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BIOGRAPHICAL MEMOIR HENRY PICKERING BOWDITCH

1840–1911.

BY

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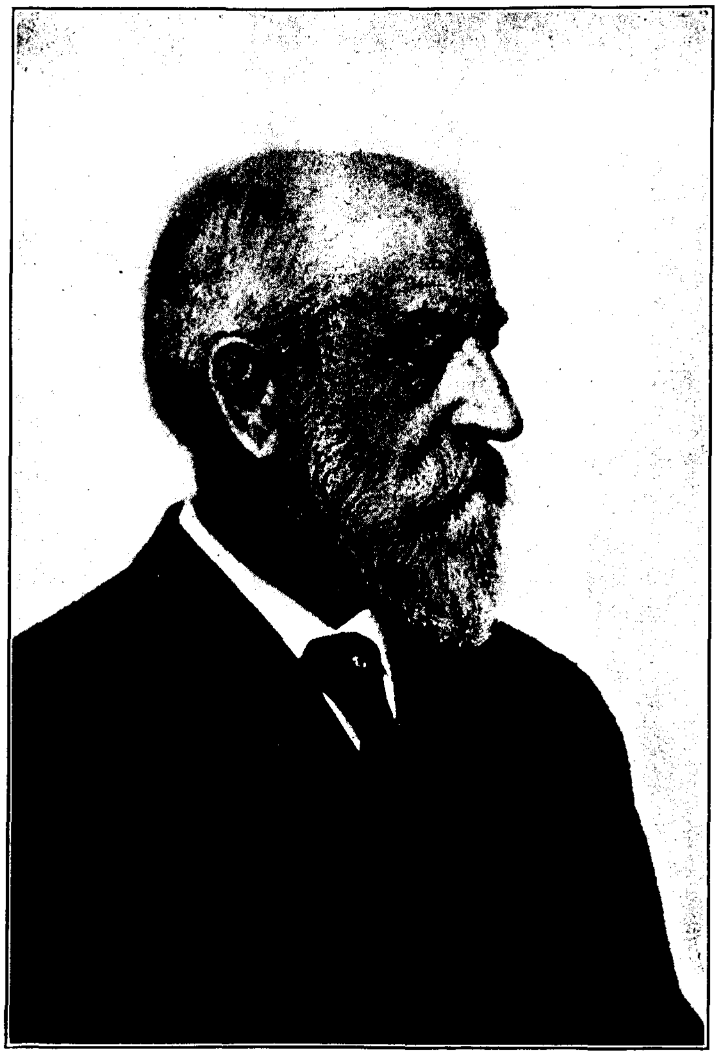

H. P. Bowditch

HENRY PICKERING BOWDITCH.

By W. B. Cannon.

Henry Pickering Bowditch was born in Boston April 4, 1840. Scientific interest and ability were manifest in both the maternal and paternal family lines. Through his mother, Lucy Orne Nichols, a woman of rare fortitude and unselfish devotion, he was related to John Pickering (a son of Col. Timothy Pickering, Washington's Secretary of State), who was a student of and an authority on Indian language. On the maternal side, also, he was related to the well-known astronomers, Edward and William Pickering, and to the mathematician, Benjamin Mills Pierce. His paternal grandfather, Nathaniel Bowditch, was a well-known mathematician who at one time followed the sea—self-educated, accurate and careful, author of "The American Practical Navigator," and translator of La Place's "Mechanique Céleste." The father, Jonathan Ingersoll Bowditch, was a Boston merchant, a man with a scientific turn of mind, who continued to edit the Practical Navigator, and who on the basis of his father's work published a set of useful nautical tables. He was interested in meteorology, and if occasion had been favorable would probably have devoted his life to scientific pursuits. He is said to have brought up his children, of whom he had five besides Henry, in a strict and uncompromising discipline.

BOYHOOD AND EARLY EDUCATION.

Life in Boston in the middle of the nineteenth century had more of the characteristics of a small town than of a city. The common was a playground for the boys, and Henry Bowditch skated on the Frog Pond in winter, "cut" behind sleighs, played "I spy," and engaged in the sports that a vigorous normal lad would naturally enjoy. When he was 13 years old the family moved to an estate in West Roxbury, situated on a hill from which there were beautiful and extensive views of Boston and the surrounding territory. Then the region was in the country, and riding and tramping were the common activities. Jamaica Pond was near and enabled the boy to become a good swimmer and diver. He and a young friend built a rowboat and he became an adept at managing it. His resourcefulness at that time is indicated by his success, when he had been blown offshore without oars, in getting to land by using the rudder as a paddle.

After his primary education he entered the school managed by Mr. Epes S. Dixwell, where he was prepared for college. The five other members of his class were Oliver Wendell Holmes, jr., Charles Greenough, Thomas B. Wales, Samuel F. Emmons, and Franklin Weld. He entered Harvard College in 1857.

About the time of his entering college he was enough interested in anatomy to clean the bones of one of his father's horses which had died, and later to set up the complete skeleton, properly articulated. His medical career, however, was not decided on till late in his college life, or after graduation,—a delay in determining his future which was very disturbing to his father. After graduation, in 1861, he entered the Lawrence Scientific School in Cambridge and started studying chemistry and natural history. The call to arms became too strong to resist, however, and he gave up his studies for service in the war.

