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THE BEGINNINGS OF PHYSIOLOGICAL RESEARCH IN AMERICA[1]

THE distinguished society of which this gathering represents a chapter has for its main purpose the exploitation of scientific research.

Every interested person who has survived the sixth decade of life must remember that time when the term "research" was the exclusive shibboleth of a very small fraction of the world community whose individuals were scattered singly or in tiny groups throughout civilized lands, who were unknown by and without influence upon the great public whom they served.

To-day the word is in the mouth of the man on the street, and every newspaper typesetter is familiar with its letters.

This extension of vogue is, of course, due to the common knowledge that it is through research alone that the vast acceleration in the accumulation of bodily comforts, of mechanisms for the control of natural forces, of means for the prevention of human ills has been made possible.

One salutary fruit of the world war has been the popular apprehension that its most infernal agencies on the one hand and its saving graces on the other all were born in the laboratories of science. Man bows to power and gladly contributes to the means for its acquisition.

The very popularity of the theme under discussion is fraught with danger to the fine essence on which its flavor depends. "Research" implies not only a problem but a mind—a certain type of mind. So modern is the content of the term that the English language has failed to develop a graceful name to characterize its votary who is, above all, a truth-seeker.

"Investigator" is clumsy; "researcher" is crude; the French "savant" is inadequate; the German "Forscher" seems more fit. It would be a boon should some student of language fish out from our linguistic melting pot some characterization, brief, smooth and descriptive.

It is a type of mind that is to be defined, not talent or genius, but an impulse to wonder, to inquire and to understand. When the problem is solved its spell is broken; "practical" results have no interest except as demonstrations of the abstract truth and progenitors of new phases of thought. The urge of the in-

[1] Read before the Colorado Chapter of Sigma Xi, June 9, 1923.

vestigator is the development of truth; the direction is subsidiary. With adequate intellectual machinery we may witness a Leonardo da Vinci, a Harvey, a Newton, a Thomas Young, a Helmholtz, a Pasteur or a Dante, a Shakespeare or a Goethe. They all wonder, inquire, construct, create because they understand. The essential spirit of the investigator pervades much of our literature not ostensibly devoted to discovery; it bristles in a fugitive article of A. Graham Bell's and is manifestly revealed in many biographies, as in that of the late Walter H. Page.

The original thinker often, *per se*, like "the lunatic, the lover and the poet is of imagination all compact," but, as in any efficient material engine, his motive power is steadied by a regulating device which, in his case, is provided by scientific training.

The subject-matter of research may be divided, after the manner of a moral code, according to the *intention* on which the endeavor is based, into abstract or pure science, on the one hand, and applied or industrial science, including invention, on the other. Scholarship and learning, however necessary to a productive technique, have no specific relation to research. Mere erudition is not fecund unless it finds a resonant receptive apparatus in the human brain.

My contention is that the characteristic of the original investigator is his mental predisposition, probably essentially a hereditary quality, obvious in every infant, which tends to submergence in later life, but which may be fostered and intensified by culture.

There has been a great change in mental or perhaps I should say ethical attitude among educationalists since the late seventies, the period treated of in these remarks. It was then a real war between the classics and science as to their relative fitness for culture of the human intellect. Intrenched in tradition the so-called "humanists" used all their polished weapons and tactics to repulse the onslaught of the uncultured hordes that threatened their stronghold. And then it was found that the very life and savor of the classics itself depended on the application to it of the same point of view and method with which the scientist consistently and consciously developed his armamentarium.

Sir. T. Clifford Allbutt,[2] in his recent characteristic essays notes, "the humanists never very friendly to science. . . . Disliking the raw anatomy of knowledge, with what they called 'The Classics' they built a walled pleasaunce for themselves and dwelt therein, raising florist's blooms and cut flowers, till Wolfe and Schliemann began to throw stones over the fence." Perhaps more than to any other person the entering wedge of science into the respectable educational curriculum was due to the blows of that doughty warrior, Thomas H. Huxley, who was, indeed, known among his intimates as the "General." And no fitter personality could have been found to lead the actual assault against the university stronghold than his intimate coadjutor, Michael Foster. Even so, Foster's increasingly popular course of physiology at Cambridge was long generally stigmatized as "stinks."

Then, in our own country the bomb was thrown by Charles Francis Adams, if I remember correctly, into the placid ranks of our own most conservative university in the form of an essay on "The modern fetich," the fetich being the assumed aggrandizement of culture through the classics.

