NATIONAL ACADEMY OF SCIENCES
BIOGRAPHICAL MEMOIRS
PART OF VOLUME VII

BIOGRAPHICAL MEMOIR

OF

WILLIAM KEITH BROOKS

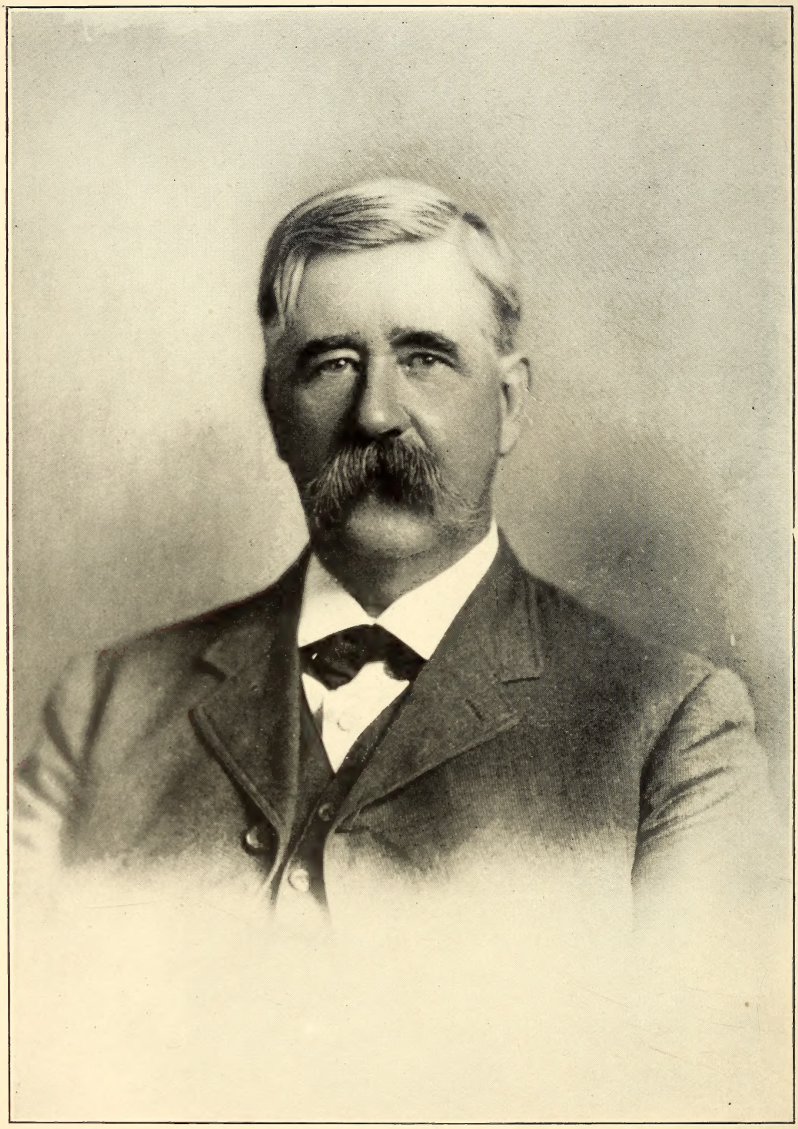
1848-1908

BY

EDWIN GRANT CONKLIN

READ BEFORE THE ACADEMY AT THE AUTUMN MEETING, 1909

CITY OF WASHINGTON
PUBLISHED BY THE NATIONAL ACADEMY OF SCIENCES
April, 1910



Yours Truly
W. K. Brooks

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WILLIAM KEITH BROOKS.*

ANCESTRY AND FAMILY.

William Keith Brooks, Professor of Zoology in the Johns Hopkins University, was born at Cleveland, Ohio, March 25, 1848, and died at his country home, "Brightside," near Baltimore, November 12, 1908.

Although Professor Brooks used to say jocosely that his known line of descent was too short to be of much interest to a student of phylogeny, it goes back, nevertheless, to some of the earliest settlers of Massachusetts. On his father's side he was descended from Thomas Brooks, who came from England to Boston prior to 1634, and soon thereafter settled in Concord. For five generations preceding the Revolution the Brooks homestead was in Concord. His great grandfather, Joshua Brooks, served in the battle of Concord; his grandfather, Joshua Brooks, was born in Lincoln, Massachusetts, in 1780, whence he removed to Burlington, Vermont; his father, Oliver Allen Brooks, was born in Middlebury, Vermont, in 1814, and moved to Cleveland, Ohio, in 1835, where he became one of the early merchants of that city.