EXPERIENCE IN THE WAR, 1861–1865.

In November, 1861, he joined the First Massachusetts Cavalry (Company G, Second Battalion) as second lieutenant. On January 13, 1862, the regiment sailed from New York for Port Royal. On June 28 Bowditch was commissioned first lieutenant and saw active service in the Battle

of Secessionville. At the Battle of Fredericksburg, December 13, his regiment was part of the reserve. He participated in General Stoneman's raid in April, 1863, and on May 13 was commissioned captain, Company E. Thereafter he was in the battles of Stevensburg, Aldie, Upperville, Culpeper, Rapidan, and Bristoe. His regiment was on important guard duties at Gettysburg. During the engagement at New Hope Church, November 27, 1863, he was shot in the right forearm while leading a charge. A furlough during his convalescence from this wound permitted him to return to Boston. On February 15, 1864, he was honorably discharged from the Army, but promptly reentered it as major in the Fifth Massachusetts Cavalry (colored). He took part in some of the earliest movements against Petersburg and entered Richmond with Weitzel on April 3, 1865.

Maj. Henry L. Higginson has described Henry Bowditch as he appeared during the war—"a handsome, refined, and homebred looking youth, with a fondness and faculty for keeping face clean and clothing neat when those attributes were a rarity * * * an upright and fine officer, often reserved and even unbending in his manner, but unflagging in his faithfulness and unflinching in his courage." In a conversation with Maj. Higginson, after the Battle of Antietam, Bowditch confessed that he had no liking for Army life, and that he longed for the time when he could devote himself to scientific studies.

MEDICAL EDUCATION.

On June 3, 1865, he resigned his command. He reentered the Lawrence Scientific School and resumed his study of comparative anatomy under Prof. Jeffries Wyman. In later years he frequently referred to Wyman's stimulating influence on his scientific development. Continuing his interests and labors at the scientific school between terms, he finished the requirements of the Harvard Medical School. As his graduating thesis, he presented a review of observations on the physiological action of potassium bromide, some of them personal. This thesis was published at the request of Prof. E. H. Clark as a "valuable addition to our knowledge." In 1886 Bowditch received the A. M. degree, and in 1868 the M. D. degree from the University.

PHYSIOLOGICAL STUDY IN PARIS.

In the late summer of 1868 he went to Paris to study. In a letter of February 12, 1869, he wrote, "I wish I could see a real good opening for a purely scientific career. Dr. Wyman and Dr. Holmes (Oliver Wendell Holmes) both advised me to study science and let practice go, but pure science in our country is rather hard to live on." At the beginning he appears to have had the idea that he might combine scientific interests and medical practice. A notebook kept during the first months in Paris has repeated references to clinics and to the great clinicians, Charcot, Broca, and Louis. He had planned, however, to work with Brown-Séquard, who had lived in Boston and Cambridge and was well known to Wyman. Brown-Séquard was encouraging, but failed to provide a place for Bowditch to work in. He therefore turned to Claude Bernard and to Ranvier, spending three days a week in physiology and the other three in microscopy. His letters home mentioned with enthusiasm the interest he found in his scientific work and the pleasures of his association with Ranvier. John Collins Warren, William James, and Charles Emerson were also in Paris at this time and together with Ranvier and other acquaintances they formed frog-hunting parties which were the source of much amusement and the occasion for establishing close friendships. After five months he wrote, "I have been devoting myself lately almost entirely to the purely scientific part of my profession, which centainly has much greater attraction for me than the more practical portion." This tendency seems to have been closely watched at home, for on March 1 his father sent him a letter urging him to follow his desires for a career in science. On March 18 the son, after expressing his gratitude, continued: "My only hesitation arose from the feeling that in following pure science I should probably not be able to support myself so soon as in taking a more practical branch. But now, being reassured in this point, I shall push on and aim at getting as thorough a physi-

ological education as possible * * *. Dr. Wyman's letter, which I received a few weeks ago, contained very strong advice for me to study pure science. He seemed to think that something was certain to turn up." In the light of later events a few lines from a letter to his mother at this period are interesting: "I have been feeling very happy at the prospect of devoting my whole time to scientific pursuits. I have been building all sorts of laboratories and medical schools in the air. In this labor I have been materially assisted by Coll. Warren (John Collins Warren), who is quite convinced that something ought to be done to raise the standard of scientific education in our community. I mean, of course, particularly medical science."

In March, 1869, he met the German physiologist, Kuhne, who, on request, laid out a career of physiological study, including a few months with Max Schultze, a year with Carl Ludwig in Leipzig, some time with Virchow in Berlin, and a final period with Helmholtz. The plan was an attractive one and Bowditch decided at once to undertake at least the first part of it.

PHYSIOLOGICAL STUDY IN LEIPZIG—MARRIAGE.

