SCIENCE

A WEEKLY JOURNAL DEVOTED TO THE ADVANCEMENT OF SCIENCE, PUBLISHING THE OFFICIAL NOTICES AND PROCEEDINGS OF THE AMERICAN ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE

FRIDAY, APRIL 17, 1908

CONTENTS

MSS. intended for publication and books, etc., intended for review should be sent to the Editor of SCIENCE, Garrison-on-Hudson, N. Y.

MEDICAL LABORATORIES: THEIR RELATIONS TO MEDICAL PRACTISE AND TO MEDICAL DISCOVERY[1]

To be asked to give an address on an occasion so worthy of joyful and honorable celebration as that which has brought us together to-day is an honor of which I am far from being insensible. When the invitation to the formal opening of your new building came in letters from my former schoolmate, Dr. Third, and the dean of your medical faculty, Dr. Connell, I was much pleased; though I knew that it came to me mainly on account of the fact that I happen to occupy a chair in an institution especially identified with medical laboratories, medical instruction and medical research, I could not help but feel grateful to fortuity for the favor she brought. Born in Canada, educated in Canadian schools, a graduate of a medical college in this province and at one time licensed to practise among the people of Ontario, I have every reason for filial affection to this great country and rejoice in my right to share your pride in its phenomenal advance. And no advance seems to me greater than that which you have been making in the betterment of medical education and in the promotion of medical knowledge; one striking evidence of it is before us in the new building which you have just now met to dedicate.

The subject which I have chosen for my remarks, namely, "Medical Laboratories:

[1] An address delivered at the formal opening of the Medical Laboratories Building, Queen's University, Kingston, Canada, January 14, 1908.

their Relations to Medical Practise and to Medical Discovery,'' is of such great importance that I wish I felt myself more competent adequately to discuss it. The topic has the advantage, however, that no skill on my part is necessary to excite your interest in it, for the current of your thought is, by the occasion, set in its direction. The completion of this building indicates the lively sympathy of members of your university with laboratory medicine; the substantial aid which an enlightened legislature has given you is proof that there is already some appreciation of the fact that the benefit of such laboratories is not to individuals alone, but also to the people at large and that the appropriation of public funds for their construction and maintenance is justifiable. Without occupying a great deal of your time or dissipating too much of your energy I shall try to make plain to the less medical portion of this audience how it is that medical laboratories such as have been built here have become a necessity, how indispensable they are for the training of doctors who are to care for the sick, of what use they may be in helping physicians actually to utilize, in cases of serious illness, the fruits of the more recent medical discoveries, and finally how, if provision be made in them, as should be and doubtless will be, for the undertaking of original investigations directed toward the solution of some of the medical problems now pressing, we may hope that here in Kingston new knowledge may be acquired which will make medical men able, better than now, accurately to predict, and give them greater power than they yet possess to cure and to control. And while I congratulate you heartily on the position to which you have now attained in the matter of laboratories, I intend to point out (what those among you best informed as to medical progress fully realize) that the policy of laboratory expansion upon which you have entered is in reality but a beginning and will lead irresistibly later on to still further, and perhaps fully as important, developments in your medical school.

THE DEVELOPMENT OF SCIENTIFIC MEDICINE AND OF MEDICAL LABORATORIES

Every one knows nowadays what is meant by the scientific method. It consists in gathering facts carefully, arranging them according to their similarities and sequences and finally epitomizing them in the form of brief formulas or so-called general laws. As a result thought is economized and suitable action follows most surely and quickly upon impressions of sense.

Medical science, like all natural science, began with simple observation. The physician first by means of his unaided sense organs collected sense impressions. This simple observation could not, however, take him very far, for it was too inexact. It became necessary to invent artificial aids for extending the powers of the sense organs and for rendering their measurements more precise. Medical men learned how to experiment so that their observations could be made under peculiarly favorable circumstances. They have found out how to interrogate nature and to compel her to answer; on inquiry they see to it that their attention is specially prepared; their interest in observation is sharpened by the particular question asked.