Through his mother he was descended from John Kingsley, who came from England to Dorchester, Massachusetts, about 1638. His maternal grandfather, the Rev. Phineas Kingsley, was born in Rutland, Vermont, in 1788, and moved to Ohio in 1847; his mother, Ellenora Bradbury Kingsley, born June 30, 1817, was married in 1840 to Oliver Allen Brooks, of Cleveland. The parents of Professor Brooks were second cousins,

* In the preparation of this memoir the writer has had the invaluable assistance of Mr. Oliver K. Brooks and Prof. E. A. Andrews. The former has supplied all information available concerning the ancestry and early life of his brother, and he has also furnished certain details concerning his later life and personal traits. Professor Andrews has assisted materially in the compilation of the bibliography, and a free use has been made of his several articles on Professor Brooks.

both of his grandmothers having been cousins of the name of Keith, and descended from the Rev. James Keith, who came from Scotland to Boston in 1662, and became the first settled minister of Bridgewater, Massachusetts.

Although the genealogy of Professor Brooks is thus known for eight generations, the characteristics of his ancestors are not sufficiently well known to justify an attempt to study his heredity. Most of his immediate ancestors in this country were farmers, but his maternal grandfather, the Rev. Phineas Kingsley, was a Congregational clergyman. He had only a common-school education, and had studied theology under a local clergyman, but he was a studious, well-informed man; he had a fund of knowledge about animals and plants, derived from his own observations, rather than from reading, and it is not improbable that his conversation and example may have turned his grandson's attention to the study of living things.*

William Keith Brooks, the subject of this memoir, was the second son of Oliver Allen and Ellenora (Kingsley) Brooks. He had three brothers, all of whom survive him; the oldest, Oliver Kingsley Brooks, born May 21, 1845; the third son, Charles Ernest Brooks, born March 30, 1851; the youngest, Edward Howard Brooks, born November 21, 1854.

Professor Brooks married, on June 13, 1878, Amelia Katherine Schultz, daughter of Edward Thomas Schultz and Susan Rebecca (Martin) Schultz, of Baltimore. To them two children were born, Charles Edward Brooks, August 26, 1879, and Manetta White Brooks, April 21, 1881; the former, after finishing his undergraduate course, took the degree of Ph. D. in mathematics at the Johns Hopkins University, and is now devoting himself to research in that subject; the latter is a graduate of Vassar College, and after the death of her mother in 1901, took charge of her father's home and became his daily companion; in 1909 she married J. Frank Daniel, Bruce Fellow in Biology in the Johns Hopkins University.

Professor Brooks rarely spoke of his ancestry or early life, and for the following illuminating account of his boyhood,

* William L. Kingsley, long-time Treasurer of Yale College, was a cousin of Phineas Kingsley.

which I have taken the liberty of editing and arranging, I am indebted to his brother, Oliver K. Brooks.

EARLY HISTORY OF W. K. BROOKS.

By Oliver K. Brooks.

EARLY DAYS IN CLEVELAND.

"The conditions in which my three brothers and I spent our childhood and youth were almost ideal. Our father lived on lower Euclid avenue, then one of the pleasantest and most agreeable residence sections of the city, now entirely given up to business. We had congenial neighbors, most of whom lived near us for a long time. Many of them had children of about our own ages who were our friends and companions.

"We lived in a large, comfortable, and substantial old frame house with large grounds, especially in the rear, where there was an apple and pear orchard and a hickory tree, reminders of the time when the place was country property, or perhaps part of a farm.

"Near the house was a builders' lumber yard, which was a favorite playground for us, and near by, in another direction, was a convent of Ursuline nuns, with extensive buildings and grounds, separated from the street by a high brick wall. This convent was a place of mystery to us.

"We had an indulgent father and a devoted mother, and an aunt, my mother's sister, who lived with us as one of the family until she married, and until some time after, when her husband, Mr. Warner, bought a house nearly opposite our own. Their house was always like a second home to us.

"My mother's father and mother lived on a small farm some five or six miles south of the city on the Columbus road. He was a retired Congregational clergyman, but he never had a church of his own after he came to Ohio, but used to preach in neighboring towns when he was needed.

"It was a great delight to us to visit our grandfather's farm, and I and my brother William used to spend Saturdays and holidays there. Grandfather used to entertain us with stories of his life in Vermont and of the pioneer days there. He had seen military service in the days preceding the War of 1812.

He had an excellent memory, and was a very good story teller. He taught us to fish, and used to take us on nutting expeditions in the fall.

"Talks with him may have had something to do with turning my brother's thoughts to the study of animated nature. He had in his small library two books—"Thompson's History of Vermont" and the "Philosophy of Natural History," by Smellie—in both of which I know my brother was interested. The first contained an account of the fauna and flora of Vermont, and served my brother as a sort of text-book. I have the book in my possession now, and in it my brother has marked the birds and other creatures which he had found about Cleveland. In some cases he had indicated where the specimens were found.

