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Addresses.

CHARLES SEDGWICK MINOT, M.D.*

By W. T. PORTER, M.D., LL.D., BOSTON.

CIRCUMSTANCES, which should have prevented the career of Charles Sedgwick Minot, contributed largely to its success—the usual paradox. He was born not merely a Bostonian, but a legendary Bostonian. All the crushing disadvantages of an assured position, binding traditions, and a competence, were his. The times themselves were not propitious. The range of thought was narrow. Boston was no longer distinctively a caravan route. Strange cargoes were less frequent. The China seas widened fewer horizons. New people were coming in, floating on the tides of unearned increment. Hardy explorers from the fabled West discovered the North Shore. The old society, solicitous for a point of view justly regarded precious, took refuge in its trenches. The use of Christian names in conversation rose from a convenience to a shibboleth. The spirit of the times was aptly characterized by the President of Harvard University, when he called the Harvard Medical School of that period a dinner club. Those were provincial days in town and nation.

Much may be said of the charm and indeed the real value of limited societies, but they are unfavorable to the development of original minds. On the other hand, once the inertia of position is overcome, the virtues of these particular defects are admirably sustaining. No doubt the Bostonian of literature was a creature never seen on land or sea, yet the Boston spirit was

nevertheless a living force. There rests not the faintest doubt that a provincialism which pitched the note upon honesty of purpose, industry, and almost unexampled devotion to the public welfare, gave to the neophyte in science the indispensable weapons of his lifelong fight. In Minot's hands they were never tarnished; honesty, industry, and public spirit were undimmed to the end.

These attributes, though sufficient for salvation in the ordinary walks of life, are but the tools of thought. The priceless gift is the power to see how known phenomena may be so combined as to reveal new truth. In the last analysis, the setting of fruitful problems is an incommunicable art. Yet those who possess originality of mind can be greatly helped by men whose genius lies in this direction, or by their disciples. Still more may they be aided toward the invention of methods and the development of critical power. The higher knowledge, impossible of record, is an oral tradition. Minot received this tradition from H. P. Bowditch, Ranvier, and especially from Ludwig. Of his debt to all three, he was ever conscious. Ludwig he regarded with true veneration. In this, Minot was not alone. The illustrious Heidenhain said at Breslau that the only physiologists who had really accomplished anything were Ludwig and Marey. Ludwig kindled fires in every civilized country. The world owes him a great debt, still unpaid. His extraordinary powers as a ferment were coupled with an engaging simplicity. Shortly before his death, in his seventy-second year, he said: "The pity of it is, I shall have to leave off just when it becomes most interesting." Ludwig gave to Minot the secret of lifelong youth, the reward of those who continually voyage for discovery.

* Read at a meeting of the Boston Society for Medical Improvement, January 25, 1915.

Minot's first physiological work was a research with Professor Bowditch entitled, *The Influence of Anesthetics on the Vasomotor Centres*. It was published in the *BOSTON MEDICAL AND SURGICAL JOURNAL* in 1874, more than forty years ago. The experiments were probably largely by Minot, but the publication itself bears unmistakably the marks of Bowditch's lucid style and careful hand. In this investigation it was shown that "in the majority of cases the rise of blood tension consequent upon irritation of the saphena nerve is less marked when the animal is under the influence of ether or chloroform than when the anesthetics are not used." This result is due to a diminished activity of the vasomotor centre. Changes in the blood pressure were also noted. Ether causes a rise in the blood tension from 9 to 51 mm. of mercury, while chloroform causes a fall of from 8 to 37 mm. The action of chloroform on blood pressure is due in large part to its influence on the vasomotor centre and only in small part to enfeeblement of the heart.

While at Leipzig Dr. Minot worked under Ludwig's direction on the formation of carbon dioxide in resting and active muscle. This work was published in 1876 in the *Arbeiten aus der physiologischen Anstalt zu Leipzig*. An artificial circulation of blood serum was established through the biceps and the semitendinosus femoris at rest and during electrical excitation of the muscles. It was found that the carbon dioxide given off to the circulating serum was not increased by tetanizing the muscles. The conclusion was that carbon dioxide is not a decomposition product of muscular contraction. The methods employed in this investigation, though good for the time, are not altogether free from loopholes, and the conclusion reached is opposed to our present knowledge that the excretion of carbon dioxide is greatly increased by muscular contractions. It is therefore suspected that the carbon dioxide is after all set free in the muscles themselves, but the evidence is not conclusive.