In those early days a line was sharply drawn between pure and applied science. For the latter was mixed with "business," which all tradition taught was of a mercenary genus. The scientific man who let himself be lured as principal or accessory into the gainful pursuit of knowledge at once hopelessly lost caste. This was before the sunrise of industrial research in science, though already slight glimmerings of the dawn lighted the sky. It has been indeed a remarkable, if inevitable and rational, revolution which to-day has added to the battalions of industry so large a contingent of the best equipped investigators as to make of industrial science a most important agency for the generation of knowledge.

The same general change that has marked the progress of science has been reflected to a degree in features of medical ethics. The profound aversion to forms of belief, as in homeopathy, has given way to tolerance and regulation by broad rules of conduct. But ever new systems of therapeutics are projecting themselves upon us and only time and patience and the spirit of science will suffice to gradually smelt the noble metal from the base—for all beliefs are mixtures. It is interesting to observe the modification of ethical judgments which has already been manifested through a broader perception of the supremacy of the claims of human welfare as exampled, for instance, in the approved patenting of remedial agencies which would be likely to accomplish harm through unregulated exploitation.

Immemorially the medical curriculum has combined these complementary if not antipathetic relations of scientific instruction, the field of thought and the field of practice, however vastly predominant in area the latter. It would be ruinous to progress and efficiency to displace either. Though we sing the attributes of research in pure science, it is the application in practice that really and immediately counts. The two activities are fairly portrayed in the parts played in a reflex action by the afferent impulse and the central mechanism, on the one hand, and the motor impulse

[2] Sir T. Clifford Allbutt, "Greek Medicine in Rome," 1921, p. 5.

and its end organ, on the other; each alone is futile, but together they accomplish a purpose.

In these latter days there has developed what seems to be a final ideal for the union of the antithetic relations of science and practice.

It is witnessed in the, as yet groping, institution of schools of preventive medicine, where the highest flights of the trained imagination of the investigator may find full scope with the single proviso that they be so reined as to effect a single purpose—the welfare of living creatures.

Within the past half century we have seen realized the ideal of a purpose so directed in the life of Pasteur. Thus does moral philosophy come to its own; the stone rejected of the builders has become the chief of the corner. The world events of the past decade form a pedestal, grave-deep, on which to carve this slogan of science.

It seems as though the evolution of education were perceptibly drawing closer to the refrain of the book of Ecclesiastes, where wisdom is pointed as the goal of the seeker; but the doctrine there is urged for a reward, the boon of self-aggrandizement. We may aspire to higher claims and seek to realize the injunction of Christ, to work for the good of others.

The dangers of accomplishment are very real. Few characters can withstand the unwonted temptations which swarm in sudden riches. Our accelerating affluence of discovery in science pure and applied, the insidious examples of luxury in the life of the unworthy threaten the character of the scientific cult. The horseless vehicle outclasses legs and we must look to it that our finest possessions, physical and ethical, do not shrivel in atrophy from disuse. It is the youth and infant of to-day who must be trained to catch the torch from the failing hand of age in the great relay race of scientific progress. The observer with a retrospect of 40 years who compares the ideals of then and now must feel a vague uneasiness that the spirit and language of pure science are fast becoming obsolescent for the newer generations. The guinea-piece damned by John Hunter seems to have come to its own.

It is not going too far afield to here applaud the isolated effort which, albeit a feeble one, the medical profession, the greatest school of practical ethics known to-day, here and there is making to withstand the surges of commercialism.

The "whole time" chairs of practical medicine in university medical departments testify to the perception of our imminent danger and the intention to combat it. Modified in detail as the plan must be with knowledge gained from experience, it gives confidence that our real leaders are prepared to grapple with the dangers that confront us.

Preventive medicine even more than the remedial practice of the art bears the stamp of wisdom; and as a spiritual exhibit of altruism it is unsoiled with the stain, "which will not out," of calculated money rewards in actual practice.

But I came here to talk about the beginnings of physiological research in America, for it had been my good fortune to be a personal witness of what might be called the birth of organized research in physiology in this country, and to have been on intimate terms with its accoucheurs.

There seemed reason to believe that a personal description of some of those who deserve to live in the history of science might not be without value and entertainment.

A judicial estimate of the importance of men and events is admittedly impossible until long after they are passed and gone.

This is largely because our own immediate interests are sensibly involved in recent history; but the final verdict more nearly approaches truth the greater the number of accurate, eye-witnessed facts it has to build on.