On May 9, 1869, he arrived at Bonn and there remained until midsummer studying microscopic anatomy under Schultze and Rindfleisch. In September he settled at Leipzig and at once entered into the activities of the physiological laboratory of Prof. Carl Ludwig. It was without doubt the most stimulating and interesting center of biological research in the world at that time. Ludwig himself was an ingenious and fertile investigator in a wide range of problems, and had a most attractive personality. Men drawn to him at first by his discoveries were held by the beauty and force of his character and became loyal friends and followers. Students gathered about him from all parts of the world. There Bowditch met Lauder Brunton of Scotland, Ray Lankester of England, Mosso of Italy, Kronecker of Germany, Ustimowitsch of Russia—all of whom became close friends. A club made up of this group dined together daily and talked over their laboratory experiences and other matters of interest. Ludwig was a constant delight to them. He had recently invented the kymograph for the registration of records of physiological processes on a moving surface. The time and the period of electrical stimulation were marked on the surface by hand. Young Bowditch invented a means of doing this automatically. In a letter written on November 7, 1869, he told of this event. "Prof. Ludwig is a very amiable and agreeable man. He must be between fifty and sixty years old, but he retains his youthful enthusiasm and a remarkable faculty of finding pleasure and amusement in trifling matters. I arranged a little apparatus yesterday attached to a metronome for the purpose of marking time on a revolving cylinder covered with smoked paper (an instrument much used in various physiological experiments), and it was real fun to see how delighted the professor was with it."

In May, 1869, Charles W. Eliot was elected president of Harvard University. In December he proposed that Bowditch return to the United States and deliver a course of university lectures on physiology during the second term of 1870-71. This Bowditch declined to do, because it would require him to give up the last and most valuable six months of his proposed period of study in Germany. A letter from his uncle, Henry I. Bowditch, a few weeks later strongly urged him not to be "wheedled into coming home"—a supporting opinion which he much appreciated.

With the exception of time spent with members of his family on trips to Italy in March and April and to England in July, Bowditch continued at work in the Leipzig Laboratory, finding "the exhaustive way in which questions are treated by the German investigators" "very satisfactory" and contrasting "very strongly with the French method." In November, 1870, he went to Munich for a month to listen to a course of lectures by Prof. Carl Voit on nutrition and metabolism —"very interesting and important," as he wrote. On returning to Leipzig he began purchasing apparatus for use in his own laboratory when he should be established in Boston or Cambridge again.

In April, 1871, President Eliot offered him the position of assistant professor of physiology at the Harvard Medical School and invited him on his return home "to take part in the good

work of reforming medical education." His uncle had warned him to be cautious about accepting a subordinate position and to insist on his "rights." But young Bowditch accepted without conditions, explaining, "on general principle I think it is best to take it for granted that people are going to do the right thing."

In August he put together in an "essay" the results of the year's investigation and handed it to Prof. Ludwig, "who seemed quite well pleased with it." A few days later he left Leipzig, Ludwig accompanying him to the station, seeing him into the cars, and kissing him "very affectionately" on taking leave of him. Thus ended an experience which had a profound effect on Bowditch's scientific interests, and which did much to impress on him and his American students the methods and standards of the Leipzig school.

From Leipzig Bowditch went to Oberammergau to witness the Passion Play. He was accompanied by his Russian colleague, Ustimowitsch, and by Miss Selma Knauth and her mother, Leipzig friends whom he had known for many months and at whose house he and other American students had received a delightful hospitality. He intended to proceed from Oberammergau to Munich "and from there straight to Paris," but on August 16, at Munich, he became engaged to Miss Knauth and his plans were changed. On September 9, at Leipzig, with Ustimowitsch as groomsman, he was married, and on September 14 he and his wife sailed from Liverpool for the United States.

So many and so varied were Dr. Bowditch's activities during the years of his service in Boston that it will be impossible to give a clear chronological account of them. Instead, the various aspects of his labors will be dealt with separately.

SERVICES TO PHYSIOLOGY.

On his return to Boston there was no physiological laboratory for Bowditch to work in. The rooms in the old Medical School Building on North Grove Street were crowded. Two small rooms in the attic were made over, however, and in them was placed the apparatus which had been brought back from Germany. This was the first physiological laboratory for the use of students in the United States.

These rooms might perhaps be better designated the first laboratory for experimental medicine established in this country, for every phase of experimental medical work was represented there within a few years after its establishment. Charles S. Minot carried on investigations in general biology, J. Ott and R. W. Lovett in experimental pharmacology, J. C. Warren in experimental pathology, G. Stanley Hall and W. F. Southard in experimental psychology, O. K. Newall in experimental surgery, and W. P. Lombard, J. J. Putnam (assisted by William James), C. S. Minot, G. M. Garland, C. H. Williams, J. W. Warren, F. H. Hooper, and F. W. Ellis in physiological researches. The hospitality of the laboratory was unbounded; indeed, some of the first careful work on bacterial cultures in this country was done there by H. C. Ernst. With Dr. Bowditch's enthusiasm and inspiration almost every scientific interest of a complete modern medical school was stimulated. From the start the emphasis was on productive scholarship. In the preface to the first collection of papers published from the laboratory the announcement was made that the contributions were presented in a volume, "not from any exaggerated idea of their value and importance, but with the hope that by calling attention to the facilities offered in the laboratory for original research a greater number of workers may be encouraged to attempt the investigation of the many physiological problems now pressing for a solution."