"My uncle, Mr. Warner, noticed my brother's taste for the study of animals, and encouraged it, and gave him a copy of "Wood's Natural History" as a Christmas present in 1862. While still a schoolboy my brother sent to a sporting paper called "Wilkes' Spirit of the Times," an interesting account of the intelligent conduct of a little dog which belonged to his grandfather. The account, I believe, was headed "Do Animals Reason," and was in the form of a letter to the paper, and was either not signed or only signed with initials. Our uncle discovered it in the paper, and guessed that it was written by my brother, and he "owned up" on being spoken to about it. I think this was his first appearance in print.

"One of our neighbors was the geologist, Prof. J. S. Newberry, afterwards of the School of Mines, Columbia College. He had several sons who were companions and playmates of my brother, and I think they used to go on excursions into the country and collect specimens together. Doctor Newberry had, in a small building near his house, a large collection of fossils and geological specimens, and a knowledge of these may have stimulated my brother to make similar collections. I remember that my brother during his school days read, with a great deal of interest, Hugh Miller's works on Geology, and the works of Doctor Buckland on the same subject, and other books of a similar nature.

"Our mother died after a very brief illness, in June, 1862. My father's mother and sister kept house for him until he married again. His second wife was a widow with a young daughter, who became a member of the family and introduced a new element of interest into our home life.

"The nearby lake, river, and canal were, of course, very attractive to young boys. There was a good bathing beach on the lake shore within walking distance of our house, and we used to go there to bathe during the summer. The river and canal abounded in fresh-water mollusks which were interesting. A part of the river, near where it emptied into the lake, had been cut off by a change of the channel, and was known as the "old river bed." Wild fowl were found there, especially in the spring and fall, and my brother once shot a blue heron there. On one of our trips to the "old river bed" my brother's dog chased some chickens. The owner, an old German, was very angry, or pretended to be, and brought out a shotgun and threatened to shoot the dog. We were thoroughly alarmed, but my brother stooped down without a moment's hesitation and put his arm around his dog and shielded him with his body. He was willing to run the risk of being shot rather than have his pet and companion exposed to danger.

"My brother became interested in aquaria, and had an aquarium in the house and a pond in the yard, stocked with tadpoles, water snails, and small fish. In this pond lived a frog which had learned to come and take flies from his hand. He always had animal pets, which he treated with great kindness; almost always a dog was his companion on his tramps, and he also had pet rabbits, cats, and squirrels. He was very skillful in training animals.

[To his students in after years Professor Brooks occasionally spoke of these early observations and experiments upon animals. In particular he recalled the great flocks of carrier pigeons which at times darkened the sky, and which flew so low after their long southward flight across Lake Erie that they could be struck with poles and clubs as they rose over the bluffs on which Cleveland stands.]

"In imitation, probably, of Professor Newberry's collection, he established a sort of museum in the upper story of the barn

back of the house, where he had a collection of shells, fossils, minerals, and geological specimens arranged on shelves, classified and labeled.

"It was probably about this time that he learned to stuff birds, or rather to prepare their skins for preservation. He may have learned to do this from some lectures given by Doctor Kirtland on the subject.

"When he grew old enough to be allowed to do so, he took long tramping expeditions into the neighboring country, sometimes hunting a little, but mostly exploring, observing, and collecting specimens. He formed a friendship with Col. Charles Whittlesey, a geologist and mineralogist, and with him explored and investigated some of the Indian mounds and earthworks in the valley of the Cuyahoga river.

"In his walks and excursions his mind seemed always occupied with problems suggested by what he saw. The commonest objects which most would pass by without a moment's thought set him to thinking and trying to work out explanations of observed features, conditions, and phenomena.

"The first microscope my brother had was made for him by his friend, Mr. Charles F. Brush, the inventor of the Brush electric light. My brother had learned to grind glasses, and devised an ingenious method of making a holder for glass he was grinding. He cut off a piece of broomstick, wrapped paper around it, letting the paper project above the end of the stick, forming a sort of cup or socket. Into this he poured lead, and before the lead had hardened he pressed a marble into it, forming a concavity which served as a socket to hold the glass while being ground.

"Some of the work on the microscope may have been done in the office of Dr. A. Maynard, a retired physician of cultivated and scholarly tastes, who had a fine metal-working lathe which he allowed my brother to use. The Doctor always took an interest in my brother's work and assisted him in many ways. I do not know when my brother first made his acquaintance, but as the Doctor was a friend of my aunt and uncle, Mr. and Mrs. Warner, it was probably at their home that the acquaintance began. The Doctor had a fine library, and encouraged my brother to come to his rooms and make use of his books.

SCHOOL DAYS.