I venture to assert that the foundation of what I have called organized physiological research in America was laid by Henry Newell Martin in the biological laboratory of Johns Hopkins University in the fall of 1876.

Do not misunderstand me to say that no physiological research had preceded this era.

None will fail to recall the undying names of Beaumont, that very personification of the genius of solitary research, of Brown-Séquard, of Weir Mitchell, of H. P. Bowditch, of H. C. Wood and many others. But these were widely isolated individuals who, separated from their generation, obeyed the call within them. High as have been the achievements of isolated great men working alone, especially in the history of English physiology, their momentum was bound to fail when not sustained by the contemporary appreciation and critical judgment of a large body of scientific men.

In the late seventies there was no such thing as physiology, in the modern sense, in America. There were not half a dozen working physiologists, no well-equipped laboratories, no students and no demand for scientific foundation in medicine either on the part of the medical profession or the public.

The only physiology was that of the text-books of which those of J. C. Dalton and of the younger Austin Flint, both of New York, were the foremost.

When a medical graduate managed to get a place on the teaching staff of a medical school, almost invariably "proprietary," it was physiology which he was assigned to expound. In the United States pathology had not been born and clinical microscopy had not begun gestation.

The ambitious and thinking student could find among us no answer to his questions nor opportunity for any but clinical training. He who could not afford to go to Germany or France was compelled to remain in ignorance. When one such, who is now a distinguished pathologist, returned to Baltimore, about 1881, after two years of what to him was an intellectual orgy in pathological institutes of Vienna, he made the mistake of presuming that his unique acquirements might be the source of a living wage as a consulting specialist on pathology in his home city. The hope proved futile, for the medical profession had not the education necessary to formulate questions on conditions it did not recognize as problems.

Though in Philadelphia, in 1876, the indomitable energy of men like H. C. Wood and Weir Mitchell, to be followed in a half decade by a galaxy of pupils, not duplicated in later years, was producing original investigation of greater or less value, there was no laboratory with the specific object of inculcating and hatching original thought in physiology. H. P. Bowditch, of Harvard, by reason of his training under Ludwig and his intrinsically high endowments, was the worthy dean of experimental physiological science in America. In contrast, I may recall that for the past decade or more every year there have come to us from a score or more of laboratories a host of original contributions in every field of biological research.

Indeed, to-day every respectable medical school has its laboratories of physiology and pathology and these, with few exceptions, are the loci of original research. To-day every branch of medicine and surgery is represented by a select coterie of active workers known as this or that society or association, who make their investigations wherever material offers, in the clinic, the laboratory or by the bedside. The distinctively laboratory branches of medical science are chiefly represented in the "Federation of American Societies for Experimental Biology" founded in 1913. This association was made by the aggregation of already existent societies, namely: The American Physiological Society, founded December, 1887; the American Society of Biological Chemists, 1906; the American Society for Pharmacology and Experimental Therapeutics, 1908; the American Society of Experimental Pathology, 1913. The total list of membership in 1922 comprised 539 names, all of them those of producing workers for the advance of biology, especially as related to medicine. A most active and productive institution of the same ideals is the Society for Experimental Biology and Medicine, founded by Meltzer in 1903. Its 19 charter members have multiplied to a roster of 549 in 1923. Other similar organizations of national scope, such as the Society for Clinical Investigation, Society for Cancer Research, etc., deserve passing mention. The developments on the morphological side of biology have been equally noteworthy.

Nothing is more indicative of the volume and educational demands of the reading population than the number and character of the scientific journals which it supports. In the first small volume of the "Index Medicus," representing the literature for 1877, there are mentioned all told 64 medical journals, mostly of very mediocre quality, as published in the United States and Canada. Of these not one was devoted to scientific research. In the index of the *Journal* of the American Medical Association for 1921 out of 110 titles of journals from the same area no less than 22 are devoted wholly to original investigations in the biological sciences directly bearing on medicine, and in the remaining 88 journals dealing with medical specialties a large proportion of the pages is devoted to the publication of high-class original research.

In former days, there was a sharp distinction drawn by even the best medical minds between subjects which were scientific or theoretical and those which were of "practical" value. To-day the leading thinkers and operators in surgery talk familiarly of "surgical physiology," and every physician recognizes that he is likely to understand his sick man in proportion as he apprehends "clinical physiology."

