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THE RELATION OF THE LABORATORY TO
MEDICINE¹

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IN addressing so representative a body as this association I can not but feel that I am engaged almost in a work of supererogation when I presume to speak upon a topic so familiar to you all. Despite this feeling on my part, I am led to believe that upon occasion an oft-told tale, if palatably redressed, may prove appetizing enough: I will venture an experiment.

A careful perusal of the pages of the history of medicine plainly demonstrates the long and tortuous path pursued from the ages of earliest record down to relatively recent times. We can see how at one time the noble art was held in the clutches of superstition, its acts governed by a deep-rooted primal belief in demonology; at another time religious doctrines dominated and intimidated progress; and at other periods metaphysical discussions held back advance and even wrecked discoveries. The history of this struggle onwards towards the light of knowledge, marked as it has been by errors and lapses, is fascinatingly punctuated by epoch-making contributions here and there along the line by an occasional genius or hard-headed thinker. It is not to be doubted, however, that had it not been for the wonderful development of the sciences, the modern status of medicine would have been held back for an indefinite period. Our debt to the pioneers in chemistry, physics and biology, and to their successors down to the present moment, is enormous, and we must

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realize that instead of holding aloof from, medicine actually shares in or belongs to all of the sciences.

The development of the laboratory and its final establishment as an aid in the furtherance of medical teaching and study has been so ably presented by such an eminent authority as Professor William H. Welch in his address on the "Evolution of Modern Scientific Laboratories," that I will not attempt the foolish task of "gilding gold"; but I need only emphasize how the invaluable researches of such as Harvey, Magendie, Hunter, Bichat, Laennec, Claude Bernard, Virchow, Pasteur and Koch paved the way for the founding of institutions where ideas might be tested, problems solved and enquiring minds trained.

What a powerful stimulus, emanating from such places, has medicine received in these latter days! In fact, the laboratory constitutes the very foundation upon which medicine of to-day rests; it is the very powerful lever resting upon the fulcrum of ascertained facts that has elevated medicine from the dust of empiricism to the cloud-level of science, along which runs a road, perhaps none the less rough and long, to a goal of ultimate success.

At this point I may seem to some of you to be carried away with the greatness of the importance of the science of the laboratory at the expense of the practise of medicine. I am not. I am conscious of the great importance of both sides of medical advance and teaching. I think that we scarcely yet realize the extent of the tremendous revolution in medical thought and practise the laboratory has introduced; we are yet involved in the process, and although some of us feel that in the training of students far too much time is expended in laboratory work, profitless it may in part appear, and too little time spent in preparation for practise, I do not

doubt but that proper adjustment will come about when the evolution in progress becomes clearer to us.

Turning now to a more critical analysis of the relation of the laboratory to medicine, I will attempt to put before you in concrete fashion what I believe to be its chief functions.

In the first instance, the laboratory occupies the very fundamental position of being the place, *par excellence*, of the inductive method of impartation of knowledge; in the second, it is or ought to be the place of sound mental training and of cultivation of powers of observation; in the third, it represents applied science, and in the fourth instance it is the place of research and experiment.

Taking these up seriatim: I. Gone forever are the days of medical instruction wherein the didactic lecture played the entire rôle as the imparters of knowledge in the medical school! The lecture, will, of course, continue to hold a place in the curriculum of studies, but not so lofty or important a one as in pre-laboratory days—it has now almost assumed the humble duties of handmaid to the laboratory course, particularly in these instances where the textbook in use in a class has developed out of the yearly lectures of the head of the department.

As a place of instruction the work of the laboratory in a department requires delicate adjustment to the medical courses. I do not now propose to enter into a discussion of the relative numbers of hours to be assigned to lectures and laboratory work, nor of the time to be given to one subject of instruction relative to that of other subjects in the curriculum; at the present juncture they are irrelevant though interesting questions. Taking into consideration as granted that a laboratory is well manned and equipped, the courses should

be planned to conform to the best usage of university standards of instruction. An ample range of instruction should be afforded both in routine work, advanced work and research—all under the immediate supervision of either the head of the department or of one or other competent assistant.

In the medical courses, to properly assign and regulate the advanced work and research is sometimes a matter of no small difficulty. The number of properly qualified students, their mental caliber, their fitness for certain lines of work, the time at their disposal, are some of the many points that have to be taken into consideration in establishing and carrying on such courses. Of the two, that of advanced work is the more easily susceptible of solution. Courses may be designed throughout the year wherein work may be assigned, for a few hours a week, say five, and the nature of the topic may be so planned as to throw the student in part upon his own resources and thus encourage in him a necessary initiative. In this work the instructor can also train the student in the best ways to gain access to the literature of the subject in hand, and even demand of him a short thesis. By a properly balanced plan for advanced work we can foster a spirit for research, and perhaps gain a recruit for a task of serious investigation.