"My brother received his early education at the public schools of Cleveland. The schools he attended were all within walking distance of our home. He first attended the "Prospect" School, primary and intermediate, quite near home. One of his teachers, a lady, says of him: "I remember him as possessing a most cheerful and loving disposition, and being very bright and quick to learn." From that school he was advanced to the "Eagle" grammar school. The principal was a Mr. Perkins, who was assisted by his wife. They remember him as a good boy of quiet and gentle manners, who never gave them any trouble, but do not recall anything to indicate the ability he afterwards developed. One of his schoolmates there was Prof. Theodore B. Comstock, now of Los Angeles, California, who wrote me as follows:

William (we called him Will) was fond of animals and was of an investigating turn of mind, as a boy. He knew more of Nature than his associates and took keen interest in what he observed. Reptiles and venomous insects were his pets. His will was strong, but not aggressive. An incident in my experience with him will illustrate this: One day I had teased him, and on our way home he quietly said, "Don't you say that again." I ran off to a safe distance and mocked him. He started for me with doubled fist, showing no emotion, but coming towards me with a steady walk. I dodged him for awhile, and then concluded he had given up the chase, as he did not appear angry and kept up his steady walk. Finally, I came over to him unconcernedly. He walked calmly by my side, raised his arm, and struck me on my shoulder. That was all, but my shoulder was very sore for many days afterwards. Aside from his attachment to animals, I remember nothing in his early youth which could be regarded as clearly indicating his later career.

"He was never a plodding student, his quickness of mind enabling him to grasp a subject rapidly, and when he had once done so he lost interest in its details. From the grammar school he went, in 1863, to the Central High School, which was then quite near our home. The principal there was Dr. Theodore Sterling, afterwards president of Kenyon College, and he was assisted by Professor Norton, now Professor of Chemistry at Ohio State University, at Columbus. Both remember him well. Doctor Sterling wrote me as follows in regard to him:

I remember he was fond of taking walks in the fields and woods, and collecting and putting in his pocket whatever interested him, whether shells or pebbles or plants or bugs. Sometimes when I met him he would empty his pockets, showing me what he had found and get what information he could from me about whatever excited his interest. This seemed to indicate that his love for natural history was very early developed.

"Professor Norton wrote:

I do not think that he studied chemistry or Virgil under me, but in all likelihood he was under me in some of his early studies, botany and natural philosophy for instance. As I call him to mind, he was a quiet, studious boy, rather reserved in his manner, and not much given to the ordinary boyhood jokes and games.

The last time I met him, so far as I can recollect, he was engaged in a summer school of natural philosophy in the upper floor of the High School, together with Prof. A. H. Tuttle, now of the University of Virginia. I was much struck with the mastery he exhibited in his school and surprised at his early maturity.

"He went by the name of 'Mummy' among his schoolmates, probably because of his silent habits. At the high school his liking for and ability in mathematics and natural science was notable, and is remembered by his teachers and fellow-students, one of whom was Dr. J. H. Lowman. He and Doctor Lowman took private lessons in Greek from Professor Rueger, who was a teacher of German in the high school, and thereafter this subject had a charm for him second only to that of mathematics and natural science.

"Doctor Lowman remembers his early work with the microscope, and being shown the teeth of a snail and the epithelial cells of tissues, and thinks he worked with the microscope in Doctor Maynard's office.

"My mother had a liking for the fine arts, and had some little native ability in drawing and coloring, although she had had no training, and very little opportunity to cultivate this natural gift. When my brother began to use the microscope, he asked me to show him how to draw the objects he was studying. I gave him a few instructions, but almost from the start he grasped the idea, and soon became very skilful in drawing with the pen. All he seemed to need was a few suggestions to start him right, and he went on without assistance and soon taught himself to make beautiful and elaborate drawings with the pen.

"He had a congenital defect of the heart which prevented his taking any active part in sports at school, but he was fond of playing checkers, and was very expert indeed at the game. A little later—perhaps he was sixteen years old at the time—he took up chess, and gave it serious thought and study. In later life he was an expert whist player, and was rarely, if ever, beaten at the game.

"He organized a society of some of his schoolmates while at the high school, and later one which met in a room in a downtown business block. This society was called "Magnus Pax," and met to read selections and discuss various subjects. There were probably not more than a dozen members, all told.

"He did not graduate at the high school, but left at the end of the third, or junior, year, in 1866, to enter Hobart College.

"I think my father's second wife felt little sympathy with my brother's desire to devote his life to study and research. She may have influenced my father to some degree, and I have no doubt my father was deeply disappointed in not being able to induce my brother to apply himself earnestly to business.

"He may have had a feeling that if he gave his sons a common school education sufficient to fit them to make their way in business, that was enough, and after that they ought to get to work and take care of themselves. He may have looked on a college education as a luxury that might render one unfit for a business career.

"Because of this feeling it was hard for him to sympathize with or encourage my brother's desire to devote himself to a life of study and research. He could not comprehend how a living could be made in that way, and he felt his sons must early find a way to support themselves. While he was ready and willing to assist them in getting a start in life, he probably felt unable to do more than this, and that to do more for one in supporting him while at college might be unjust to the others, or might limit his ability to help them in turn. Still, when he found my brother bent on having a college education, he gave him all the assistance he thought he could afford, and when he achieved success and had recognition, he was very proud of him.

