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"WE HAVE REASON TO THINK . . ."*

BY

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I doubly appreciate the honour of being asked to give the prizes here to-day. In the first place it emphasizes the association which has lasted so long between my university and your hospital. We have recently benefited by the munificent bequest of one who was a loyal son of Cambridge and who also served this hospital well; I mean the late Mr. Marmaduke Sheild. Through that bequest we have been able, among other things, to re-establish pharmacology in its proper place, and we confidently expect that Professor Verney will continue the successful work of that department, which owed so much in the past to the late Dr. W. E. Dixon.

In the second place it emphasizes another association: that between my hospital of St. Bartholomew's and yours. That we have sent you good men the past and the present attest alike. At the present time my predecessor, Sir Humphry Rolleston, and your dean, Dr. Anthony Feiling, exemplify the association between St. George's and Cambridge on the one side and St. Bartholomew's on the other. In the past the name which has perhaps most closely linked our hospitals together is that of John Hunter, who may be said to be the first to regard medicine as a branch of experimental biology. His famous aphorism, "Don't think, try," may have been misinterpreted, but never more sardonically than by a friend of mine, who commented that out of respect to John Hunter the medical profession for more than a century had been trying not to think. And although we realize that Hunter was merely advocating experiment rather than speculation, there is a sting of truth in the comment. A hundred and fifty years ago the need for the collection of data was paramount; to-day there is at least an equal need for the data to be assimilated and co-ordinated by careful thinking.

Man's Orientation of Man

Let us think for a moment of the enormous change that has occurred since the beginning of the nineteenth century in our realization of the nature and position of man. True the astronomers had already orientated man in space, but there was no conception of his position in time. The grandfathers of all my contemporaries believed that the world was created in 4004 B.C. The record of the rocks was not correctly deciphered until early in the nineteenth century: geology proved to be the Rosetta stone for the interpretation of the age of the world. Then came biology to teach man that he was no special creation, but the outcome of a long process of evolution. In these latter days psychology has shown not only that this applies to man's structure, but that there are sub-human strata also in the dark recesses of his mind. Finally, the modern physicist is upsetting the orderly

Newtonian physics and neat Daltonian chemistry in which we seniors were brought up, until man is beginning to doubt whether there is any substance in the material universe at all. He is being told that even mathematical truth is only a tribute to the innate craving for order in his own mind. He is being thrown back on the old adage "Cogito, ergo sum." All the more reason, then, that he should try to think.

It is perhaps a too ambitious task to attempt to describe how man came to think; but it may be of interest to note how different is our approach to such a problem from the methods followed in the seventeenth century by such a man as John Locke. Natural science has given us an inevitable bias to proceed from the simple to the complex. The scientist of to-day does not start with the human understanding as Locke did, but with the genesis of the nervous system. For the time being man seems to have lost his curiosity as to the origin of life; he recognizes that this is a problem beyond him. Fifty years ago it was not so, and colloidal jellies dredged from the depths of the sea were eagerly scanned for evidence of the transition from the non-living to the living, while Charlton Bastian attempted to demonstrate spontaneous generation to the International Medical Congress in London in 1881, regardless of the horrified and repeated cries of "Mon Dieu, mon Dieu" from the lips of the great Pasteur.

But if we are willing to leave the origin of life unexplored, we are the more interested in its manifestations. Amid all the bombardment which atoms receive at the hands of physicists, until we are doubtful of the entity of any element, life remains faithful to its central carbon atom, with its apparently infinite capacity for forming chains and rings. Only with such chains and rings do we find life associated. Another striking characteristic of life, to which Sir Gowland Hopkins recently called attention, is that it alone, in a universe of which the energy is ceaselessly running down, can oppose a dam, as it were, and hold up that energy at a useful level. It cannot reverse the second law of thermodynamics, of course, but it can delay its action. On this globe, at least, we can assert that the one thing which checks the degradation of energy is life. That is one of its proud prerogatives.

Nerve Cells of First Living Organisms

That life, whatever its origin, started and still starts as a single cell is a biological axiom. The next step was when a merely colonial existence of single cells, all doing the same work, was fused into a new entity in which different cells did different work. But even single-celled organisms, or colonies of such, show a characteristic feature of life in their irritability, in the biological sense, or responsiveness to various stimuli. In the simplest forms

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of life this was of the nature of response to light and to chemical substances, a method of response which we still show. But a subtler method was soon evolved when many-celled organisms appeared. The general "responsiveness" of the outer protective coat or skin became specialized in two different types of cells. They were, indeed, the parents of sensory and of neuro-muscular cells. It became necessary for the guidance of the body that such perceptive cells should develop particularly at its front end. Here, therefore, the organs of special sense appear, by which the animal knows what it is approaching, by which, indeed, as Sherrington phrased it, the animal carries its immediate future in front of it.