The Leipzig Laboratory was characterized by the simultaneous pursuit of a variety of problems. It was characterized also by the attempt to explain physiological facts in physical terms and by the use of physical methods. Thus Dr. Bowditch had come to know "the many physiological problems" and had learned ways of attacking them. The employment of physical apparatus gave play to his inventive faculties. As already noted, one of the first things he did at Leipzig was the contriving of records of time and stimulation periods on the kymograph to accompany the physiological tracing—a device said to have first directed Ludwig's attention to

the young American's abilities. The invention of the "Bowditch clock" to mark various periods time was another product of his Leipzig experience. In the Harvard Laboratory a new form of induction apparatus, with the secondary coil turning at various angles to the primary, and permitting in brief compass variation of intensity of the induced current, a new form of plethysmograph to register changes in the volume of organs, a new apparatus for artificial respiration, a novel animal holder, a cannula for observing the vocal cords, and a special arrangement of unpolarizable electrodes were evidences of his ingenuity. Apparatus, however was always a means to an end and never became a central interest for him.

Two papers were published on the basis of work done under Ludwig's direction. The first, on peculiarities of the irritability of cardiac muscle, has become a classic in physiological literature. In this contribution are pointed out two fundamental characteristics—the "Treppe," or step-like increase of contraction, in response to a repetition of uniform stimuli, which is accounted for by the effect of activity itself in causing greater responsiveness in the tissue; and the "all-or-none law," i. e., the contraction of cardiac muscle to a maximal extent, at the moment, independently of the strength of stimulation, or no contraction whatever. The former observation has been proved to be generally true of irritable structures and is at the basis of "warming up" for action; the latter has been extended in recent years to the contraction of the fibers of skeletal muscle and to the passage of impulses along nerve trunks. The second paper was concerned with the interference between accelerator and inhibitor nerves on the heart as influenced by variations of arterial blood pressure.

Interest in the physiology of cardiac muscle was continued in the laboratory at the Harvard Medical School, and resulted in a demonstration of the incapacity of the apex of the frog's ventricle to show a spontaneous rhythm after being isolated from the base, though normally nourished and though remaining irritable to external stimuli.

Wyman had called attention to the ability of ciliated epithelium to exert a force by no means inconsiderable. This observation Bowditch made the subject of an investigation and by having the ciliated cells move weights up an inclined surface he calculated that in a minute they did an amount of work equal to lifting their own weight 4.25 meters. When he demonstrated this effect in Leipzig at one of his visits to Ludwig it aroused much interest among the group of investigators there.

Another line of interest developed in the Harvard Laboratory was concerned with the nervous control of blood vessels. As early as 1874, Bowditch and Minot published a paper showing that chloroform has a much more profound effect than ether in depressing vasomotor reflexes. Later Bowditch and Warren undertook an extensive investigation of the influence of different rates and strengths of peripheral stimulation on the contraction and relaxation of blood vessels. This study, which has received much attention, showed that by varying the nature of the stimuli it was possible to produce constriction, or constriction followed by dilation, or dilation alone—rapid stimulation favoring constriction and later dilation. This mode of separating vasoconstrictor and vasodilator effects was extended by means of experiments on degenerated nerves. It was found that whereas immediately after nerve section a given stimulus caused pure constriction, the same stimulus applied to a nerve which had been severed four days previously induced a pure dilation. These results have suggestive values which have not yet been fully appreciated. Similar reversals of effect were reported by Bowditch in relation to etherization. Thus the glottis may be constricted or dilated according to the degree of etherization and the strength of the stimulus applied to the recurrent laryngeal nerve. Likewise in the frog extension of the leg and abduction of the toes, as a result of exciting the sciatic, will give place, under ether, to flexation and abduction.

With Garland, Bowditch investigated the effect of the respiratory movements on the pulmonary circulation, and came to the conclusion that expansion of the lungs diminishes the size of the pulmonary vessels, and that collapse of the lungs has the opposite effect, the changes being more marked on the venous than on the arterial side.

The functioning of the nervous system was for a time a central interest in Bowditch's thinking. "What conception can one form of the physical or chemical changes which take

place in those white glistening bands which are for us the only channels through which knowledge of the physical universe can be obtained and which also enable us to impress upon the world around us the evidence of our conscious personality?" Bernstein had concluded that a nerve fiber could be exhausted by tetanic stimulation for 5 to 15 minutes. Widenski, however, had not been able to demonstrate exhaustion during stimulation for several hours. Using curare as a temporary block to nerve impulses, Bowditch stimulated the peripheral end of the cut sciatic from one and a half to four hours and as the effect of the drug wore off saw the muscle respond. Thus new evidence was obtained of the indefatigability of the nerve trunk—a fundamental fact in the physiology of the nervous system.

Another research, on conditions modifying the knee jerk, conducted in cooperation with Warren, brought out important new facts regarding the interaction of influences in the nervous system. Voluntary contraction of another part of the body had been used by clinicians for some years as a means of reinforcing the patellar tendon reflex. In this research it was shown that not only voluntary effort but also afferent stimuli applied to different parts of the body could affect the degree of response, and furthermore that the reinforcement occurred only during a fraction of a second and was commonly followed by a period of depression, lasting a second or two, in which the jerk was diminished or abolished. Thus activity in one part of the nervous system may first exalt and then depress the activity in another part.

