Its only serious rival is the hygienic laboratory test of the United States, first put forward by Anderson and McClintic.¹³ This test is essentially of the same nature as the Rideal-Walker; it has been studied more elaborately and repeatedly modified with a view to greater precision,^{14 15} perhaps because it has enjoyed official recognition for many years. In its present form it differs from the Rideal-Walker test in the employment of a different culture medium, a different strain of *B. typhosus*, a platinum loop constructed to deliver a more constant inoculum, and in the calculation of the coefficient from readings at four time intervals instead of one. The *Lancet* test, devised by Ponder and Woodhead in 1909,¹⁶ was of similar nature, but *B. coli* served as the test organism, and other modifications were introduced which have since been more criticized than approved or adopted.

Tests of this nature can be made to yield very accurate and consistent results if all their conditions are carefully observed, but they are limited both in application and in significance, even should they be performed with a variety of bacteria instead of with *B. typhosus* alone. Some classes of disinfectant either act slowly or inhibit growth in high dilution without necessarily killing; with these the results obtained are quite misleading. Others, and especially those owing their activity to iodine, chlorine,

or oxygen, are effective in extreme dilution under the conditions of the test, when they encounter almost "naked" bacteria (the only organic matter present being that contained in 0.2 c.cm. of broth), but may be neutralized and rendered inert by the presence of other material such as a disinfectant encounters in practice. It remains to consider tests which take this factor into account.

Tests of Excremental Disinfectants

A disinfectant in this class may be used for a typhoid stool, a cow-byre, or a railway truck, but wherever it goes it meets dirt, and that dirt often contains excrement. The notion that it should be tested on or in the presence of excreta is therefore natural, and, in fact, provided nearly thirty years ago a battle-ground on which Kenwood and Hewlett, Winter Blyth, and others^{17 18 19 20} fought for a test incorporating faeces or other complex material such as urine or milk in the mixture to be disinfected, their main opponents being Sommerville and Walker,^{21 22} who maintained that such materials are so inconstant in composition as to be unserviceable.

Two methods in present use are traceable to this controversy: the Admiralty test,²³ in which the organic matter is gelatin and starch, materials proposed by Sommerville and Walker; and the Chick-Martin test,²⁴ in which the organic matter is dried human faeces. Either of these additions reduces the activity of disinfectants which are highly susceptible to the influence of organic matter, but the Chick-Martin is much the more severe, and the origin and quantity of the organic matter used are both more appropriate. Unfortunately, the process of drying, sieving, and weighing faeces is both time-consuming and unpleasant, but it is not for this reason alone that the test has failed of general adoption; a greater objection is that workers with it have been unable to obtain consistent results. I have recently investigated the process of disinfection under the conditions of this test,²⁵ and found that its progress depends on a number of unsuspected factors, including the degree of subdivision of the faecal particles and the formation of a deposit protective to the few bacteria contained in it, which are incapable of exact control. Since this test is the only available one of its kind, and the use of disinfectants under certain statutes is governed by the results officially obtained with it, improvements in the method which would ensure greater accuracy are highly desirable. Although some improvement could probably be secured by minor modifications, my provisional suggestion is that the use of faeces should be discontinued altogether. Its strictly imitative character has doubtless much to commend it, but this advantage is more than counterbalanced by variability in composition. A suspension of yeast, however, is nearly constant, both in chemical composition, which is sufficiently complex, and in particle size, and does, in fact, similarly reduce the activity of disinfectants.

Whatever method ultimately secures approval for this purpose, it must be one in which complex organic matter, both particulate and in solution, is furnished in adequate amount to parallel the conditions obtaining in the reasonable use of disinfectants outside the body.

The Testing of Surgical Disinfectants

It is often forgotten that disinfectants are used clinically in many different ways, in some of which their task is easy and in others manifestly impossible. Among the former are the sterilization of the intact skin or of a recently inflicted wound, in which bacteria are still on the surface of exposed tissue and not within it; among the latter are application to deeply infected tissues and such therapeutic optimism as attempting to kill bacteria in the blood stream. There is a world of difference here between prophylaxis and treatment, and few would be so bold as

to suggest that any *in vitro* test can be a sufficient guide to the merits of disinfectants in the treatment of established infections, although its indications may nevertheless be of some value. But the conditions in prophylaxis are different, and tests incorporating such materials as blood, or serum and muscle extract, are distinctly applicable to the problem of the recent wound.

It is idle to discuss individual methods such as these, since every investigator has devised his own, and results are therefore quite incomparable. The essential feature of most is the addition to the test mixture of either serum or blood, in concentrations varying between 1 per cent. and 50 per cent., simply in order to determine how far these additions diminish bactericidal action. The ingenious "slide cell" method²⁶ goes further than this, since it also indicates the concentration in which the disinfectant interferes with phagocytosis.

It is really lamentable that there should be no universally recognized and reasonably appropriate test by which surgical disinfectants could at least be broadly classified as good, bad, and indifferent, and indeed awarded a numerical coefficient with a definite comparative significance. If necessary, its conditions could be varied somewhat with the class and type of action of the disinfectant concerned, each class having its own standard for comparison; thus, for example, phenol would serve for disinfectants of coal-tar origin and a mercury salt for compounds of the heavy metals. Such a test would employ one of the pyogenic cocci as the test organism, and preferably blood as organic matter. Its results would at least serve to show in what concentration, if any, a disinfectant is calculated to destroy bacteria during brief application to a recently inflicted wound.