Before long these special cells, which we may now call nerve cells, began to retreat to a more protected position, and to congregate into the beginnings of a central nervous system, while retaining their connexion with the exterior by means of nerve fibres. It is a little difficult to realize that the brain and spinal cord are buried embryonic skin, and that it is skin which receives, and modified skin which interprets, the messages we receive from the outside world.

Development of Central Nervous System

Although the sensory message can at once evoke a motor reply, as in a simple reflex action, it is the appearance of a new nerve cell—the connector, or association cell—between the sensory and motor units, which marks the beginning of a central nervous system, and it is the multiplication of such association cells on which the growth and increasing complexity of the nervous system mainly depends. Unfortunately for the invertebrates the arrangement of this nervous system around the mouth restricts the growth of the brain, so much that only a limited number of patterns, as it were, are possible in their responses. To a remarkable extent this limitation was surmounted by the social habits of certain insects where the whole structure is modified according to the duties they have to perform. In the invertebrates with the most developed brains the mouth is so closely encircled by the nervous system that they have, perforce, to confine their feeding to blood sucking.

The evolution of vertebrates, however achieved, freed the brain for almost unlimited development. And when some fishes struggled gasping on to the land and became amphibians further development was urgently called for, not only to face a new environment, but to restrain automatic movements, which, however appropriate to fishes balancing themselves in water, had become highly inappropriate to land animals in which fins had become limbs. And so we find, hand-in-hand, the development of increased skilled movements and of the inhibition of unsuitable movements. At this stage we meet not only with simple but also with conditioned reflexes. When Pavlov, already famous for his researches on digestion, visited England in 1906 to describe the way in which he could modify the reflexes in his dogs by training, I little realized how far-reaching the influence of those observations would be. May I say, in passing, that he was particularly happy in his selection of his animal, for no animal is so malleable at the hands of man, whether as to structure or as to conduct, as the dog. The cat will condition her own reflexes, but for the dog our prohibitions soon become his inhibitions.

I need not recapitulate Pavlov's well-known experiments, but I would like to emphasize just three points. First, the chain of association of ideas in a dog is a short one, not being capable of more than three links, whereas in ourselves, with our much greater wealth of association cells, the chain of ideas aroused by, say, a few chords of music may extend almost to infinity. Secondly, if the dog is deliberately given signals difficult for him to discriminate, all his conditioned reflexes

become upset and he becomes neurotic. Pavlov maintains that this is due to his being exposed to an excessive demand for internal inhibitions, a cause, one may say, which is responsible for human neuroses also. Thirdly, if the area of inhibitions is spread widely enough, the dog simply goes to sleep. Note the behaviour of your dog at your meal time: if he knows he will not be fed himself, and that your attention will be diverted from himself, the series of negations piles up and soon he is fast asleep, until you rise from the table and he wakes at once. When we wish to sleep we cut off as many afferent impulses as we can, and seek darkness—not to mention quiet, if haply we may find it in this generation which seeketh after noise. But nevertheless in darkness and in quiet the long chain of association cells may carry impulse after impulse, and we may woo sleep in vain.

I should like to emphasize again the great leap forward which the brain achieved when vertebrates took to the land. In the ancient part of the brain common to fishes and all other vertebrates reside the centres which order the functions of organic life, but in this part are also the centres of emotional expression, such as we deliberately deny to fishes, when, for instance, we describe a man as "fish-like." Of recent years we have learned much of the functions of these basal ganglia from the grotesque and cruel ravages of the epidemic of lethargic encephalitis. Not only did it disorganize the statics of the body, but it often played havoc with the emotions and conduct of the unfortunate victim. And so we discovered how deep down in the brain the emotions and passions resided, and how violent and unrestrained might be their manifestations when cut off from the control of the calmer, more reasoning, newer part. Disease thus confirmed and extended the experimental evidence obtained by Sherrington and by Head and Rivers.