The foregoing review of Dr. Bowditch's contributions to physiology shows the variety of interests which he entertained and the suggestive character of the work which he performed. It was typical of his papers that they dealt very little with speculative features. This was not due to lack of imagination, for many of the reports of his work promised further pursuit of the subject, showing that he saw the interesting problems hinted at by the results that were obtained.

Aside from engaging in physiological research and stimulating young men to engage in it, Dr. Bowditch for years wrote for the *Boston Medical and Surgical Journal* semiannual reports on the progress of physiology. In these reports he summarized the results of a group of investigations on one or more broad topics, and commented upon them. It was a practice which served to keep his interests extended and to suggest to him new lines of study and research.

He was one of the principal founders of the American Physiological Society, in 1887, and succeeded S. Weir Mitchell in 1888 as its second president. He was reelected president during the years 1891–1895, and served for many years besides as a member of the council. The traditions of the society, particularly its character as an association to encourage research, are largely the result of his initiative. His attendance at its meetings was regular, and his example and his genuine appreciation of new work as it was reported were a wholesome stimulus to young men beginning physiological investigation.

In 1877, when Michael Foster started the English *Journal of Physiology*, Bowditch was consulted and agreed to serve as one of the American editors. Until 1898 the publications from the Harvard Laboratory appeared in that *Journal*. When the activities of American physiologists became sufficiently great to warrant the establishment of an American journal, Dr. Bowditch gave support and encouragement to the efforts of Dr. W. T. Porter, a member of his departmental staff, in establishing the *American Journal of Physiology*, and was on its first editorial board.

SERVICES TO PSYCHOLOGY.

For many years, and especially in his later life, Dr. Bowditch was interested in the physiology of the senses, an aspect of physiology which has since been taken over largely by the experimental psychologist. In 1881 he published, in cooperation with W. F. Southard, an investigation into the relative accuracy of our knowledge of position in space as obtained by sight and by touch. Evidence was adduced showing that direct vision gave the most accurate special knowledge, with touch second, when tested by the hand which had been experienced in

locating the object. For details of this interesting paper, such as the influence of time, etc., the reader should consult the original.

With G. Stanley Hall, Dr. Bowditch made a study of certain illusions of motion, e. g., the influence on the observer of watching a revolving spiral, the "waterfall effect," the apparent rotation of concentric circles when subjected to a "rinsing" movement. These curious phenomena were tested by modifications of the figures and were given explanations. The attention to the physiology and psychology of vision, which this and the previous research initiated, persisted to the end of Dr. Bowditch's scientific career. When other activities consumed most of his time, he still kept abreast of the literature of this field.

With a small group of colleagues in Boston he took up psychical research and aided in founding and for several years in managing the American branch of the Society for Psychical Research. His open-mindedness was revealed in this action and was characteristic, but his experience finally rendered him extremely skeptical as to the reality of telepathy and other alleged psychical phenomena.

SERVICES TO ANTHROPOMETRY.

At a meeting of the Boston Society of Medical Sciences, September 24, 1872, Dr. Bowditch exhibited diagrams showing the rate of growth of a small number of boys and girls near the age of puberty that differed from Quetelet's Belgian figures, in that the average height of the girls was greater than that of the boys at about the thirteenth and fourteenth years, a relation that was thereafter reversed. Dr. Bowditch's suggestion that more extensive data, especially related to the influence of race and climatic conditions on growth, would be interesting was the occasion for a vote authorizing such a study in Boston school children (1875). This novel undertaking was regarded as basal for similar studies elsewhere, under different climatic circumstances, and with different foreign elements predominating in the school population. To only a small degree has the opening thus made been utilized in other communities. The main points brought out by Bowditch's pioneer work were (1) that until 11 or 12 years of age boys are taller and heavier than girls of the same age, then girls begin to grow rapidly and for two or three years surpass boys of the same age in both height and weight, whereupon boys begin to forge ahead of the girls who have nearly completed their full growth; (2) that children of American-born parents are taller and heavier than those of foreign-born (Irish) parents; (3) that children of American parentage in selected schools are superior in height and weight to corresponding children in the public schools; and (4) that these same children (in the selected schools) are superior to English boys in public schools and universities, particularly with regard to weight. Six important new lines of study were indicated at the end of the report (which was issued by the State board of health in 1877) in case similar examinations were made in other communities.

It was suggested that the difference between the growth of the native and the foreign born (point 2, above) might be due to more favorable living conditions in the former group or to differences of race and stock. To throw light on this problem the data were retabulated according to the occupation of the parents and the results published in a supplementary report in 1879. Although the classifying of occupations could not be accurate, the results justified the cautious conclusion that probably the mode of life, as a factor in determining the size of growing children in Boston, is at least equal to, and possibly even greater than, that of race.