Hippocrates, the most accurate of ancient medical observers, realized the importance of contact with natural objects; it was his opinion that this must be the basis of all medical knowledge. ''The student must rub and grind at nature, using his reason at the same time; but his reason must be a perceptive and interpretative, not a productive, faculty, for he who lends himself to plausible ratiocination will find himself

ere long in a blind alley; and those who have pursued this course have done no enduring service to medicine." It was the accessibility of external medicine or surgery to direct observation that accounts for the more solid foundation early laid in that branch of medicine; inner medicine, in which there was but relatively little opportunity for direct observation, was the field for rank speculation for centuries, and it was not until experimental researches began to be undertaken systematically that inner, as contrasted with outer, medicine began to make significant progress.[2]

The history of the development of experimental work is very closely connected with the history of scientific laboratories. The bibliography of this subject is surprisingly small; an unusual opportunity for an interesting and instructive historical contribution lies open to him who will trace carefully the origins of laboratory work and their relation to the development of natural science in general.[3] In the third century before Christ several natural sciences, including anatomy, physiology and pathology, were cultivated in state-supported institutes in Alexandria. Though the apparatus was probably crude, there is evidence that students in these institutes studied nature by coming into direct personal contact with the objects of study. With the decline of the Alexandrian school, however, this method of practical study fell into desuetude, and, except for the experimental physiological methods of Galen (second century A.D.), and perhaps a little anatomical work at Salernum (thirteenth century), it was chiefly the surgeons —men like Hugh of Lucca, Theodoric of Cervia, Guy of Chauliac—who, keeping their hands at work, managed to cultivate medical studies more or less objectively. Benivieni (1448–1502), the founder of the craft of pathological anatomy and forerunner of Morgagni, seems to have been "the first to make the custom, and to declare the need of necropsy to reveal what he called . . . the hidden causes of diseases." In the fifteenth and sixteenth centuries came the great development of human anatomy. Vesalius published his wonderful volume in 1543, and anatomy has ever since his time been studied by dissection of the human body. Anatomical laboratories for teaching and investigation have been in existence for more than three hundred years; indeed, the anatomical laboratory has priority in foundation over all other scientific laboratories.

It was not, however, until the nineteenth century that the scientific spirit and scientific work became the main characteristic of the age. The nineteenth century has been designated therefore the scientific century, just as the eighteenth was called the philosophical century, the sixteenth the century of the Reformation and the fifteenth the century of the Renaissance.[4] The great inventions before the nineteenth century were made without special scientific knowledge and were brought about "more by accident or by the practical requirements of the age than by the power of an unusual insight acquired by study." During the last fifty years the great discoveries have been made in scientific laboratories. Whereas, formerly, necessity was the mother of invention, latterly the tables

[2] Cf. Allbutt, T. C., "The Historical Relations of Medicine and Surgery." Reports of the Congress of Arts and Science, Universal Exposition, St. Louis, 1904, Vol. VI.; Boston and New York, 1906, 189–209.

[3] An excellent résumé of the subject as far as medical laboratories are concerned is to be found in an address by Professor W. H. Welch entitled "The Evolution of Modern Scientific Laboratories," delivered at the opening of the William Pepper Laboratory of Clinical Medicine. *Johns Hopkins Hosp. Bull.*, Baltimore, 1896, VII., 19–24.

[4] Cf. Merz, J. T., "A History of European Thought in the Nineteenth Century," Edinburgh and London, 1904, p. 89.

have been turned and scientific discoveries have produced new practical needs and created new spheres of labor, industry and commerce.

Though physical researches were carried on from the time of Galileo downward and chemical work goes back to the age of the alchemists who sought for the philosopher's stone, the first distinctly modern scientific laboratories appeared in Europe in 1824 and 1825. In the former year Purkinje established a physiological laboratory in Breslau, and the year after Liebig, in Giessen, opened a chemical laboratory for the use of students and investigators; the latter laboratory, stimulated from two independent centers—Berzelius's laboratory in Sweden and Gay-Lussac's in Paris—developing in the atmosphere of the German ideal of *Wissenschaft,* was destined to exert the greatest influence upon the development and organization of other laboratories for scientific work. In 1856 Virchow established the first pathological laboratory in Berlin. Dorpat was the home of the earliest independent pharmacological laboratory, established there by Buchheim in 1849. Physiological chemistry was housed in a laboratory of its own in Strassburg in 1872 (Hoppe-Seyler), and hygiene at the instance of Pettenkoffer was given a special institute by the Bavarian government in 1872. The first clinical laboratory proper was started in the Munich Hospital by von Ziemmsen about 1886. Still later came special laboratories for psychopathic studies. Now every university in Germany has a complete set of these laboratories and there are in that country, all told, more than two hundred such medical institutes.