Sensory Nerve Stimuli and Brain Activity

We have travelled far in this brief and, of necessity, superficial review of the building up of the brain. We must now hark back for a moment to the periphery, where we left the nerve fibres embedded in the skin, for they, meanwhile, have been wrapping themselves up in touch corpuscles of varying structure and complexity. Naked nerve endings can apparently only convey one kind of sensation, that of pain—for example, those on the surface of the cornea. Any nerve ending, clothed or naked, if adequately stimulated, can give rise to pain. But the end-organ allows of discrimination; it can register an impression too slight to cause pain. Thus the retina can convey the sensation of a dim light, while a blinding light may cause actual pain. A light touch or gentle heat are appreciated as such, but either can be intensified to cause pain. These sensory structures, then, are like outposts to the body, increasing its awareness and powers of discrimination and selection, but also ready to flare up into urgent messages of pain. At the other end these messages are received by the optic thalami and relayed to the sensory cortex of the brain, which has the power within limits to decide how to act. Thus the same painful message may result in the recipient launching out a violent blow against the offender; or the cortex, recognizing that the pain is due to the knife of the surgeon, cruel only to be kind, inhibits movement of the part attacked, and diverts its energy into a loud yell. Or the attention of the cortex may be diverted, so that the painful stimulus is not felt, and a man is unaware of a wound received in the excitement of battle.

Ordinary sensations, then, have a low threshold; they enter the nervous system easily, and, as Adrian has shown, travel rapidly; they are dealt with by the brain according to its needs and moods. Sensations of pain have a higher threshold, not gaining admission so easily;

nor travelling so fast ; but, once admitted, may give rise to a positive explosion of nervous activity. For further elaboration of this line of thought I may refer you to the philosophical writings of Wilfred Trotter.

Clearly the activities of the brain depend largely on the stream of impulses received from the outside world. Michael Foster recorded a case of a boy who had general cutaneous anaesthesia, who was deaf, and also blind in one eye. His sole tie with the outside world was through the remaining eye, and when this was covered he went to sleep. But the case of Helen Keller shows how adequately the brain can develop even when the avenues of sight and hearing are both closed. She, however, was nearly 2 years old when she became blind and deaf. For that the brain needs the stimulus of such impulses even to complete its structure is shown by the fact that a baby born prematurely and dying at the time it should have been born has a more developed brain than a baby stillborn at full term, and that although it had been exposed to an environment unsuited to its tender age. If structure is necessary for function the converse also holds in the case of that master tissue, the central nervous system.

Instinct and Intelligence

But the central nervous system has to deal both with internal and with external relations, to ensure both internal harmony and harmony as far as may be with the outside world. The infant comes into the world well equipped in the former respect, but very imperfectly in the latter. Its complete helplessness is in sharp contrast with that of many lower animals at birth. And that leads us to contrast instinct with intelligence. A recent writer, H. E. Mellersh, said :

"Most of us have no great affection for fishes or lizards or snakes, nor feel anything but intense dislike for that large, grim, silent phylum that comprises the crabs and lobsters, the spiders and scorpions, and all the insects. I have often come away from the insect house at the Zoo with a feeling of real nausea, and wondered what it was that disgusted, depressed, and even half-frightened me. Positively, I think, it is their slow, reasonless, undivertible intentness. But what is it negatively? What do they lack? One might say they lacked a sense of humour, and be stating a rather obvious but still somehow relevant fact. But one probably could not do better than say: they never play."

This division of the forms of life into those that can and do play and those that do not and cannot is, in fact, an important and significant one. Only mammals and birds play—the warm-blooded creatures. And it is the warm-blooded creatures whose lives are by far the least guided by instinct ; there is the significant connexion. A German, Karl Groos, was the first to stress and satisfactorily to explain this connexion. And he did it so well that although his book, *The Play of Animals*, was first published in 1897, it is still not superseded. The insect, it is pointed out by Groos, is marvellously complete with instincts ; it has practically nothing to learn. The mosquito can fly perfectly, and sting perfectly, as soon as it has changed from that eagerly wriggling larva, hanging head downwards from the surface of the water, and has squeezed out from its sheath and dried its wings. The bee can build her cells, always hexagonal, and can perform the honey-dance to inform her mates of a new store found, all without learning. But with birds and mammals it is different. The inherited memory is not there ; those incredibly specialized brain tracks do not exist. Indeed, it is only with a great effort that we can realize how much of the elementary art of keeping alive we humans have had to learn.