We can maintain, therefore, that the period of the past 47 years has witnessed the birth and vigorous development of American biology, of which the supporting trunk is, and must ever be, physiology.

When in the middle seventies, Johns Hopkins, a citizen of Baltimore, determined to devote his great estate to the upbuilding of higher education and of higher medical education in particular, he chose as advisers a group of reflective and far-seeing men who for the most part had been trained in the self-restraint of a Quaker upbringing.

The soundness of judgment displayed by this body of technically ignorant citizens must remain an enduring monument to their sagacity and high character. They culled from the world advisers who were themselves broad humanitarians and foremost among the producers of scientific progress. Perhaps the chief among these were Huxley in England and John S. Billings in this country.

It was realized that education in this country, beginning in the primary school and ending in college, included a field of activity of two dimensions only. No upward growth could be hoped for except from teachers who could produce knowledge as well as impart it. Europe had already found that the development of sound education of any grade depended on the mitosis of original research carried on in laboratory and study of trained and devoted men. To

Europe our young men had been forced to migrate to get behind the scenes or read between the lines of their text-books.

The founders of the Johns Hopkins University determined to establish a new order of institution, one devoted primarily to original research and the critical study of existing knowledge.

Its main body of students from the outset was culled from college graduates, who felt the call of higher science, literature or mathematics. To-day, throughout the length and breadth of the land, the nodes of education are infiltrated with the spiritual enzymes propagated in the mother culture at Baltimore. What was taught there was, perhaps, not so important as knowledge as the way of looking at knowledge. Within the past month Dr. H. S. Pritchett,[3] president of the Carnegie Institute for the Advancement of Teaching, has publicly deplored the calamity suffered by American education through the alleged fall of Johns Hopkins University from its preeminence by reason of the diversion of its energies to the attraction of undergraduate students.

One of the main departments of the university was that devoted to biology which, as Huxley had defined, might be considered to include all the attributes of living matter, but as a matter of fact was there limited to what is known as zoology, the study of the lower forms of animal life, embryology and to animal physiology.

As head of the department of biology a young man was chosen, Henry Newell Martin, who was a direct product of the influence and teaching of the two most understanding men of biological science in England, T. H. Huxley and Michael Foster. The following characterization is largely directly drawn from a biographical sketch of Martin published twelve years ago.[4]

The study of physiology as implanted at the Johns Hopkins University by Martin in October, 1876, was a graft from English physiology, and it may be of interest to you to hear in the words of one of the foremost teachers of English physiology an account of the modern development of his science.

In England, as in America, physiological science from the time of Harvey and before had attracted the loving labors of great men here and there, but never had there been organized instruction in the experimental method, by which alone new discovery of function is possible, until the period of which I am about to speak.

When Sir Michael Foster stopped in Denver, in September, 1900, on his way home after delivering the Lane Lectures in San Francisco, he consented to talk before the local medical school of his own memories of physiology and physiologists in England.

By great good fortune Dr. W. N. Beggs, then editor of the *Colorado Medical Journal*, arranged for a stenographic report of the colloquial lecture, which may be found in the *Colorado Medical Journal*, 1900, VI, 419.

It seems to me to be one of the most living historical sketches I have ever seen and nothing can better serve my purpose than to quote from Foster's extemporaneous words. He says:

> It was in the year 1854 when I began my medical studies, but I had a year before attended a course of lectures on physiology breaking into my ordinary studies in order to do that, and my teacher was a man by the name of William Sharpey, a very great man but a man whose name, perhaps, will not occupy the place as that of a great physiologist which it really deserves. Those of you who have studied the structure of bone will remember his name under the title of "Sharpey's fibres." Indeed, he was one of the first to give an accurate description of the true structure of bone.
>
> He was at that time the only pure physiologist in England. . . . Sharpey may perhaps be known to you also as the editor of a book, which for years and years has been and still is a standard work in anatomy in England, "Quain's Anatomy," which deals not only with topographical anatomy, but also with minute structure, with what we now call histology; and Sharpey was the first man to teach histology in a thoroughly systematic method in England. . . . Now Sharpey was, at the time I am speaking of, the greatest physiologist in England, the only person who devoted his whole time to science; and yet even he taught physiology wholly by lectures. He had no physiological laboratory. He had no physiological apparatus whatever. All he did in the way of practical teaching at that time was to show us under the microscope preparations of various tissues. There was no attempt whatever at any practical teaching in physiology. I remember very well when he was lecturing on blood pressure, and was describing to us the then new results of Ludwig, endeavoring to explain to us the blood pressure curve. All he had to help him was his cylinder hat, which he put upon the lecture table before him and with his finger traced upon the hat the course of the curve. That was the way that physiology was taught by Sharpey in England in the year 1854. And yet Sharpey taught it as nobody else taught it. Nobody else in England then was teaching physiology as Sharpey taught it and, as I tell you, he used his hat, and a very old hat it was, as a kymographion, for blood pressure. I remember very well going to him one day after his lecture, in which he had been speaking of the functions of the liver (by that time he had recognized that I had a special interest in physiology) and he said to me, "Well," he said, "I didn't like to say anything about it in my lecture but Claude Bernard in Paris has just sent me a paper which he read before the Academy of Sciences at Paris, and in that paper he has proved that there is present in the