From Germany the exact spirit of research by means of organized laboratories spread rapidly to other countries—to England, Scotland and America, but Germany has the credit of the first and most extensive laboratory development; it is to this development that she owes her leadership in medicine and the biological sciences during the last eighty years.

Liebig's chemical laboratory was opened in a small town, not in a great city, and in this there were certain advantages. In an autobiographical memoir Liebig has said: "I always remember with pleasure the twenty-eight years which I passed at Giessen; it was, as it were, a higher providence which led me to the small university. At a large university, or in a larger town, my powers would have been broken up and frittered away, and the attainment of the aim which I had in view would have been much more difficult, if not impossible; but at Giessen all were concentrated in the work, and this was a passionate enjoyment." "A kindly fate had brought together in Giessen the most talented youths from all countries of Europe. . . . Every one was obliged to find his own way for himself. . . . We worked from dawn to the fall of night: there were no recreations and pleasures at Giessen. The only complaints were those of the attendant, who in the evenings, when he had to clean, could not get the workers to leave the laboratory.[5]

The peculiar advance made by Liebig's laboratory was the introduction of systematic and methodical training on an especially devised plan by which young men were introduced to a thorough practical knowledge of chemical properties and manipulations. The laboratory became the training school for the majority of chemists outside of Paris, and was used as a model for similar establishments in other cities in Germany as well as in other countries. This laboratory convinced the world of what could be done in an institution containing suitable workrooms and adequate equipment in apparatus, with proper materials for study, including ready access

[5] Cf. *Deutsche Rundschau,* Vol. LXVI., 30–39. Cited by Merz.

to books and scientific journals, especially when a director, who can give his whole time to teaching and research and is filled with the enthusiasm of his subject, leads the way. Later on, in Berlin, Johannes Müller did for physiology what Liebig had done for chemistry, and many of the physiological chairs in European universities were filled subsequently by men who had worked under Müller.

It goes without saying that laboratory buildings alone, even when adequately equipped and with a liberal maintenance budget, are far less important than the men who work in them. Nevertheless, experience teaches that in cities and countries where the laboratory facilities are most ample there, on the whole, more and better men apply for training, and a greater number of important discoveries are made.

An obstacle in the way of laboratory expansion has been the great cost of such institutions. While the buildings themselves are not necessarily very expensive, still the outfit needed often entails a large outlay, and unless the director and his assistants are paid sufficient salaries to permit them to devote all or almost all their time and energies to the work but little progress is likely to be made. Moreover, the expense of supplies for the experimental work in such laboratories is great and a liberal annual budget is therefore an essential. The scientific workers, too, should be provided with a certain number of paid mechanical helpers, for where the best brains in the laboratory are hampered by the necessity of doing the work which could just as well be done by laboratory servants a serious economic mistake is made.

The endowment necessary for modern laboratories has been one of the main factors in leading to the disappearance of proprietary medical schools, since a medical school conducted by modern methods can no longer be run for profit. Indeed, large sums of money are absolutely necessary for the conduct of modern medical education, and unless these endowments are available through private benefaction, they should be provided by the state. It may be asserted safely that at the present time money can not be invested to better purpose than in judicious support of medical laboratory work. A survey of the results of such work shows a greater return in practical benefits to mankind than can be claimed perhaps by any other mode of utilizing the money. The medical discoveries of the last twenty-five years demonstrate conclusively that the endowment of medical science yields an enormous reward, and nothing seems more likely than the probability that those medical schools and those countries which fall behind in the maintenance of medical laboratories and of scientific workers in medicine are destined to occupy an inferior place in medical education and to remain behind in social and economic importance.