In 1889 was published Galton's "Natural Inheritance," in which he elaborated his scheme of "percentile grades" as a means of displaying the results of statistical inquiry and facilitating a comparison between various sets of observations. In a paper on the "Physique of Women in Massachusetts" Dr. Bowditch, in 1890, called attention to the advantages of this scheme, and in 1891 he published a review of his data on the growth of school children, based on the application of Galton's method. One of the new points thus brought out was that the period of acceleration, which is so prominent a phenomenon in the growth of children, occurs at an earlier age in large than in small children. For other inferences and for the discussion the reader must consult the original paper. The conclusions, of course, were based on data from children

measured at different ages and involved the assumption that large, small, and medium-sized children remained in those groups as the years passed. Dr. Bowditch recognized the possibility of error in this assumption and urged the importance of securing reliable observations made at frequent regular intervals on the same children during the period of adolescence. We should then be able, he declared, "to draw fairly accurate conclusions as to the normal range of variation in percentile rank during the period of growth and to determine how far the rate of growth in the earlier years of life is to be regarded as an indication of the size to be subsequently attained." This suggestion is now being realized and within a short time we should have normal standards of development derived from observations through a series of years on large groups of children.

Another hint offered by Galton that bore fruit in Bowditch's activities was the use of composite photographs as a method of recording typical or generic features. In a popular article published in 1894 he reproduced some of the results of his own studies. At the close of it he pointed out various interesting applications of the method which might be made even by the amateur photographer.

In 1881, before the section on children's diseases of the American Medical Association, Bowditch presented a communication calling attention to the loss of weight in growing children just antecedent to the onset of acute or chronic illness. He urged the importance of further studies to determine the relations between growth rate and disease, with the hope that the data thus accumulated might be useful in preventive medicine as applied to childhood.

A set of rules regarding the mode of collecting information at autopsies, which was prepared by Dr. Bowditch and Dr. F. A. Harris in 1882, was further evidence of his interest in anthropometry. In this field, as in physiology itself, his labors were varied and were most suggestive. In many respects the lines of work laid down by him have not been much extended since his pioneer work was done, and offer now as many valuable hints for further investigation as they did when he wrote.

SERVICES IN THE PROTECTION OF MEDICAL RESEARCH.

Beginning in 1896, when the antivivisectionists made a vigorous effort to obtain legislation restrictive of animal experimentation in Massachusetts, Dr. Bowditch became an ardent defender of freedom of research within the law. In association with H. C. Ernst and others he appeared repeatedly before legislative committees both in Boston and in Washington, giving reasons for opposing bills directed toward restricting the activities of medical investigators. In an important address before the Massachusetts Medical Society in 1896, he summarized these reasons as follows: "(1) That the men in charge of the institutions where vivisections are practiced in this State are no less humane than those who desire to supervise their actions, while they are, at the same time, vastly better informed with regard to the importance of animal experimentation and the amount of suffering which it involves; (2) that no abuse of the right to vivisect has been shown to exist in these institutions: (3) that the governing bodies of these institutions possess both the will and the power to put a stop to such abuses should they arise: (4) and that the existing statutes furnish sufficient protection against cruelty in vivisection as well as against cruelty in general." His hostility to *any* restrictive legislation some of his friends found difficulty in understanding. It was based on two considerations; first, as stated above, that the existing anticruelty laws are adequate to punish any experimenter who is wantonly cruel in the course of experimental procedures; and second, that the passage of restrictive legislation in England had not lessened but had increased the efforts of the antivivisectionists. In other words, the aim of these agitators is complete abolition of the use of animals for medical advance—a result which, as he sanely regarded it, would be disastrous to the welfare of both man and the lower animals themselves. In the legislative hearings on this subject his manifest honesty and singleness of purpose added weight to the evidence he brought forward and to the opinions he expressed. The struggle to preserve freedom of medical investigation in this country has been carried on along lines which he followed and by the open and frank methods which he employed.

SERVICES ON COMMISSIONS ON THE ALCOHOL PROBLEM AND SANITATION.

As early as 1872, Dr. Bowditch read before the Boston Society of Medical Sciences a discussion of alcohol as a nutritive agent. He there raised the question whether in morbid conditions, when in large amounts it does not induce narcotism, it may not have nutritive values which it does not offer to the healthy organism. This early interest in the pharmacological action of alcohol, as well as an interest in the social problems attending its use, he maintained for many years. In 1893 he and John Lowell and John Graham Brooks were appointed by the Governer of Massachusetts as a commission to investigate the Gothenburg and Norwegian systems of licensing the sale of intoxicating liquors. An extensive report of their examination of these systems was rendered in 1894.

Dr. Bowditch was a member of the Committee of Fifty to investigate the liquor problem and was on the subcommittee on the physiological and pathological aspects of the problem. With Dr. C. F. Hodge he made an extensive report, in 1903, on the statements given in textbooks and by eminent physiologists both in the United States and in Europe regarding the physiological action of alcohol.

In 1874, Bowditch served with C. W. Swan and E. S. Wood, on a commission appointed by the mayor of Boston to examine and report upon the comparative desirability, on sanitary grounds, of the rivers near Boston which might serve for additional water supply.

SERVICES TO MEDICAL EDUCATION.