"An old friend of Doctor Maynard, mentioned above, told me the following incident:

"The Doctor told him that my father at one time came to him in a good deal of perplexity, to ask his advice about Will, who had then been taken into his store, but who showed no interest in business and no inclination for it, but, on the contrary, seemed to have his mind occupied with other matters which had no relation to business, and of which my father could not see the use. The Doctor had seen a good deal of Will, and Will had talked with him pretty freely about the subjects and studies which attracted him, and he told my father he thought it was better to let Will follow his evident inclination for a life of study and research, believing he would never adapt himself to a business life, and would only be made unhappy by being confined to an uncongenial occupation, but that he was in no danger of becoming a mere idle loafer, and, on the contrary, had ability which would become evident if he were allowed to follow his inclinations, and that if so allowed the boy would show he had good stuff in him and a mind above the ordinary, and would probably succeed."

COLLEGE AND UNIVERSITY CAREER.

He entered Hobart College, Geneva, New York, in the fall of 1866, and left at the completion of his sophomore year. His cousin, the Rev. Wm. J. Cleveland, of Bostonia, California, writes: "We were at Hobart College together for some time, and it may have been through my being there and urging him to come that he began his higher studies there." He remembers that he was liked by the best element among his fellow-students for his cheerful, gentlemanly bearing, coupled with a quiet but telling wit. He was not a plodding book slave, but quick of intellect and wide-awake, and he found his recreation more in mental than in physical activity. His son, Dr. Charles E. Brooks, informs me that while his father was a freshman at Hobart he won the White Essay Prize, never before taken by a freshman. That he had already begun to read and appreciate philosophy is shown by the fact that his volume on "The foundations of zoology," published in 1898, is dedicated "To Hobart College, where I learned to study and, I hope, to profit

by, but not to blindly follow, the writings of that great thinker on the principles of science, George Berkeley."

Leaving Hobart at the end of his sophomore year, he entered the junior class at Williams College in the fall of 1868. Concerning his life at Williams, Mr. T. H. Brooks, of Cleveland, a lifelong friend, but not a relative, writes:

> I look back over half a century of acquaintance with Prof. William K. Brooks, commencing, of course, at a very early period in our lives. We played together, went to the public school here together, and later were classmates at Williams College, and were both graduated from there in 1870. I never knew him otherwise than kind, gentle, thoughtful, and studious; not demonstrative in his friendships, but thoroughly loyal and sincere. He cared nothing for marks or prizes in college, was very liable to burn the midnight oil over some subject that specially appealed to him, and then "cut" prayers and early recitations the next morning. He never put himself forward to answer the questions of the class room, but when called upon always gave a good account of himself. College boys, so far as my experience goes, take the problems of calculus without question and almost without understanding, but he grasped and was delighted with every proposition, and to the utter amazement of his professors and classmates, discovered a mistake in the text-book used. He was generally acknowledged to have been the most brilliant student in mathematics Williams had ever seen."

His love of the natural sciences was fostered by the Lyceum of Natural History at Williams, an active organization which at one time sent a natural history expedition across South America, and by Sanborn Tenny, botanist and zoologist, under whom he studied. But the history of his whole life indicates that he was not led into the study of zoology by teachers or environment. We may apply to him with especial force the following sentiment from his address before the Seventh International Zoological Congress (p. 34): "Most of us have, no doubt, been drawn to our specialty by the natural bent of our minds, rather than by deliberate choice. The zoologist who best deserves the name is one whose natural bent has been too strong for him, so that he has studied zoology because he could not help it." Prof. E. A. Birge, of the University of Wisconsin, was a freshman at Williams when Brooks was a senior. He remembers that Brooks had a microscope, a rare thing in those days, and that with it he showed many interesting things to his fellow-students, who frequented his room, evenings. On

one occasion he undertook to demonstrate a cross-section of a hair, and after much difficulty in trying to cut a free-hand section, he lathered and shaved a portion of his face, and then engaged the students in other things, while he waited a half hour for the hair to grow before he shaved again.

Prof. S. F. Clarke, of Williams College, one of his first students at the Johns Hopkins University, said of him in an obituary notice in the Williams Record:

> His mind was markedly of the philosophical type which appeared even in his college days, when he was known among his classmates as "the philosopher." I remember his saying that there were two things in his college course which were of special interest to him, and which also in the retrospect gave him the most satisfaction: one was solving the problems of Euclid; the other was the study of philosophy under Mark Hopkins.