[3] *Scribner's Mag.*, May, 1923, p. 556.

[4] *Bull.* Johns Hopkins Hosp., 1911, xxii, 327.

liver a substance resembling starch which is easily converted into sugar.'' I said to him, ''Good gracious, that is something quite new, isn't it?'' That was Claude Bernard's discovery of glycogen.

In words which it seems a pity to delete, Foster goes on to describe how with the aid of Sharpey there was installed for the first time at University College, London, a subordinate position, a lectureship on practical physiology. Foster received the appointment about '64 or '65. But he says:

What could be done was very little. I had a small room. I had a few microscopes. But I began to carry out the instruction in a more systematic manner than had been done before. For instance, I made the men prepare the tissues for themselves. That was a new thing then in histology, and I also made them do for themselves simple experiments on muscle and nerve and other tissues and on live animals. That, I may say, was the beginning of teaching of practical physiology in England. . . . These lectures on physiology were absolutely voluntary, and only the better students were willing to give up the time needed to get a more thorough grasp of physiology. Well, I appointed a time to see the few who wished to spend some time in this new study of luxury, and there came to me a boy, nothing more than a boy, at least he looked like a boy, who said: ''I am very sorry, sir; I should like to take your course if I could, but you see my parents are not very well off, and I get my board and lodging by living with a doctor close by.'' Doctors in England then, as indeed they do very largely now, dispensed their own medicines. I mean when they saw a patient they sent in afterwards the medicines required. In those days medicines were not as compendious as they now are; the doctor could not take the whole pharmacopaeia about in a little case. He either with his own hand or by the help of an assistant had to do a good deal in the way of preparation of medicines, making infusions, rolling pills and making up mixtures and draughts, doing all the things which went under the general name of dispensing. The lad I am speaking of said to me, ''I have, in return for my board, to dispense all the doctor's medicines, and that dispensing takes from 2 to 5 o'clock; now your lectures begin at 4, I can not come for the first hour. You go on to six. May I come in for the second hour? I will work hard and try to make up the lost time.'' I said, ''Certainly, certainly.'' So he came in regularly late. The other boys rather laughed at his coming in late. He came in regularly at 5 o'clock and he worked with such purpose that, in the examination which I had at the end of the course, I awarded him the prize. Well, his name was Henry Newell Martin, and I was so struck with him that I asked him to assist me in my course and he became my demonstrator.

After we had been at University College for either two or three years, Martin carrying on his studies and at the same time helping me, he came to me one day in great trouble because he could not make up his mind. He had obtained what they call a scholarship at Christ College at Cambridge and he could not make up his mind to accept it and go there. He said he didn't want to leave me. But I was able to tell him what nobody else knew at that time . . . that I was going to Cambridge, too, having been invited to be a lecturer on physiology there. So we both went to Cambridge at the same time, and he became at Cambridge at once my demonstrator, as he had been in London, and after a career of considerable brilliancy of some years at Cambridge there came to him an invitation to Johns Hopkins University at Baltimore. So, if I have done nothing more, at all events I sent Henry Newell Martin to America.

Martin was born July 1, 1848, and he was therefore but 28 years old, and looked still younger, when he took up the duties of the most responsible pedagogic position in the United States. He was of Irish parentage and the eldest of twelve children. His father was a clergyman from the south of Ireland, at first a Congregational minister and later a school teacher. His mother, to whom he was manifestly greatly devoted, was from the north of Ireland. A unique course of laboratory work, designed to give a broad view of living forms and functions, had been introduced by Professor Huxley in 1873. Martin helped to import the course at Cambridge and later assisted Huxley himself and under his directions prepared the famous text-book on "Practical Biology."