MEDICAL LABORATORIES AS A TRAINING PLACE FOR PHYSICIANS

A large part of the education which medical students receive nowadays is given to them in laboratories. Instead of the didactic lecture of former periods the student in a medical school of our time does practical work in nearly all the subjects of the medical course. In the anatomical laboratory he dissects the human body and examines its constituent organs, tissues and cells under the microscope, making many of the preparations for himself. In the physiological laboratory he studies the functions of the animal body less from books and from lectures than from actual observation, as he repeats the experiments of the great masters who have made fundamental physiological discoveries. In the pathological laboratory he assists in the

making of post-mortem examinations, studies the changes in form, consistence and color of organs in disease, and under the microscope investigates the finer changes in the cells and intercellular substances in pathological states. In the better laboratories of this sort, too, he has the opportunity of witnessing the phenomena of life as manifested under abnormal conditions, and though pathological physiology as such has not yet reached the place in our medical schools which it seems destined to occupy, it is rapidly being developed and promises to become in the near future one of the most important features of undergraduate medical instruction. In the bacteriological laboratory the student not only hears of bacteria and of their relations to fermentation and to disease, but he handles these bacteria himself, studies them, alive and dead, under an oil immersion lens, grows them artificially upon media prepared by himself, produces certain of the infectious diseases experimentally by inoculation of animals, and recovers from the bodies of the diseased the same microorganisms which he has inoculated. He is given, too, a practical acquaintance with the simpler methods of studying the phenomena of immunity, and gains in this way a unique conception of the nature of infection and the tendency of self-limitation of the infectious diseases; he becomes familiar with the fundamental principles of contagion on the one hand and of prevention on the other. These studies, together with those which he makes in the laboratory of hygiene, prepare him, in a way unequaled by any other form of preparation, for meeting those problems of personal hygiene and public safety which confront the medical man in private practise and in the protection of the public health. In the laboratory of physiological chemistry the medical student perfects his methods of chemical manipulation and examines for himself the various chemical constituents of the human body and its secretions and excretions. One needs no special prophetic instinct to recognize how important a training of this kind is for the prospective physician who will wish to keep abreast of medical advance during the next two decades, for there seems to be but little doubt in the minds of those best informed that the laboratories of physiology and physiological chemistry are to stand in much the same important relation to medicine during the next twenty years as that occupied by the laboratories of pathology and bacteriology since 1880. Furthermore, practical pharmacological studies are now essential for the medical student. The undergraduate who in the pharmacological laboratory studies the physiological effects of drugs by actual observation of the effects produced after administration to animals, making accurate measurements by the precise methods of physics and chemistry, will acquire an insight into the possibilities and limitations of treatment by drugs which will protect him from a pessimistic nihilism on the one hand, and, even more important, from uncritical enthusiasm on the other. The student thus trained will be less likely to fall a prey to the proprietary medicine manufacturer and the nostrum monger than the physician who has obtained all his knowledge concerning the action of drugs from books, lectures or the circulars of manufacturers.

In the clinical laboratories associated with the wards of the hospital the student will be taught how to apply the knowledge gained in all the laboratories just mentioned to the problems of diagnosis and treatment as he actually meets them in his study of patients in the hospital wards and dispensaries. These hospital clinical laboratories have only just begun their development, and there are but few medical schools which have made adequate provision for

them. I have in another place[6] called attention to the great importance of these laboratories for the training of medical students as well as for the advance of practical medicine, and have tried to show that it is just as necessary for physicians and surgeons to have their own special laboratories attached to their wards, in which chemical, physical, bacteriological and psychic investigations can be made as it is for aniline dye manufacturers to have chemical laboratories attached to their plants for solving their special problems, or for brewers to have bacteriological laboratories and skilled bacteriologists constantly at work to maintain and improve the standard of their products. It will not do for the sciences of diagnosis and therapy to rely upon the laboratories of chemistry, physiology and pathology in the medical school to solve their particular problems for them. The more fundamental sciences have their own problems of a more abstract nature which it is their duty to investigate, and the time has certainly come for diagnosis and therapy to develop the laboratory sides of these sciences for themselves.