Within the limits of our ordinarily organized four-year course in medicine it seems to me to be an almost hopeless task to carry through successfully a piece of work worthy the name of research, even with our most promising students. The curriculum is so crowded and the routine so oppressive that they impose both a mental and a physical strain upon the individual, no matter how full of enthusiasm he be, that attempting research under such

conditions seems unjustifiable and indefensible.

True, research among our students should be encouraged, but let it be inaugurated at the termination of the periods of either the scientific or clinical courses, when the burden of routine may be abolished or mitigated for nine months or a year or two. If such a plan were carried out, a better choice could be made of candidates upon the basis of fitness, and would lead to the performance of investigation of a sound and creditable character, not masquerading under the name "research." By the encouragement of properly conducted research we may also be able to develop men and conserve their services at a later date for scientific pursuit and teaching instead of losing them in the alluring field of active practise. For I would have you remember that the future will make even greater demands upon us than has the past for suitable assistants and worthier successors in the fundamental branches of our profession.

II. For affording a sound mental training and for cultivating the powers of observation among a body of students, it goes without saying that the laboratory must be officered by capable persons, who, in addition to being well versed in their subject, ought to be selected also for their ability to impart knowledge. Examples can be recalled by most of us when as students we sat under men noted for their erudition but displaying an alarming innocence of even moderate pedagogical ability, which to some may have proved a stumbling-block to progress and implanted in us perhaps a veritable dislike for our studies. Or classes may be handled by instructors who are "unfaithful servants," regarding the students collectively as an intolerable burden, feeling that their duty is done if

they dispense knowledge after the manner of the "quick-lunch" counter.

On the contrary, no better reward can come to the conscientious instructor than in the very apparent, although verbally unexpressed, appreciativeness on the part of the class of his efforts to give the best that is in him. This success may be attained by giving the greatest amount of personal attention to the class as individuals, combined with general criticism, demonstration and sharp questioning concerning the occurrence of phenomena in the course of close objective study. It is quite remarkable how frequently a class of seeming mediocrity may be spurred on to good and reasonable endeavor by carefully applied methods for stimulating mental processes and awakening latent powers of observation. This leads usually to a development of a healthy independence of mind which is far removed from that mental type that is content with a senseless cramming-up of oftentimes dissociated bookish statements of facts.

Of the utmost importance is the attainment of that open manifestation in the student body of the fruits of a careful laboratory training upon entrance on the clinical period of study. For then it is that the ready aid of an alert and reasoning mind and a keen power of observation is so necessary to the student, if he is to successfully solve the thousand and one enigmas to be met daily in the dispensary classes and ward rounds. The effects of a training such as has been described are destined to last him throughout his career either as an investigator or a practising physician.

There may be some present who will be inclined to disagree with me on this statement; who already feel that our students are so crammed full of "science" that the laboratory training unfits them for acquiring a due appreciation of clinical view-

points and methods. In fact, I have heard it time and again expressed, "We don't want to turn out scientists, but practitioners of medicine!" Then, in Heaven's name, O clinicians, go to, turn our youthful so-called scientists into practitioners! The matter of so doing lies in your hands, not ours! To fail is to proclaim your own inefficiency as teachers. For I can assure you, out of an experience of some length of service, that the bulk of student material is to-day not worse than formerly, but better; more alert, more discriminating and more enquiring. He who would be their teacher must himself arise with the lark!

Another point redounding to the credit of careful laboratory instruction ought to be mentioned here. By the very processes used to develop mentally robust students, those to whom nature with niggard bounty has allotted the amount or quality of nervous gray-matter are with sureness eliminated from the race.

I maintain then that the laboratory justifies most thoroughly the high place it now occupies in the teaching of medicine, not merely from the fact that it is one of the great dispensators of knowledge, but largely because, if wisely conducted, it is the strongest of developmental forces in the successful making of future disciples of *Æsculapius*.

III. It is almost needless for me to lay emphasis on the importance of the laboratory as the place of applied science—I need only mention the daily use in hospital service of the microscope, polariscope, the X-ray, radium emanations, the many clinical, bacteriological and biological tests, and at times even the procedure of the physiologist, to prove the value of the laboratory as an indispensable adjunct to the practise of clinical medicine.

This appreciation of practical science is again shown in the establishment by city,

provincial and state authorities of laboratories more or less well-equipped for aiding the busy practitioner in his problems of service to his patients. Private laboratories for the same purpose exist in many places, where for reasonable remuneration all sorts of tests and examinations are carried out. In not a few instances men with large practises employ in their offices of consultation skillful persons, usually recent graduates, who render prompt and efficient service in clinical diagnosis.

IV. As a place of experiment and research, I feel that in the highest degree the laboratory more than justifies its existence. It constitutes the great testing-shop of ideas and theories, either generated within its walls as the result perhaps of previous experiment, or of those coming to it from beyond, the results of which may at once be made available for application in the clinical field.