Each epoch in the world's history is characterized by specific points of view and conflict of opinion on questions that seem for the moment all important. A perfect history would bring to us the environment in time, place, circumstance and feeling of any age.

As said in a previous sketch of Martin: "No adequate estimate of the specific educational forces at work in the late seventies can fail to take into account the influence on the youth of that period of the intellectual atmosphere emanating from the doctrine of evolution."

Darwin's "Descent of Man" appeared in 1871, and soon a strife was on between a protesting and enraged orthodoxy on the one hand and the often iconoclastic forces of thought-liberty on the other.

Professor Huxley, known affectionately by those near him as the "General," as the commander of a ship is known as "the old man," was the splendid and aggressive leader of the Anglo-Saxon believers in evolution. It is not surprising that the internal tempest bred by thoughts of the supernatural in the mind of every thinking youth should have found its outlet along the channels of reason as suggested by evolution when intolerant of traditions of mysticism.

To be frank, the popular notion that the prevailing spirit of the Johns Hopkins staff in those days, at least as regards the biological department, was "agnostic" was sufficiently correct. To-day the conflict between the book of Genesis and science had long been as a tale that is told until a contemporary and a

neighbor of our own bethought him that faded fame might be polished with the ashes of this dead issue.

In those days the student was thrilled by the new demonstrations of the application of the law of the conservation of energy to the living body and a definition of physiology as the "chemistry and physics of the living body" was made with arrogant good faith.

The old doctrine of "vitalism," by which the masters for centuries had explained the phenomena of life, was thought to have been buried forever. It seemed as if at last the phenomena of life itself were soon to surrender themselves to the art of mathematical treatment. But since those days a panorama of discoveries has again well-nigh reduced us to chaos in belief. Then we knew nothing of hormones, of internal secretions, of vitamines, of the ubiquity of enzyme action in vital phenomena. Colloidal chemistry was a nursling. There was no worthy conception of specific surface energies, of adsorption or of ions. The atom was still the ultimate indivisible unit of matter. But, withal, to-day doubt still withholds a verdict as between the mechanistic and vitalistic conceptions of life.

It was one of the chances which determine the course of human life by which it happened that your speaker, a native of Baltimore, graduated at the age of 21 from a New England college some three months before the inauguration of the Johns Hopkins University. His design of studying medicine, which had been constantly in view from the earliest days of volition, found a peremptory obstruction in the lack of funds necessary to such a course.

But thrilled with the divine curiosity concerning the nature and operation of the forces of life, the main thing was to get a chance to study under a competent teacher. A member of the board of trustees of the university secured for me an appointment to visit Professor Martin, whose sufficient distinction it was to have been an associate of Huxley, that grand Napoleon of biological science, who had already enthralled the youth of two continents.

I called on Professor Martin at his rooms and my spirits were lightened when I saw a very young man—he was then 28 and looked younger—who treated me at once something like a companion. He was scarcely of medium height, of slight but well-developed frame. His head was rather small, the eyes blue and wide-open, nose thin and fine, complexion fair and mustache blond. His dress was always strikingly neat, without being foppish. I can not but fancy that Martin then was homesick and keen to relish the devotion of one not far from his own age. Martin accepted me as his assistant in the biological laboratory at a stipend of $250.00 for the first six months. . . .

Martin's ability as a teacher is attested by the eminence of many pupils; his talent as an investigator is recorded in the literature of physiology; but the personality of the man, his kindly tact, the sincerity, the unassuming modesty, devoid of self-consciousness, the loyalty to truth and the indefinable emanation that reaches from man to man, the memory of these is apt to fall with the heartbeats of his companions. I well remember the first week of preparation for class work. There was as yet no laboratory "Diener," and a hundred tasks of household preparation were to be completed in advance. Martin was kinder than he could have known when he stood beside his assistant washing bottles for reagents; and in this, as in every other field, what would have sorely hurt as a menial service he turned into the routine of technical manipulation. While he never gave way to sentimentality, his invariable kindness where he bestowed confidence withstood every strain of daily intercourse. On one occasion he loaned me overnight the manuscript of an important public address which was to be published. Next morning the roll was missing and apparently lost beyond repair, but the delinquent was the only one ruffled by the accident. To his great joy the papers were found to have been left on the counter of a friendly shopkeeper.