By far the greatest advantage of instruction of the medical student by the laboratory method is, however, his training in the scientific habit of thought. What helps him is less the facts which he learns, or the memory of the experiments he makes, than the establishment in him of the conception that in order really to understand it is necessary to come into direct personal contact with the object to be understood. If some of his teachers are, and certainly some of them should be, productive investigators, he is likely to be impressed with the necessity of accuracy in work, of patience in it, if things are to be accomplished, of steady industry and persevering effort. He learns also to have a love for detail and a desire for complete and exhaustive knowledge; he comes to appreciate skill in invention and in the application of new and precise methods, and there grows in him a desire for full appreciation of the value of all existing methods or principles which will prevent him from falling a prey to sectionalism in medicine or to any single idea or principle which is limited in its nature. In other words, he develops in those three directions of thought which characterize three more or less distinct and important attitudes of the human mind; namely, the exact habit or attitude of thought, the historical and the critical.

[6] Barker, L. F., "The Organization of the Laboratories in the Medical Clinic of the Johns Hopkins Hospital," *Johns Hopkins Hosp. Bull.*, June–July, 1907.

THE UTILIZATION OF LABORATORIES BY PRACTITIONERS AND HEALTH OFFICERS FOR THE DIAGNOSIS, CURE AND PREVENTION OF DISEASE

I have referred incidentally to the use of hospital laboratories by hospital physicians and surgeons as direct aids in the diagnosis and treatment of their cases. The chemical, physical, microscopical and bacteriological studies now made in hospital wards form a large part of the occupation of resident and attending physicians in those institutions; indeed, the examinations of the blood, of the urine, of the stomach juice, of the sputum, of the fæces, of the cerebro-spinal fluid, of the contents of abscesses and cysts, of portions of tissue removed at operation and X-ray and electrical examinations have become so potent a factor in medical diagnosis that many have begun to fear that physicians and medical students in their enthusiasm for the clean-cut results which they yield may come too much to neglect the older fundamental methods of inspection, palpation, percussion, auscultation and mensuration. And it is certainly wise that a note of warning should in this connection be

sounded, for it would be a grave error to deprive ourselves of what is good in the old because of the helpfulness of the new. That such a fear should be expressed, however, shows how tremendous a hold laboratory methods are taking of the minds of developing clinicians.

Aside, however, from the laboratories connected with hospital wards there has been in recent years a phenomenal growth of private and public laboratories in our towns and cities for the use of private practitioners of medicine and officers of public health. I am sure that the laity scarcely realizes how much such laboratories promote the early diagnosis and facilitate the treatment of disease, and especially to how great an extent through them infectious and contagious diseases in the community are prevented and controlled. Time will not permit me to enter upon an enumeration of these particular benefits. I desire, however, to express my gratification at learning that at least some portion of these new laboratories which you have built in Kingston is to be devoted to the service of the public health, and I predict that no small part of their usefulness to this community and to the people of this province will result from the activities of the public health division of your laboratories.

MEDICAL LABORATORIES AS CENTERS OF RESEARCH

In addition to being necessary and desirable places of instruction for medical students and also institutions for practical use in the prevention and cure of disease by physicians and officers of the public health, medical laboratories subserve a still higher purpose, to which we should for a few moments advert,—I mean the function of medical research. In university circles no special plea for original research is necessary I know, for in those circles the advantages of creative inquiry, both from the economic side and from the standpoint of the highest human ideals, are well understood. It is to be feared, however, that the general public, sympathetic as it is with scientific advance in general and with the efforts made by scientific investigators in the struggle for enlightenment, has no adequate realization of the results which have already attended the studies of medical scientists or of the urgency for the promotion of original studies in strictly medical domains. The public has always been willing to pay for hospitals to care for the sick, but it is only in recent years that it has begun to awaken to the possibilities of preventing disease by the endowment of research specifically directed thereto.

The advances which have been made in our own time by investigative medicine are truly phenomenal, and no layman, unless he has made a special point of looking into the matter, has any conception of the increased power medical men now possess to lessen physical suffering from disease and accident, or the means at their command for controlling the spread of infectious and contagious disease. Not only has the prospect of life for each human individual been markedly lengthened, but immeasurable advantages have accrued to the race as a whole, no small part of our industrial development at home and the opening up of countries abroad hitherto inaccessible to civilized whites having been due to the protective discoveries of modern medical science. It is not my purpose at this time to review even briefly the triumphs of modern preventive medicine, interesting as it would be to outline to you what has been done regarding the cause and the prevention of diseases like typhoid fever, Asiatic cholera, bubonic plague, yellow fever and malaria. The advances made in the prevention and cure of diphtheria and in the lessening of infant mortality are