Until 1865, instruction in physiology at the Harvard Medical School was given by Oliver Wendell Holmes, Parkman professor of anatomy and physiology. It consisted of remarks on function during anatomy lectures and of a relatively small number of lectures on physiology itself at the end of the course. From 1865 to 1870, Dr. Josiah S. Lombard aided in the physiological teaching, and during the year 1870-71, Dr. William T. Lusk, as lecturer in physiology, presented the subject and illustrated it with numerous experiments. This subordinate position of physiology in the medical curriculum was changed when Bowditch returned from European study in 1871. The Parkman professorship was restricted to anatomy, and though Bowditch had the title of assistant professor he had full charge of physiological instruction and at once instituted an admirable course of lectures and demonstrations. He continued in active service for 35 years. In 1876, he was appointed professor, and from 1903 until his resignation in 1906 occupied the newly established George Higginson professorship of physiology in the Harvard Medical School.

In the teaching of physiology Dr. Bowditch's instruction was marked by wide learning, clear discussion of controverted questions, cautious inference when convincing facts were not at hand, and by orderly exposition. His lectures were unusually well illustrated by methods which made lasting impressions. A notable contribution to educational procedure was the sending of students to the original sources for material for physiological theses which were read before the class. The conferences at which these theses were presented and the weekly quizzes which Dr. Bowditch conducted were delightfully informal and conversational. Although welcoming with open mind the introduction of the laboratory method of teaching physiology in the later years of his service as a professor, he warned against too great a reaction from purely didactic methods of instruction "lest useful as well as useless things be swept away," and declared that "a good teacher with a bad method is more effective than a bad teacher with a good method."

Looking back on 27 years of experience he was so impressed by the vast increase of knowledge of medical science and of diagnostic and therapeutic procedures that he urged, in 1898, as president of the American Society of Naturalists, certain reforms in medical education. Again in 1900, as president of the Congress of American Physicians and Surgeons, he returned to the problem presented by the immense mass of information which medical schools are attempting to crowd into students during the four-year course, and in an address on "The Medical School of the Future" ventured certain predictions. Because the future medical school must

offer advanced instruction in all subjects, and because this will be more than any student can reasonably learn, an elective system will be adopted. This involves, as he had previously shown, drawing a distinction between essential subjects which every student should know, and desirable subjects which certain students should know, i. e., provision for required and for elective studies. Besides this feature of future medical instruction, greater emphasis on practical experience, concentration of attention on one principal subject at a time, with arrangements for natural sequence of these subjects, and such examinations as will test the student's permanent acquisition of usable medical knowledge, were emphasized as probable characteristics of the way in which the teaching of medicine will develop. Twenty-one years have passed since this address was given. During that time the pressure on the medical student has increased still further, so that the problem discussed by Dr. Bowditch has become more acute than ever, and medical teachers are laboring to seek the relief which he sought. To what degree his suggestions will prove to be wise is not yet clear.

SERVICES TO THE COMMUNITY, TO GENERAL SCIENTIFIC ORGANIZATIONS, AND TO THE UNIVERSITY.

In spite of his large interest in medical research and education, Dr. Bowditch maintained throughout his life useful relations with public affairs nonprofessional in character. From 1877 to 1881 he was a member of the Boston school committee. In 1886 he was president of the Massachusetts Infant Asylum. He was also president of the Boston Children's Aid Society and helped to broaden its scope and importance. Between 1895 and 1902, as a trustee of the Boston Public Library, he was active in favoring the dissemination of good literature. He served on the joint special committee on education and health of the American Social Science Association, the function of which was to consider public schools in their relation to public health.

In 1872 he was elected a fellow of the American Academy of Arts and Sciences. During the year 1877 he was its recording secretary, and from 1881 to 1883 a member of its council. For 22 years he served on the library committee. In his address as vice president of section F (biology) of the American Association for the Advancement of Science he summarized the evidence which he and others had obtained regarding the nature of the nerve impulse. To the affairs of the National Academy of Sciences, to which he was elected in 1887, he gave his time generously and helpfully. He was actively interested from the beginning in the promotion of the International Physiological Congresses which brought together every three years physiologists from all parts of the world. From its foundation in 1886 until 1906 he acted as trustee of the Elizabeth Thompson science fund and to him belongs much of the credit for its successful administration.

It will be recalled that when Bowditch was in Europe in 1870 President Eliot invited him to return to the University "to take part in the good work of reforming medical education." In the pioneer work of developing a graded course of instruction and in the other reforms which the new president struggled to institute he found Dr. Bowditch a staunch supporter. After the resignation, in 1883, of Dr. Calvin Ellis, who had been dean of the school during the years of its transformation into a true university department, Dr. Bowditch was appointed dean and served in that capacity for 10 years (until 1893). During that period important changes were introduced in the medical department. Bacteriology was recognized as a regular study, a novel venture under Bowditch's leadership. The four years' required course was adopted, another forward step which the Harvard Medical School was among the first to take. A further significant innovation was the calling of outstanding men from other universities to assume positions in the school—Dr. W. H. Howell came from Michigan to be associate professor of physiology and Dr. W. T. Councilman came from Johns Hopkins to be professor of pathology.