In 1878 Dr. Minot published in the *Journal of Anatomy and Physiology* his experiments on tetanus, made in the Physiological Laboratory of the Harvard Medical School. They showed that when a muscle is forced to contract by a succession of induction shocks, the phenomena are essentially the same whether the interval between two shocks be several seconds or a small fraction of a single second. In other words, the difference between the various forms of muscular contraction depends merely upon the interval between the single shocks and the variations in the rate of the return of the muscle to its original length. This research was ingenious, laborious, meticulous, a conscientious collection of crumbs left by those earlier at the feast. It marks the end of Dr. Minot's first manner.

The paper on muscle contraction, like the two preceding papers, dealt with problems treated from a purely physical standpoint—an index of the times. Johannes Müller, that great genius who is justly called the Father of modern phys-

iology, had begun the good fight to place physiology among the true sciences, to express biological phenomena in grams, centimetres, and seconds. Helmholtz, von Brücke, Ludwig, and DuBois-Reymond completed his work. In my day, as a student in the University of Berlin, the Kneipe in which physiology was given its modern dress was still pointed out to reverent youth. The job was done most thoroughly—so thoroughly that, after a time, the method became somewhat irksome to persons not especially fitted to be sappers and miners. Whether the scholastic excesses of the physical school caused Minot's revolt or whether his apostasy from the rigid sectarians was a consequence of new studies connected with his appointment to teach histology and embryology in the Harvard Medical School, I will not attempt to say. It is enough to know that he left his foster nurse for what was then called biology, a hybrid of physiology and anatomy, alleged at that time to have inherited the virtues but not the faults of both its parents.

It was a conscious and deliberate revolt. In that same year, 1890, he thus exalts the Egeria of his choice: "We should not study merely the organs of the body, whether in their anatomical or their functional relations. There are persons who never understand the arrangement which Nature has established. We are always separating things from their natural connection and taking up a special series of views, instead of more general ones. There is in the direction of true *general* biology, a vast opportunity which I hope will soon be generously taken advantage of. There are many things which we can hope to understand only when study is prosecuted from that point of view. All of the important phenomena of reproduction, of heredity, of the evolution of species, and of all the relations of actual organisms to the general economy of nature, of sex, of growth and variation, even of death itself, which is a problem I believe capable of scientific solution;—all these things are hidden away to a large extent from the morphologist and the physiologist, they are open to the general biologist." (*American Association for the Advancement of Science*, 1890, xxxix, p. 18.)

It is enough to say that this belief in the perfectibility of the very human biologist has not yet been realized. The hope was common in those days. The history of thought is strewn with broken dreams. They rise like the mirage. The weary traveller, toiling through arid facts, as numerous and as unrelated as the sands of the Sahara, sees afar off the shining lakes of Theory. There, on the horizon, is that which shall fit the desert to be the abode of men. The traveller presses on. The mirage dissolves, and from afar the sphinx, inscrutable, looks down upon the immemorial sand. The biologist may dress himself tastefully in the plumage of the physiologist and the anatomist, but this will not create him a new species. Dr. Minot remained essentially a physiologist all his life, though, like many physiologists, he worked from time to time on structure.

His devotion to morphology had probably a deeper source than his special chair in Harvard University. In his youth, the stamp of Ludwig's genius gave his mind a lasting impression. Many years after the Leipzig days, Minot, in a public letter to Mosso, declared that from Ludwig he "had learned to regard the living organism as an apparatus, of which it was necessary to learn both the construction and the working, and always to seek the explanation of the working on the basis of the construction." In Ludwig's generation this passed for truth. So artists once painted portraits by drawing the features and afterwards coloring them. They did not know that the lines of a face are not lines, but the edges of fields of light. Vermeer marks the eye by a clear light upon the lid and a patch of shadow beneath it. The eye is there in unsurpassed perfection and not a line is drawn. Experience has shown that structure is an unsafe guide to function. Anatomy led the infant physiology by the hand and taught the gifted child some lessons that did not stand the test of experience. It was from the anatomist, for example, that physiologists got the notion that the respiratory centre must be a circumscribed group of nerve cells like the nucleus of the hypoglossus. Eight physiologists found this centre each in a different part of the bulb. Later investigators removed each of these centres, but respiration still went on. So it was proved that a community of function may exist in widely separated cells. A physiological centre may or may not be a group of cells closely related in space; it need only be a group closely related in function. But Ludwig's view was orthodox in his day, and powerfully influenced his disciples.