familiar even to the layman, and in the great crusade against tuberculosis now in progress all over the world we have a demonstration of the growing consciousness of the public that it is necessary for it to combine with physicians in applying scientific methods to the extermination of that dreadful malady which is the cause of death of one out of every eight of our people. Since scientific methods when applied to the solution of medical problems have so soon been able to yield the striking results at which I have hinted, what may not be done if more men and more money can be made available for the study of the diseases which as yet can not be controlled. Think of the benefits to the human race which would follow the discovery of a means for preventing or curing pneumonia, an infection which in spite of all the work yet done upon it kills as many people to-day as it did one hundred years ago; or what a boon it would be to human society if the secret of cancer and sarcoma and other malignant tumors could be unraveled and these dire diseases become as controllable as have diphtheria and wound infection. Another most important field for investigation is that which deals with the disorders which affect human beings after middle life is past and account for much of the misery which leadens the sky of so many men and women in their advancing years; I mean those degenerations of the blood vessels, kidneys, liver and brain, the origins of which are as yet obscure and the prevention of which we have yet to learn.

Germany took the lead in the recognition of this special research-function of the medical laboratory and of its significance for social progress. In 1880 the German government endowed a special laboratory—that of the Imperial Health Office—for the investigation of the infectious diseases, and put Koch at its head. France followed quickly with that great institution of international reputation founded for Pasteur after his epoch-making discovery of a method for preventing the development of hydrophobia after mad-dog bites. Since then special institutes for purely investigative purposes have been springing up like mushrooms, part of them supported by national governments, others endowed by private individuals of wealth and insight. I need only mention the Imperial Institute for Experimental Medicine in St. Petersburg (1890), the Institute for Infectious Diseases in Berlin (1891), the laboratory now known as the Lister Institute in London (1891), the Institute for Experimental Therapeutics in Frankfurt (1896), the State Laboratory for the Investigation of Cancer in Buffalo (1899), the Rockefeller Institute for Medical Research in New York (1901), the Institute for Infectious Diseases in Chicago (1902) and the Phipps Institute for the Study of Tuberculosis in Philadelphia (1903)—all establishments dedicated to original medical inquiry—to show you how rapid has been the expansion in this direction. Nor does such an enumeration exhaust by any means the list of medical laboratories engaged in special research. The better university laboratories combine research work with the work of instruction, and much excellent scientific labor is also performed in the laboratories of boards of health in our larger towns and cities.[7]

The people of Canada and the United States are to be congratulated upon the increase in public interest in medical research on this side the Atlantic during the last few years; nevertheless, there is still

[7] Cf. Welch, W. H., "The Benefits of the Endowment of Medical Research," an address delivered at the opening of the laboratories of the Rockefeller Institute for Medical Research, New York, 1906.

a great shortage of men here as compared with the number available for such work in European countries. It must be confessed, too, that the scientific output of individual workers in this country is smaller than it should be and could be were the conditions for work made more favorable. As yet we have only a handful of men who devote their whole time and energies to this kind of study and these are hampered in their work by serious defects in the conditions which surround medical research in America. In our medical schools the professors who are able to do investigative work and have the desire therefor, are often so overloaded with the routine work of lecturing, laboratory instruction and administration, that they really have not the time for the intense and absolutely undisturbed work necessary for the creative mind. Further, it is rare in this country to find an investigating professor supplied with research assistants to help him practically to carry out his ideas, whereas in Germany, by means of a graded staff and a department budget which permits the employment of several research assistants, the hands of the man with original notions are multiplied several fold and there is a much more rapid conversion of new ideas into new results.[8] Another hindrance to research lies in the insufficient financial rewards of academic work. We are undoubtedly holding back our people and the prestige of the country in which we live by the inadequate provision we are now making for the material side of the lives of professors in our universities and medical schools. This is false economy; commercially speaking, it is bad business. Until university trustees and the public generally recognize the necessity of retaining the best brains which develop among us in the service of instruction and research the activities of those brains will inevitably, in many instances, be diverted to other fields. The man with investigative ability, with the power of observing closely, of reasoning accurately, of thinking originally and of experimenting rigorously, is rare. The critical attitude of mind, the inspiration to originate, the training which makes men able to extend the boundaries of knowledge and to win new power from nature, is not common. Only a few men have the faculty of determining and grasping facts, and of verifying and digesting them; and still fewer have the ability to conceive fruitful hypotheses connecting these facts or explanations, united with the initiative necessary to test the validity of the hypotheses by experiment. Research work requires a patience and an enthusiasm, a self-denial and a perspicacity unknown to the average man. When we discover a worker who can find his way in medical regions as yet untrodden, who can discern new relationships among facts, who can elucidate some of the mysteries which for centuries have puzzled us, we should cherish him. He needs all our sympathy and support, for the conditions under which he works are lonely and difficult. He has, as a rule, but few companions, and his work is not in the public eye. He has to set his own tasks and to establish his own standards of excellence. Fortunately, he is a man of high ideals and his reward comes chiefly from his work, from the actual joy of the labor. But, since the results not only increase knowledge but promote the safety and happiness of the people, it is the duty of society to provide the facilities and conditions for his work, to elevate his position in life and to give him the honor and appreciation consonant with his high calling.[9]