The advantage would seem at first sight to be with those forms of life so well equipped with particular

instincts. And yet we all know that the skill of the mammal, his power to reason and to adjust his action finely in an emergency, is an infinitely more useful possession than the most perfect set of particular (but unadaptable) instincts. The only question is, How does the mammal acquire this skill, this power of reasoned and delicate response? And the answer is, of course, play. So Karl Groos, with much detail, pointed out. He called play an instinct in itself—one generalized instinct in substitution for a great number of particular ones. He showed in strict Darwinian fashion how the possession of such a generalized instinct would have a "survival value." If you have acquired no complete set of cut-and-dried answers to the problems of life, but only a single urge to find out the answers for yourself, then you have set a premium at once upon intelligence. And since intelligence is without question Nature's most powerful weapon for progress, those who use intelligence will win the race from those who do not.

Karl Groos quotes innumerable examples to prove his point that play is for the young an instinct—that is to say, a definite urge. And what is play? It is mimicry and make-believe. It is, biologically speaking, a practice of powers that have appeared in a crude form early in life, so that when they are needed later they may already be near perfection. It is not enough for the grown animal to have the simple and unelaborated instinct to fight or to fly in an emergency ; he must have practised those responses assiduously. The necessity for mimicry, therefore, mimicry of one's elders, is obvious. But the need for make-believe is essential too. For the real situation either will not or cannot be allowed to arrive in youth. The kitten must needs be able to pretend to itself that the paper is the live mouse before it can acquire the skill to catch one ; the hare must learn to be fleet and nimble without a real carnivore after it every time. And so we begin to see how the enormous power to make-believe arrives in us human beings. It has, again, a "survival value" ; it is part of us, it is a fundamental instinct. Our theatre and our arts come (via the meetings, ceremonies, and solemn dances of primitive man) from this manifestation of the mammal's necessary urge to play.

And though that is an old story, perhaps it has not been pondered upon quite enough. Karl Groos pondered upon it further, and came to the conclusion that there was an added inducement to make-believe in the "freedom" that it gave. In real life we are too often the playthings of the opposing forces about us, but in make-believe it is ourselves who are always the masters, who make things happen. Life, in fact, is too real—and so play is earnest. All we warm-blooded animals love to feel that we are the prime movers of something, however trivial ; we love to "work our own sweet will." We all (as the psychologists say now) love to exert the power instinct.

Man loves to play and make-believe through all his life ; there we are different from the other mammals, who do not seem much driven by the play-instinct once they are grown up. It is the birds who, besides ourselves, play most when they are no longer young. And it is the birds who are excitable creatures, have a blood heat even above our own, and have another element and another dimension in which to sport. And yet man is the supreme grown-up play addict. The urge has, in fact, become most elaborated in him, the most elaborated creation. It may be caused by many desires, seemingly contradictory, but all arising from that original generalized instinct of the warm-blooded. We may play from a desire to practice and "keep fit," a desire to turn from difficult reality to pleasant make-believe, a desire to exercise power and skill, a desire for excitement, a desire to achieve "thrills." And here we may recall Keith's saying that man, of all animals, has retained the power to carry on youthful

characteristics into adult life. He may, indeed, carry them too far, as I thought when a man of 45 told me that the one thing he lived for was to lower his handicap at golf!

Elliot-Smith tells us that the development of intelligence was enormously helped for those animals who, by shortening their noses, were able to achieve binocular and therefore stereoscopic vision, thus obtaining an accurate sense of form and solidity. This led to a greatly increased prehensile and tactile capacity in the fore-limbs, and so knowledge of the outside world was increased in its turn.

Reason and the Emotions

But intelligence and accurate perception, however necessary to thought, do not themselves constitute thought. If Socrates, discoursing with Phaedro on the banks of the Ilissus, could not define thought, neither can I be expected to do so. But I like Rodin's sculptured vision of "Le Penseur." At first sight that low-browed squatting figure, brooding with chin resting on knuckle, hardly seems to typify thought, until one realizes that it represents the dawn of thought, the painful gestation of ideas in the caveman's mind. At what stage, precisely, do the twin streams of temperament arising from the internal afferent impulses and from perceptions of the outside world, ascending through chains of association cells enriched by experience, attain in the highest levels of the brain to the dignity of abstract thought?

You will, I hope, forgive me if I attempt a biological rather than a metaphysical approach to a problem I am not prepared to solve. For I do believe that this method has in comparatively few years carried us further towards a comprehension of the workings of man's mind than centuries of metaphysics have achieved. As Robert Bridges said: "Man's Reason is in such deep insolvency to sense" that

"Not without alliance of the animal senses
Hath she any miracle."