For one of his public lectures before a fashionable, and chiefly feminine, audience plans had been devised for the demonstration on a projection screen of familiar physiological activities, such as muscular contraction, reflex action and the heart beat in the frog. Unfortunately the apparatus was not available for proper rehearsal and when the fateful hour came, the nerves and muscles rebelled at the "lime light." Martin would graphically describe a function and then call for demonstration. Again and again I failed him and things looked desperate when he asked in the gloom of turned down lights, "Sewall, is your heart going?"

Humiliation was relieved by the titter that restored the humor of the fair audience. A lecturer might well feel murderous towards an assistant who so failed him, but if Martin felt that way he gave no sign. . . .

Looking back over the history of those days one must marvel at the felicity with which Martin made and then developed opportunities in the unbroken field before him.

Courses in practical biology and practical physiology formed the routine of laboratory work. But soon there were established accessory classes in demonstration and practice.

A selected number of teachers of Baltimore were offered a course of study on Saturday mornings. Listening first to a brief descriptive lecture by the professor, they then adjourned to the laboratory and with

their own hands and eyes carried on for two or three hours such a nature study as had not been conceived in those days.

It was a duty of your speaker to prepare material for that Saturday's class and the obligation fully occupied the spare time of the preceding week. The physicians of the community were invited to a course of physiological demonstrations and many eagerly availed themselves of the opportunity. Martin's unselfish and impelling nature sought the utmost development of all about him.

Martin soon came to be looked upon as the scientific exponent of the medical profession, and through lectures and practical demonstrations he illuminated the minds and raised the ideals of the more ambitious members of the cult. With infinite tact he made abstruse subjects so plain and practical that his hearers often volunteered as real students and helpers. . . . To my mind the most useful teaching of Martin's career is found in an analysis of the elements of his success. It was clear in his case, as has often been established in others, that his success depended on careful preparation for every effort made. I was very much impressed when, after I had spent two years in special study of gastric digestion and he had appointed me to make my maiden lecture on the subject, he asked me a full month before the time whether I had prepared my lecture yet. The thought sprang to my mind, "It may be that this ultra-preparedness has something to do with Martin's success."

Again, once when we were giving parallel courses to the same class, he in the morning and I in the afternoon, he one day apparently ran out of prepared material and to my horror, being one of the audience, he deliberately appropriated the most harmonious thunder I had laboriously stored for the afternoon. I hastened to privately reproach him on the subject, but he only replied, "It doesn't matter, it will do them more good to hear it a second time." This reminds one of the summing up which a great teacher, Michael Foster, I think, made of his pedagogic experience: "Every year I put less into my lectures and say it over oftener." I can recall but two personal criticisms Martin ever made to me; one was because of a tendency to neglect to expound familiar and obvious details in making a physiological demonstration and the other was for a proneness to procrastinate the preparation for a remote exposition.

Martin found time in 1880 to write an excellent text-book of physiology, "The Human Body," which has become very popular in colleges and in a short time a separate, condensed edition, "The Briefer Course," was prepared for use in secondary schools. Nothing that I have said predicates for Johns Hopkins University or its biological department a position of peculiar preeminence among American institutions of learning. Yet it is now a matter of history that to the university was conceded a unique position as an educational leader almost from the opening of its doors.

With phenomenal wisdom the administrators of the university chose for the heads of its departments men who were not merely good lecturers but were investigators and sources of inspiration in their respective fields. The three departments of natural science established, physics, chemistry and biology, were all under the direction of men still far short of middle age.

In those days the young men gathered there were all votaries of what Huxley called "the divine dipsomania of original research."

Of inexpressible value to us, often ill-formed but devoted students, were the precepts and examples of leaders trained in the way of making knowledge. Martin's achievements inculcated the encouraging lesson that the prime requisite of a successful investigator is not "genius" or even great talent, but above all, a faithful, unerring, insatiable desire for truth as a point of view to which must be added a working energy of indomitable persistence and guided by a faith that nothing happens without a reason.

Martin was not a voluminous writer. In his seventeen years of service in Baltimore there were produced by him but fifteen papers covering the results of original researches. . . . I very well remember one morning, I think it was in the fall of 1880, Martin said to me, in effect, "I could not sleep last night and the thought came to me that the problem of isolating the mammalian heart might be solved by getting a return circulation through the coronary vessels." The idea seemed reasonable, and at the close of the day's work we anesthetized a dog, prepared him for artificial respiration and then Professor Martin opened the chest and ligatured one by one the venae cavae and aorta in such a way as to leave sufficient amount of blood in the heart itself. The heart continued to beat in a normal manner, the circuit made by the blood being from the right side, through the lungs to the left side and back again through the coronary vessels in the heart wall to the right ventricle. Thus heart and lungs were completely isolated from the rest of the body and could be studied unaffected by the interference of factors foreign to itself. . . . Isolation of the mammalian heart by the "method of Langendorff" is now a common procedure. Probably few are aware of the real discoverer of the idea. It is interesting to note the character of the problems with which Martin busied himself, and his persistent search for an *experimentum crucis*.