In 1870 he received the degree of Bachelor of Arts and was elected to the honor society, Phi Beta Kappa. It is probable that at this time he had decided to follow a career of teaching and investigation, but it seems likely that he doubted whether he could find an opportunity to teach natural history, for in after years he said that he was in doubt when he left Williams whether he should teach mathematics, Greek, or biology. However proficient he may have been in the two former, there can be no doubt that by nature, early training, and inclination he was especially fitted for the career which he later entered. As indicating the manner in which he was "finding himself" at this time, the following extract from a letter of his cousin, the Rev. William J. Cleveland, is of interest:

> On another occasion, I think it was in 1869 or '70, after I had graduated, he visited me at Orange, N. J., and was full of the idea of teaching. He had with him a big lot of specimens of one kind and another, and his ambition was to try the experiment of giving public lectures. Enlisting me as assistant in a business way in this enterprise, a hall was engaged and announcements made in a small town "up the road" from Orange. I do not recall whether it was Milburn or Chatham, but at one of them he delivered what, no doubt, was his first public lecture. There was not a big crowd, but my recollection is that there was a very respectable and interested audience, and that all passed off nicely. He was in no sense oratorical or florid, but he went straight to his subject and on with it to the end, relying solely upon the interest of the subject itself, which was so great to him, to hold the attention of the audience.

I have tried hard, but with very meager results, to recall the topic and subject-matter of the lecture. I feel quite sure now, however, that the subject was "Mollusks," but I remember nothing of what he said except that he spent considerable time, as it seemed to me at the time, in explaining to the audience what Mollusca were.

I believe his only object then was to try the experiment of giving a public lecture and to find out how he stood the ordeal. For that reason, perhaps, he chose a (then) small and out of the way place, and the whole venture was managed in the most quiet and unpretentious way. As I remember, no hand-bills or other printing of advertisements was resorted to to draw a crowd. To give a lecture before a mixed audience in some public place and get enough out of it financially to fairly meet expenses, was all he aimed at. That experience, no doubt, had some influence in convincing him that the class room rather than the platform was the place where he could do his most efficient work.

Following his graduation from college, young Brooks spent the year 1870-71 in business with his father, who was an importer and wholesale dealer in crockery, china, and glassware. Prof. E. A. Andrews, in his biographical sketch (Johns Hopkins University Circular, No. 212, January, 1909), says that during this year "he exhibited characteristic interest in the solution of problems and distaste for such mechanical drudgery as had only practical and not theoretical ends in view, by the invention of a calculating machine to lessen the amount of unprofitable manual labor." There is evidence that he continued his reading and study during this year, as much as his other duties would permit, and he and other young men continued to meet at his club for talks and discussions.

In the fall of 1871 he entered definitely upon his career as a teacher. He was employed as one of the masters at De Veaux College, Niagara Falls, New York, where he remained for two years. His ability to win the confidence, respect, and affection of his students was notable even at this early stage in his career. He had a way of not only interesting his scholars, but also of attaching them to him personally. The Hon. Herbert P. Bissell, of Buffalo, New York, who was a student at De Veaux College at that time, has written the following concerning Professor Brooks:

I have consulted with several old De Veaux boys, but none of them could add very much to my own knowledge of Professor Brooks. We all remember him as a man devoted to scientific research and constantly

studying the geology and the flora and fauna along the Niagara River. I recall the interest he would take in any geological specimens that we would find underneath the high bank of the Niagara River. He would give us his opinion promptly as to the geological age to which the specimen belonged, etc. His work at De Veaux College was most satisfactory; he was an excellent and interesting teacher and, as I have intimated, devotedly attached to scientific investigation.

He remained at De Veaux College for two years, and then entered upon the professional course of training in zoology for which he had been planning and preparing. At Harvard, Louis Agassiz was at the climax of his wonderful career, and many young men, who afterward became leaders in biology, went there to study under this great master. In particular in the summer of 1873 the establishment of Agassiz's new seaside laboratory on the island of Penikese, in Buzzards Bay, attracted wide attention. This new departure, the first of the summer schools, was projected by Agassiz in the preceding winter; the island and a fund for the establishment of the school were given by Mr. John Anderson, of New York, in March, and the large buildings were hastily constructed, and were scarcely ready for occupancy when the school opened early in July. Between fifty and sixty teachers and investigators were present, and among these was Brooks. From that time until his death he remained a student of marine life. The sea, with its teeming multitudes of living things, always had a particular charm for him, not merely because of the interest and variety of its forms of life, but also because it was probably the scene of the earliest acts in the drama of evolution.