We suspect that in his heart Dr. Minot concealed a regret that he could not become a philosopher. In his letter to Mosso he says: "The agnostic position is the only possible and defensible one for a scientific man to occupy, who is loyal to the spirit of research.—No hypothesis of life yet offered requires serious scientific consideration. A confession of agnosticism is here a positive contribution to the truth. On the other hand, there is no reason for giving up the endeavor to get nearer to the final goal of biology because attempts to reach it by the short cut of speculation have always failed."

He was we perceive, wise enough to bind himself fast to the mast of demonstrable fact, before he listened to the ravishing song of the sirens of philosophy. There is a brave optimism in his search for an answer to the problem of life. We applaud the bold adventurer the more, because he has set his face against the disheartening conclusion that there is, at present, perhaps no logical hope that the Grail of physiological science can ever be found. The physiologist who seeks the key of life must proceed from established premises. The established data show that the biological scene is a succession of permutations, of momentary equilibriums, of resultants ex-

pressing the interaction of a multitude of factors. But as soon as the individual factors rise above a number so small as to constitute the major criticism upon our petty minds—we speak of chance. It is probable that the riddle of existence will never be solved, because the factors and their possible interactions exceed the apparatus for their detection. No mental gifts will ever make us hear the high-pitched sounds audible to insects, nor shall we ever listen to the music of the spheres.

Dr. Minot began his new scientific life by a study of growth, senescence, and death, subjects which occupied him for thirty years. Very likely he was first attracted to this field by the memorable researches of Dr. Bowditch on the growth of children. Dr. Bowditch often lamented that measurements of children in statistical quantities could hardly be obtained before and after the school age. Nor was it possible to follow month by month the growth of thousands of individuals from birth to maturity. Dr. Minot determined therefore to study growth as a function of age in one of the higher vertebrates other than man. His observations were begun in the physiological laboratory of the Harvard Medical School about 1885. Hundreds of guinea-pigs were weighed every day from birth up to 40 days, then every fifth day up to 215 days, then three times a month to the end of the second year after birth. Most of the results of this great task were published in 1891, in the *English Journal of Physiology*. One of the most important fruits of these studies was the recognition of a new and more accurate method of expressing growth. All previous investigators had figured the absolute rate of growth, i.e. the growth of a child in any one year was the number of pounds gained in that year. Minot points out that five pounds gained by a small child is a greater gain than five pounds gained by a large child. The true rate of growth, he very rightly insists, is expressed by the relation between the growth in any one year and the weight at the beginning of that year. This is Minot's percentile rate of growth.

The principal fact developed in the paper of 1891 was that there is in guinea-pigs a progressive loss in the power of growth, extraordinarily rapid in the early hours of life. In the first forty-five days the ability to grow decreases four-fifths.

The work with guinea-pigs was followed by valuable studies on intra-uterine growth.

Eighteen years after his first publication on growth Dr. Minot summed up his studies in this direction in a book entitled *Age, Growth, and Death*. Here he demonstrates that the rate of growth is highest at segmentation and from that hour declines, at first with great rapidity and then more slowly. The period of most rapid decline is youth; the period of slowest decline is old age. If we consider death to be the bankruptcy of an organism which spends energy beyond its income, the final dissolution is almost

complete before the highly efficient life in the womb is exchanged for that in a much less favorable environment. The paradoxes demonstrated as truths by Dr. Minot's work show us how far from correct are the conventional ideas of life. Birth and death, the accumulation and the discharge of energy, go on unceasingly side by side. There are no terminal stations. Energy is a stream that empties into its source, and life is a function of time.