There is the same lack of uniformity in methods of studying the disinfection of normal skin, the treated area being swabbed, scraped, or excised, and cultivated with or without sufficient dilution or neutralization in a variety of ways.^{27 28 29 30} The capacity of disinfectants for penetrating tissue has been studied little; recorded methods are attempts to sterilize whole pieces of infected tissue,³¹ histological demonstration in treated tissue,³² and the treatment of infected blood clots.³³ Finally, there are methods, with which this paper is not concerned, of demonstrating prophylactic efficiency by animal experiment. These have been recently reviewed in these columns by Browning,³⁴ and their results indicate that bacteria freshly introduced into the body, under conditions exactly parallel to those of the recently inflicted wound in the human patient, can be destroyed by chemical means. In this important field standardization of methods is perhaps scarcely feasible.

The Toxicity of Disinfectants

The possible efficiency of a disinfectant about the body is conditioned not only by its bactericidal activity but by its toxicity, which limits the concentration in which it can be used. There is no generally accepted method of determining this. Administration to animals may be either subcutaneous, oral, or intravenous: according to Hale,³⁵ who made an extensive study of coal-tar disinfectants from this point of view, the subcutaneous and oral routes give results in close agreement, and he adopted the former. Hewlett³⁶ makes the same claim for intraperitoneal injection. Methods not depending on lethal effect are the treatment of tissue cultures (Lambert,³⁷ Hata³⁸) and the study of interference with phagocytosis (Browning *et al.*,³⁹ Bond⁴⁰). A curious but perhaps not wholly fanciful suggestion is the immersion of earthworms in disinfectant solutions for varying periods (Winter Blyth¹⁸). It appears desirable that some method of administration to animals should be adopted generally as a yardstick by which toxicity may be judged.

Discussion

This subject was reviewed in the Milroy Lectures of 1909 by Hewlett,⁴¹ and a comparison of the position at that time with that of the present day reveals that it has altered singularly little in a quarter of a century. There were then two recognized tests, the Rideal-Walker and the Chick-Martin, each having a limited sphere of usefulness; they exist to-day in forms which respectively are slightly modified and entirely unaltered. There was then no appropriate and recognized method of testing a surgical disinfectant; there is none now. Disinfectants having multiplied during this period, the position is, if anything, more confusing than before, in spite of more extended study. It is, briefly, that significant comparative data on the practical action of certain classes of disinfectant are almost unobtainable, simply because there are no generally accepted terms in which to express them. A test yielding such information must take into account six variable factors, and unless investigators can be induced to standardize the conditions of their tests the isolated scraps of knowledge which they furnish cannot be co-ordinated.

In other spheres regulation of this sort has been an outstanding success. The control and standardization of therapeutic substances has made rapid progress, especially in this country, and if accepted methods of assay can be devised for vitamins, hormones, and drugs, they presumably can be for disinfectants. It is certainly desirable that they should be in the mere interests of truth, but if, as many believe, chemical sterilization is feasible in a variety of circumstances in which faulty methods at present fail to achieve it, then a valuable preventive weapon is capable of being brought into more effective use.

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THE PROVISION FOR MAJOR SURGICAL TREATMENT OF PULMONARY TUBERCULOSIS

BY

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Institutional treatment has played a very prominent part in the management of cases of pulmonary tuberculosis for the last forty years. Sanatoria have been regarded as places for the treatment of phthisical patients whose prospect of recovery is good, but until recent years little or no provision has been made for the advanced case or for the one requiring prolonged rest in bed and careful nursing. Stress has been laid upon the point that advanced cases must not be mixed with early ones owing to the depressing influence of the former upon the latter, and a number of local authorities have established homes for the hopeless cases. These are generally unpopular with both the patients and the staff. It is often difficult to get the former to consent to admission and more difficult to persuade them to remain, while the staff dislike working in a place devoid of hope, with the patients slowly fading away and meanwhile producing a daily crop of grumbles because they have nothing else to do but think of their ills and brood over their misfortunes.

It naturally follows that quite a large proportion of cases with extensive disease find their way into sanatoria, partly owing to the complete absence of symptoms in the early stages of particular cases, partly owing to the desire to escape the home for the dying, and partly owing to the inadequate provision for cases which are not hopeless, but require prolonged rest before any hope of recovery can be entertained. Where this has occurred it is found that the boggy of depression caused by mixing advanced and early cases does not exist. The general cheerful atmosphere of the sanatorium is not affected by the increased number of bed patients, although the problem of providing the necessary suitable accommodation becomes very serious, and a constant trial to those in authority.

The division of tuberculosis institutions into two classes—one for the reception of early cases and one for the advanced cases—is impracticable, and does not produce the best results for the money expended. A better method is to segregate the patients according to the treatment they require rather than according to the extent of their lesions; the sanatorium mainly providing routine treatment, special courses of chemotherapy, and the minor surgery of collapse therapy, while the tuberculosis hospital and a special department of the municipal hospital accommodate cases requiring major surgical treatment, observation, and prolonged rest in bed prior to a period of sanatorium treatment.

While the patient requires lengthy treatment in bed it is both unnecessary and uneconomical to send him far from home into the depth of the country, for bed cases require a large, well-trained staff, which are often not easy to obtain and keep in areas remote from towns. Also patients are much happier and more contented during the period they are confined to bed if they can be visited easily and regularly without great expense to their relatives. Observation cases, too, should be in hospitals where it is easy to obtain a full and complete examination of the patient with the assistance of the expert opinion of a radiologist, pathologist, and other specialists as occasions arise, along with the close co-operation of the tuberculosis officer or the physician primarily interested in the case.