From this time forward throughout almost his whole life he spent a part, at least, of every summer at the shore. In 1874 he was again at Penikese at the last session of that famous but short-lived laboratory. In 1875 he was with Alexander Agassiz at his private laboratory in Newport, Rhode Island, working on the embryology of Salpa, and tutoring one of Mr. Agassiz's sons. In 1878 began the sessions of the Chesapeake Zoological Laboratory, which he founded and directed for many years. In the summers of 1888 and 1889 he was at the U. S. Fish Commission Laboratory at Woods Hole, Massachusetts, and in later years he was frequently at the Commis-

sion's Laboratory at Beaufort, North Carolina. He was a trustee of the Marine Biological Laboratory almost from its foundation until his death. In the summers of 1905 and 1906 he was at the marine laboratory of the Carnegie Institution of Washington, at Tortugas, Florida. His scientific life was thus closely identified with marine laboratories, beginning with the earliest of these at Penikese, and ending with the latest at Tortugas.

In the fall of 1873 he entered the graduate school of Harvard University, where he continued two years, receiving the degree of Doctor of Philosophy in 1875. At Cambridge he came to know several zoologists whose work and influence helped in some measure to shape his career. First among these must be named Louis Agassiz, of whom Brooks occasionally spoke in later life and whose influence upon him was profound though brief. Agassiz died in December, 1873, and Brooks' association with him was thus limited to the summer session at Penikese and the autumn term at Harvard. Among others whose influence he felt must be mentioned Alexander Agassiz, McCrady, and Hyatt.

While at Harvard Brooks and some other young zoologists lived in an old wooden building known as Zoological Hall, which stood where the Peabody Museum now stands. Professor Birge, who lived in the same building and thus saw Brooks frequently, remembers that he lived very simply and was apparently supporting himself, and that his usual carelessness of dress was emphasized by the fact that he mended his torn clothes with white string. His life was studious and generally solitary, save for the companionship of a great St. Bernard dog, "Tige," who always walked with him when he went out and who occupied most of his bed at night. "I hardly think," says Professor Birge, "that any of his ideals were shaped by the men with whom he worked. He read much and thought for himelf. One day he brought me a new copy of Darwin's Origin of Species, and when I asked him what this meant, he told me that he had borrowed mine one day when I was out, and, having kept it a good while, had written so many notes in it that he preferred to buy me a new copy rather than give the old one back."

In the summer of 1875, after his graduation from Harvard and before his visit to Mr. Agassiz's laboratory at Newport, in August and September of that year, he was instrumental in organizing a laboratory for instruction in Biology in Cleveland. As no fees were charged for this course it seems probable that his purpose was to gain experience in teaching, as well as the purely disinterested aim of establishing an inland Penikese for the instruction of teachers and students of natural history. In his address at the dedication of the new biological laboratory of Western Reserve University, in 1899, he described that enterprise in the following words:

> It was my good fortune to have a share in one of the first attempts to organize laboratory instruction in Cleveland, and I hope you will pardon me if, on this occasion, my mind runs back to this old undertaking. In 1875 three young men who had begun to train themselves as naturalists, came together for their summer vacation, at their homes in Cleveland. They were Theodore B. Comstock, afterwards President of the University of Arizona; Albert H. Tuttle, now Professor of Biology in the University of Virginia, and myself. We were filled with enthusiasm for our work, and, like all earnest students from Chaucer's day to this, as glad to teach as to learn, and we determined to organize a summer class for laboratory instruction in zoology and botany. Money for our expenses was liberally supplied by R. K. Winslow, Leonard Case, and other citizens; the authorities granted us the use of the old high-school building on Euclid avenue near Erie street, and we were soon able to issue notices of our undertaking, and invitations to all who wished to join the class, asking them to do so without the payment of any fee. Some twenty-five were soon enrolled, most of them teachers, some from a distance, and work was begun with a class which shared all the earnestness and enthusiasm of their instructors. We had daily lectures or demonstrations, followed by four or five hours of work in the laboratory, while two afternoons in each week were given to excursions to Rocky River, Cuyahoga Falls, and other places favorable for the out-of-door study of nature. As a small steamboat had been placed at our service, we made two excursions upon the lake, and thus gave to the class an opportunity to learn the use of the naturalist's dredge for collecting the animals of the bottom. Our work was in part the study of the animals and plants which we obtained on these expeditions, and we also made use of a supply of marine animals which had been gathered for the purpose at the seashore.

This account is interesting not merely as a bit of local history, but rather because it reveals thus early in his career his

love of teaching and his methods of instruction; the latter, we may be sure, largely influenced by his experience at Penikese.

During the year 1875-76 Brooks was assistant in the museum of the Boston Society of Natural History. This was practically his only experience in museum work. He was not a museum man, being one of the first zoologists in this country to demonstrate in practice that the museum is distinctly inferior to the laboratory as a means of teaching and research. Apart from a small teaching collection he undertook to establish no museum at the Johns Hopkins University, and such collections as he had were for use rather than for exhibition. If a student needed for the sake of his research to dissect a museum specimen, he might feel certain that Doctor Brooks would offer no objection. He appeared to be wholly lacking in that reverence for specimens as such, which the typical museum man is supposed to have. Some of his early students who had been trained in the museum methods then prevalent at some of our oldest and largest universities have confessed that 'when they went dredging with Brooks it made their hair stand on end to see the way in which he chucked material overboard.' With him research was the all-important thing, to which collecting and collections were always subordinate. The writer remembers that on one occasion he brought a distinguished medical man into the students' laboratory in Baltimore, and after showing him a series of sections of a larval Amblystoma, said to him: "Here is a little piece of glass which you can carry in your vest pocket, and which is worth more to one who wishes a knowledge of anatomy than a whole museum full of specimens."