The book on Age, Growth, and Death treats also of Dr. Minot's views, first expressed in 1890, regarding the increase in the amount of protoplasm within the limits of single cells. By the study of the proportionate volumes of the nucleus and the cell body, he believed he could demonstrate certain laws governing that proportion, and prove that the variations of the proportion establish conditions which are fundamental to the correct conception of growth, differentiation, death, and sex. The most characteristic peculiarity of advancing age, of increasing development, is, in Dr. Minot's opinion, the relative growth of protoplasm. The possession of a large relative quantity of protoplasm is a sign of age. It is essential to rapid growth that the proportion of protoplasm should be small. The development of protoplasm, Dr. Minot taught, is the cause of the loss of power of growth.

It will be observed that this stimulating but incomplete list of Dr. Minot's services to physiology touches but one side of his activity. I have not spoken of his many valuable contributions to morphology, of his text-books, the first of which, especially, much enlarged the influence of the young science of embryology; of his admirable addresses at scientific meetings nor of his ingenious inventions such as the rocking microtome. Time does not serve, nor can one man speak with authority of services in so many fields. Perhaps the highest praise a man can have, is that his biography must be written by a company rather than by a single individual.

It remains to speak of Dr. Minot as a friend. But of his friendship and our personal relations I cannot trust myself to speak. He shone brightest in the adversity of his friends, both by his resolute bearing toward opponents and by his counsel. Of all the words I was privileged to have from him, I best remember his saying that a scientist should never consult his personal happiness and that injuries were best forgiven and forgotten.

I believe that Charles Sedgwick Minot, the friend, the comrade, the distinguished scientist in whose honor we are met, will be in death as in life a staff for the weak, a mark for the strong, a light to guide and cheer despondent men. The weak will see in him a triumph over circumstance; the strong will draw new strength from his unrelenting years of high endeavor; and the despondent, averting their sad eyes from the fields on which so many of our ideals have lately fallen, will find in his career fresh hope

and a renewed belief that life is after all worth living.

JAMES GREGORY MUMFORD, M.D.*

By RICHARD C. CABOT, M.D., BOSTON.

AMONG those who knew James Gregory Mumford and realized his physical limitations, it has become a familiar miracle,—how he accomplished the enormous and varied work which stands today to his credit. But when one looks back over the remembrances of many years and pictures the man,—his looks, his voice, his manner, his build,—the victory over his own temperament seems even more remarkable than his conquest of physical handicaps. He was a reformer yet without many of the reformer's natural attributes. Of the reformer's traditional buoyancy and high spirits, he had not a trace. He was never buoyant or spontaneously expansive. He did not bubble over. He had none of the qualities of a steam roller; yet he was always pressing relentlessly on. He was thin-skinned, sensitive, shy and modest, yet he set himself to push through obstacles that would tear the average man to pieces.

Reformers are usually cock sure. Mumford was never so. He had almost an ironic consciousness of human fallibility,—in himself most of all. His plans and achievements never swept him away. He was their impelling force himself. In a letter written in 1910 to the secretary of his college class, he portrays his work without any of the reformer's ardor and confidence.

"So the simple record runs on," he says, "telling of mild employments in the Harvard Medical School and elsewhere. I like teaching; students pass me out the usual compliments due to credulous senility. (He was 47 when he thus described himself.) I like practising surgery; patients toss me roses mingled with thorns. I like writing about people and things, for the reviewers deal me comments which chasten the soul. Altogether, life continues a pleasant experience. I look forward with composure to the next twenty-five years."

Anyone who did not know his arduous achievements, his daring ideals, his ever-renewed battle with fate and conservatism, might gather from words like these,—indeed from most of his writings,—that he took life easily, smilingly, indulgently. His style has often the light, whimsical quality of one who looks on with tolerance and amusement at the crusading reformers. Yet he was himself a crusader and a reformer. His life never mirrored the easy-chair quality of his style; perhaps it was his way of resting from the sterner efforts of his medical career.

He had the look and manner of a recluse and I doubt if he was ever happier than when alone with his wife in the woods or by his library fire.

* Read at a meeting of the Boston Society for Medical Improvement, January 25, 1915.