[8] Cf. Stieglitz, J., "Chemical Research in American Universities," Science, N. S., 7, 1907.

[9] Cf. Eliot, C. W., "The Qualities of the Scientific Investigator," address at the opening of the laboratories of the Rockefeller Institute, New York, May 11, 1906.

In bringing my remarks to a close I hope that their main intent, despite their rambling and somewhat desultory character, may have become plain to you. I have tried to show you that medical laboratories such as these are indispensable in medical schools which are at all worthy of being known as the medical departments of true universities, and I have maintained that only in such laboratories can students be properly taught, for they come there into direct personal contact with the objects of study, a requisite if the scientific habit of thought is to be engendered. To them, too, your physicians and your guardians of the community's health may resort for making the special laboratory examinations now necessary for the diagnosis, the cure and the prevention of the ills by which your people are afflicted. And, above all, opening off these halls there are some rooms which will, I trust, become the workshops of mature original investigators and others which will serve as nurseries in which will be cultivated those qualities of mind, heart and hand which make men dissatisfied with knowledge as it is and compel them to try to extend it.

Untrammeled by the traditions and ultra-conservatism which are holding medicine back in the mother country, yet protected by intimate connection with her from the whimsical vagaries, the wildness and the freakishness which might otherwise tend to bring medical science here into disrepute, Canadians have an opportunity and a privilege in medicine they will not be slow to take advantage of, a duty they are sure manfully to assume. There are many young men and women in this country and this province capable of devotion to an ideal cause, independent of personal gain and glory. It is to the credit of Canadian parents that they instil into their children high and noble aspirations, that they teach them to endure privations cheerfully for the sake of things greater than mere physical comforts, and that they cultivate that generosity and elevation of spirit which make unselfish human effort not only possible, but really desirable. The fruits of this training will, I dare prophesy, become evident sooner or later in the activities of these laboratories. In them there will be professors and students who will choose as their life work the pursuit of medical truth and the acquisition of medical knowledge for its own sake; as a result of this ennobling and worthy occupation human suffering will be ameliorated, and, perhaps, some patients suffering from maladies now incurable may be healed. May the high aims and purposes of those who have planned these buildings and made their erection possible be realized! May the good that you hope for be the outcome of work in the laboratories which with suitable solemnity and earnest purpose you have set apart and consecrated to a special service to-day!

LEWELLYS F. BARKER
THE JOHNS HOPKINS UNIVERSITY

THE AMERICAN ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE SECTION B—PHYSICS

II

A Relation of Mass to Energy: DANIEL F. COMSTOCK, Ph.D. (Read by title.)

In the paper of which this is an abstract it is shown that the momentum of any purely electric system having any internal motions and constraints, but possessing on the whole a kind of average symmetry, is given by the expression

$$M = \frac{2W^T v}{V^2[1 + (v/V)^2]}.$$

Here M is the momentum of the system, (v) its velocity as a whole, V the velocity of light and W^T the part of the total electromagnetic energy which is represented