It may be fairly said that one of the most recent achievements of man's reason is his recognition of how unreasonable a being he is. To quote the same poet:

"How small a part of Universal Mind can conscient Reason
claim!
'Tis to the unconscious mind as the habitable crust is
to the mass of the earth."

But this narrow crust of reason has a great, and as Rodin saw, a painful task. It has to co-ordinate here and repress there these streams of afferent impulses which, pouring through the basal ganglia, have gained in turbulence and in turbidity by stirring emotional depths inherited from long dead ancestors as well as those acquired in earlier life. It is no light task to provide for the precipitation of the mud, the clarification of the streams, and, to pursue the simile, usefully to employ them to irrigate the higher centres for the fertilization of thought. Perhaps, as Adler says, nothing is quite so conscious and nothing quite so unconscious as we imagine. Indeed, the frontier is an indefinite and changing one. But reason properly used will agree to recognize the place that the emotions should be accorded in life.

Association of Ideas Without Reason

It is perhaps due to mental attitudes in the past which tended to exaggerate the role of reason that there has been an undoubted and undue depreciation of reason in these latter days. For whole nations politics have become total abandonment of the right of judgement into the hands of a dictator, while a religious movement of the day relegates the individual conscience to the guidance of a group. I do not intend to discuss either politics or religion. I merely wish to illustrate how widespread is the individual's lack of confidence to-day in his own

power of reason. But perhaps the process can be best observed in certain literary movements, which, starting with an angry reaction against the intellect, such as D. H. Lawrence, for instance, displayed, has gradually deteriorated into what appears to me to be mere baby talk. Whatever this may mean to the writer himself—or herself, I must add, since Gertrude Stein is one of the most notorious exponents of the "cocky-locky, henny-penny" style of writing, which was formerly reserved for the delectation of the nursery—it can, from the nature of the case, communicate very little to anyone who does not possess the key. That inspiration wells up from the unconscious, or at least the subconscious, would be generally admitted, but just as the highest level of the brain selects the sensory impressions to which it will pay attention, so reason must arrange and select the messages from the emotional levels.

To-day only too often a writer fishes up from the unconscious what appears to him to be a pearl worthy to be treasured, but which seems to the onlooker nothing but a worthless pebble. Why are other people's dreams so utterly boring to everyone except a psycho-analyst? Because the narrator cannot reproduce the emotional affect which accompanied the dream. The artist, by judicious and intellectual arrangement of the material derived from this inspiration, may be able to convey the thrill, but the writers against whom I am protesting persist in hurling the crude material at one in raw slabs. Another barrier to comprehension they raise is this. On the way up from the deeper layers an impulse may run through a series of association cells, stimulating memories which are entirely individual to the person who experiences them. If he flings those associated ideas at us without a clue he is really speaking in a foreign language. Although this method is used even in prose, it is, of course, more frequently employed in what is called modern poetry. Mr. T. S. Eliot, for instance, who is bleakly austere in prose, says that in poetry meaning only plays the part of the lump of meat in the turned-up end of the dog stealer's trousers. Meaning is only required to focus the reader's attention until the poem has him in thrall. Well that may be so, but I still hanker after that bit of meat when I read an alleged poem like this:

"If it was to be a prize a surprise
if it was to be a surprise to realise,
if it was to be if it were to be, was it to be.
What was it to be. It was to be what it was.
And it was. So it was. As it was. As it is.
As it as it is. It is and as it is and as it is.
And so and so as it was.
Keep it in sight alright."

"Milton, thou shouldst be living at this hour. England hath need of thee." One can parallel this passage from Gertrude Stein's prose.

It is interesting to recall, by the way, that a tendency to link words together by sound rather than by meaning is a reversion to an infantile mode. The repetition of such sounds is attributed to the control over the speech not being as yet completely developed. It is shown in the first words the child speaks, "Mamma, Papa, Nana," and this kind of repetition is to be noted in the stories which delight very young children. It is therefore not without significance that one of the new artistic movements christened itself "Dada."

Well, the more youthful members of my audience may say, How can you expect to appreciate the new beauties that are being revealed by these modern writers? You are so hardened by established conventions and outworn modes that naturally you are deaf to this new music. Very well; then let me ask you to listen to the views of Mr. John Sparrow, an eminent but youthful critic. His recent book, *Sense and Poetry*, from which the

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.