As already stated, young Bowditch wrote to his mother from Paris in 1869, when he first had the prospect of a purely scientific career, "I have been building all sorts of medical schools and laboratories in the air." He took a leading part in the planning of the new building started on Boylston Street in 1881, and his deanship coincided with the first 10 years of occupancy of

that building. In 1899 and 1900 Dr. Bowditch initiated in the faculty the movement for the new buildings of the Harvard Medical School, and for securing the land for neighboring hospitals. During the next few years he cooperated with Dr. John Collins Warren, his friend of Paris days, in raising the funds needed to complete the great project. The group of splendid structures, which were completed in 1906, together with the hospitals now surrounding them, are a monument to the vision and faith and devoted efforts of these lifelong companions.

GENERAL CHARACTERISTICS, HONORS, LAST YEARS.

Everyone who came in close contact with Dr. Bowditch was impressed with his rare combination of sure and sober judgment, vigorous will, and readiness for action—qualities which made him a natural leader. His imagination was fertile with ingenious and effective ways to secure the accomplishment of worthy ends. He was eminently single-minded; the matter in hand was always the important matter to be attended to. Persons who knew him well for many years recall that he seldom spoke of the past, almost never of his experiences in the Civil War, and rarely of his earlier researches. The forward look to the fulfillment of plans already started was typical of him to the last.

The qualities of energetic leadership were tempered by unfailing courtesy, fairness, and good will. His conversation was not witty and lacked the light touch, but he had a keen sense of fun, and his hearty laugh was rewarding to the humorous fancies of his fellows. These lovable traits brought to him the friendship and lasting devotion of the foremost men of medical science, as well as of his students and his associates in his various interests. The Bowditch Club, an organization of active medical investigators in Boston, started during the late nineties and, continuing until after his death, was a tribute not only to his eminence in science but to his genial and wholesome spirit. Friendship was to him a blessing to be cultivated. He rejoiced in having his friends with him at his beautiful home near Jamaica Pond in Boston, and in his summer camp, or in going to be with them. Comrades of his Leipzig days visited him thus, as well as Sir Michael Foster, Prof. Mosso of Turin, Prof. Gaskell of Cambridge, England, and Prof. Waller of London; and he frequently renewed association with them in Europe.

His interest in the physiology of vision may have been related to the fact that he was himself red-green color blind. He had no appreciation for music and could not sing, nor play any musical instrument. It is said that he had little insight into any but the realistic qualities of pictorial art. He loved outdoor life. Skating, mountain climbing, and kite flying were among his diversions. He was skillful at the lathe and in glass blowing. His inventiveness and his manual skill were put to use frequently in the laboratory and also in the rough life of the Adirondack camp. The Bowditch chair, a remarkably comfortable piece of furniture, was the outcome of these abilities applied to side interests.

Numerous honors came to him in this country and abroad. Election to the National Academy of Sciences has been mentioned. He was also a member of the American Philosophical Society and of many other scientific bodies. The Royal Society of Medicine and Natural Science of Brussels and the Academy of Science of Rome enrolled him among their members. The University of Cambridge made him doctor of science in 1898; and Edinburgh (1898), Toronto (1903), Pennsylvania (1904), and Harvard (1906) gave him the degree of doctor of laws.

When the new buildings of the medical school were dedicated in 1906, the disease, paralysis agitans, which five years later proved fatal, had already made serious inroads on his health. Gradually his strength and his ability to take part in outside activities became more and more limited. Aware of the hopelessness of his condition, he surrendered with patience and fortitude to the confinement which was forced upon him. Almost to the last, however, he welcomed the visit of friends, and manifested a keen interest in the affairs with which he had been associated in his active years. On March 13, 1911, he quietly passed away.

Dr. Bowditch's traits and achievements bring into prominence the transmission of exceptional qualities through the generations. His grandfather was a man of unusual originality and force. His father's scientific interests were maintained along with a business career. A

brother, Charles P. Bowditch, like the father, though engaging in business pursuits, was keenly alive to scientific matters and made important contributions to American archeology. Five daughters and two sons survive in the line of Henry P. Bowditch to carry on the family characteristics.

There is an intellectual inheritance which may be transmitted from person to person outside of family ties. The stimulating eagerness for research received from Ludwig his students carried far and wide. Bowditch brought the spirit to the United States. The manifold services demanded of him and regarded by him as duties, that have been referred to in the foregoing pages, encroached upon his time and prevented him from devoting himself, as he otherwise might have done, to physiological research. The conflict between scientific study and administrative activities seems to have disturbed him, for it is recorded that occasionally in the late years of his life he would ask a friend whether his life would not have been of greater service if he had devoted himself exclusively to experimental physiology. The question is a difficult one to answer. It is true, however, that he was not drawn away from research until he had transmitted to others the inspiration he had drawn from Ludwig and the Leipzig group. Thus in the line of intellectual inheritance he could claim, among his own direct successors, William James, James J. Putnam, G. Stanley Hall, Warren P. Lombard, Walter B. Cannon, Joseph W. Warren, and many others whom his enthusiasm and his imagination and his sterling honesty and love of truth had influenced.

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