As previously pointed out, medicine is no longer confined within narrow bounds, but constitutes a field of activity so wide as to demand the assistance of the other sciences to help solve its problems. And realizing full well that in this day and generation of progress in knowledge no one man is capable of becoming an expert in all of the sciences, we are in consequence witnessing medical research develop in complex form; where laboratories are established for research in physiology, pathology, chemistry, sanitary science and the like—attached to or entirely apart from the organization of medical school or university.

And so profoundly has the development of the laboratory in late years affected the course of medicine abroad, particularly in Germany, that that "holy of holies" of the clinicians, the hospital ward, is regarded as a laboratory of research, as it essentially is and properly should be. There the professor of medicine and his chief assistants

are both excellent clinicians and excellent laboratory workers; their duties to the hospital markedly limit or abolish private practise and leave ample time for carrying out instruction and research. In the United States the same development has begun; witness the establishment of the hospital in connection with the Rockefeller Institute for Medical Research, where diseases of all sorts may be intensively studied by combined clinical and scientific methods, the right of remunerative practise being denied the staff. At the present moment, too, the authorities of the Johns Hopkins University, appreciating the great value of this movement in modern medicine, are formulating plans whereby the heads of all the clinical branches be denied the right of private practise and be required to confine their whole attention to the development of ward material for purposes of instruction and research.

Reading then the signs of the times correctly, it appears that medicine has now entered upon a new and profitable era; upon a period of development wherein the scientific or laboratory idea is effecting a cleavage in the clinical field both in its methods and in its personnel. Revolutionary as it may now seem, the clinical branches in our teaching institutions in the future will probably be most largely filled by those who are at the same time competent clinicians and carefully trained workers in one or other line of scientific research, devoting most of their time to instruction and investigation and less or none to the distractions of private practise.

At this juncture I do not wish to be adjudged as one who is engaged in belittling the efforts of the clinical professor, past or present; that would be wickedly unjust, but I do believe that the time has come when not to acknowledge this evolutionary trend in clinical medicine is to

deny rational progress towards the solution of the innumerable and weighty problems confronting us.

Let me say in conclusion that it is my firm belief that in the untrammelled concentrated study of the phenomena of disease, with the ward as the laboratory, will medicine become truly scientific (in the best sense of that word), therefore truly rational, with hopes of conquest its best endeavor and success its ultimate goal. The change will evolve a man better taught, better trained and possibly possessed of better judgment. The numbers of those who practise or pursue the "art" of medicine will yet increase and reap larger and more abundant rewards in satisfaction of work well done than has hitherto been dreamed of. For the new era will demand the survival of the fittest to survive, and the practise of the profession of medicine will in even greater degree be counted the most honorable of all professions.

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THEORIES OF SOLUTIONS¹

TWENTY-ONE years ago the Chemistry Section of the British Association at its meeting in Leeds was the scene of a great discussion on the nature of solutions. It was my first experience of a British Association meeting, and I well remember the stimulating effect of the lively discussion on all who took part in it. To-day, speaking from the honorable position of president of the section, I conceive I can do no better than indicate the position of the question at the present time. And this appears to me the more appropriate as our science has had this year to mourn the departure of van't Hoff, the founder of the

modern theory of solution, whose name will remain one of the greatest in theoretical chemistry—in time to come, it will, I think, be considered almost the greatest. He had expressed the hope that he might attend this meeting as he did that twenty-one years ago. The hope is not fulfilled: his activity is merged in the final equilibrium of death. But his ideas are part and parcel of the chemical equipment of every one of us, and we know that whatever form the fundamental conceptions of chemistry may assume, the quantitative idea of osmotic pressure will be to the theory of solution what the quantitative idea of the atom is to chemical composition and properties. For I must emphasize the fact that chemistry is essentially a quantitative science, and no chemical theory, no partial chemical theory even, can be successful unless its character is quantitative. To quote the words of Lord Kelvin:

I often say that when you can measure what you are speaking about, and express it in numbers, you know something about it; but when you can not measure it, when you can not express it in numbers, your knowledge is of a meager and unsatisfactory kind; it may be the beginning of knowledge, but you have scarcely in your thoughts advanced to the stage of science.

A general theory of solutions must be applicable to all solutions—to those in which solvent and solute exist in practically mere intermixture, as well to those in which solute and solvent are bound together in what we can not sharply distinguish from ordinary chemical union. Between these extremes all grades of binding between solvent and solute exist, and it may be well to give a few examples illustrating the various types of solution.

Where no affinity exists between solvent and solute, the solution is practically of the same type as a mixture of two gases which are without chemical action on each other. The solute is merely diluted by the solvent

¹ Address of the president of the Chemical Section of the British Association for the Advancement of Science. Portsmouth, 1911.