Assisted by Sedgwick he apparently settled experimentally the disputed function of the internal intercostal muscles. They also succeeded in putting a

cannula in a coronary artery of the living dog's heart and directly measuring the blood pressure and pulse wave in the coronary system, though the great Cohnheim had laid down the dictum that occlusion of a main coronary artery was immediately fatal to the physiological action of the heart.

In Martin's time the leaders of thought in physiology felt themselves confronted with a calamity which endangered the autonomy of their science. Physiology in this country did not exist as a profession. Its reason for existence in the mind of even the educated public rested on its relation to medical instruction and it held somewhat the same position in the technical curriculum as grammar does in the academic course. Martin, following the lead of his scientific forebears, insisted that physiology should be regarded as the benefactor not the handmaid of medicine and that it should be cultivated as a pure science absolutely independent of any so-called practical affiliation.

Martin glimpsed the future as by inspiration.

The vast development of our conceptions of vital reactions as manifested in the doctrines of immunity, has occurred wholly since his day. As he foresaw, the temptation to achieve discovery directly applicable to the cure of disease has attracted an overwhelming majority of those whose tastes and talents might have been devoted to a sounder development of the principles of science. The student and the prospector for precious metals both tend to rush to the new field of rumored richness.

The history of science is thickly studded with examples of facts and laws unearthed in the pursuit of pure knowledge which have turned out to be indispensable foundations of daily thought and action. Never could they have been discovered by one bent upon so-called "practical" or patentable information. Both theory and experience combine to uphold the doctrine that *knowledge,* irrespective of human uses, must ever be the foundation of both intellectual and material development.

To come, now, down to a focal conclusion and to try and distil in a sentence what would need a volume to elaborate, what should be our attitude towards offering facilities for research and for training in clinical practice, respectively, in medical education?

It has been postulated here that the original investigator is characterized by a specific trend of mind which makes him ever an amateur insatiate for new things, a type on which the advance of knowledge is almost wholly dependent. But such a type is no more fitted, *per se,* to carry on the details of medical practice or apply the fruits of discovery in the infinite vicissitudes of clinical experience than would the explorer or the pioneer settler of a new country be qualified by nature or training to conduct the civic affairs of a highly organized community.

To help humanity is the goal of mass education.

Science is worthless for the people until in applied art it is coordinated to approximate mechanical exactness.

The clinician must hope to acquire through long years of extramural education a method of thought and action not taught in the medical curriculum. A method to which, indeed, the requirements and attributes of experimental science are largely antagonistic; a peculiar point of view and a communistic method of dealing with human minds and conditions. It would be an egregious tactical blunder to attempt to train all students as investigators; but without injury to any, all may be given the opportunity of an environment to which may react a small percentage of minds attuned by nature to respond to the call of truth Promethean.

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RESEARCH COMMITTEES[1]

THE GROWING COMPLEXITY OF ORGANIZATION FOR RESEARCH

RESEARCH enjoys a vogue at present, fortunately and rightly. It is believed in almost as a religion, with much lip service. Lips are likely to be tightly closed when the collection plate is passed.

The organization of research and research committees proceeds apace, to the extent that the unit of ultimate value in fundamental research, that is, the individual research worker is encompassed about with so great a cloud of witnesses.

The American Society of Civil Engineers, the American Concrete Institute, the Western Society of Engineers have research committees and also certain governmental departments. There is the National Research Council, the Engineering Foundation, the research organization of the Association of Land Grant Colleges, which is one of the most powerful of the agencies.

Now, one aspect of science is the simplification and economy of thought, and one aspect of engineering is economy of action. It would be profitable to inquire into the function of any proposed committee before adding to the structure of such committees, in which duplication of effort is less defensible than in the activities of research workers themselves.

For indeed parallel attacks on any research problems are desirable. It is only necessary that researchers should have a knowledge of mutual progress, and

[1] Discussion read before American Society for Testing Materials, June, 1923.