On the founding of the Johns Hopkins University in 1876 Brooks applied for and obtained one of their twenty famous fellowships, which have done so much to change the character of university work and ideals in this country. Before he entered upon his fellowship his abilities as a teacher were recognized and he was appointed associate in biology. In 1883 he was appointed associate professor of morphology, and in 1889 professor in that subject. On the retirement of Prof. H. Newell Martin from the headship of the biological department in 1894, Professor Brooks became head of the department and

continued in that position until his death. His active scientific life was therefore coextensive with that of the Johns Hopkins University, and his love of the biological department, and his loyalty to his university were always evident.

CHARACTERISTICS AS TEACHER AND INVESTIGATOR.

Although his publications were numerous and important, I think that his influence was greatest and most far-reaching in his work as a teacher and scientific director. To few zoologists, perhaps to no other in the history of this country, has it been given to direct the work and shape the scientific ideals of so large and influential a body of young men. Among those who took their doctor's degrees under him are more than a score of the leading zoologists of this country, while many other distinguished scholars of this and foreign lands were his pupils.

As a teacher, Professor Brooks was characterized by his breadth of view and his interesting and illuminating style, rather than by his accuracy in details. Like all great teachers, he knew that the primary purpose of teaching is inspiration and illumination, and that information is only of secondary importance. A candidate for the doctor's degree expressed to Professor Brooks, on the morning after his major examination, his mortification that he had blundered in answering one of the questions. With apparent seriousness Brooks said: "Your mistake is a serious one, for it makes you responsible for misinforming my whole class on that subject; I used your answer in my lecture this morning."

His lectures were often vivid and picturesque, as well as clear and logical; and this, joined with his habit of taking little for granted on the part of his hearers and of dealing with the broader and more general phases of a subject, made his lectures interesting not only to biologists, but also to those having no special knowledge of the subject. He invariably lectured without notes, and yet his lectures were so orderly and logical that they bespoke the logical character of his mind. Professor Howell in his memorial address (Johns Hopkins University Circular, No. 212, January, 1909) said, with regard to this, that "when it was known that Brooks was to give a paper

before the scientific association of the university it was a custom for men in all the graduate departments to attend the meeting, so much did they appreciate the charm and clearness with which he could present the problems of his subject." I well remember the first time I saw and heard him; it was on the occasion of the annual opening of the graduate school in the fall of 1888. His appearance was neither impressive nor prepossessing, but when he began to speak the closest attention was paid to him. In fascinating terms he described the beauties of the Bahama Islands, with their cocoanut palms and coral reefs; and I shall never forget the enthusiasm and the calm but almost dramatic manner with which he described the finding of the eggs of Gonodactylus in the twilight of his first day in the Bahamas. Equally vivid are the memories in the minds of all his students of his description of the way in which a starfish eats an oyster; of the comparison of a starfish with a sea urchin; of the structure and movements of a jelly fish; of the structure of a squid (in which his own body represented the visceral mass and his coat the mantle); of Salpa, "a barrel with muscular hoops," or Pyrosoma, which at night looked like "a redhot cannon ball." Most delightful, too, were his references to the history of zoological discovery, as, for example, Aristotle's knowledge of the relationships between the various members of a colony of bees, or Chamisso's discovery of the supposed alternation of generations in Salpa.

His blackboard drawings added very much to the interest and value of his lectures; with a firm, even hand he would sketch the form he was describing, and he rarely needed any other eraser than his forefinger. He had learned, early in life, to draw on the blackboard with both hands, by observing the work of Prof. E. S. Morse, while lecturing in Cleveland. He was really an artist of considerable ability and his published drawings were made with much care; in general, they were not only accurate, but also artistic. He was a great believer in pen and ink drawings, and the time and care which he devoted to putting in round and equidistant stipples seemed excessive, until one learned that these were times of reflection with him. His fondness for innovation was shown by his adoption, at one time, of a method of drawing with lithographic

pencils on paper, which drawings were then transferred directly from the paper to the stone. In later years he made much use of sepia washes, and he had all his students using them. He expected all his students to learn to draw; to some of them he would say time and time again, "You'd better learn to draw," apparently unmindful of the fact that he had given this advice before, and that they were trying to learn as rapidly as possible; and sometimes, when shown a drawing of which the maker was rather proud, his only comment would be, "You can't do anything well without patience."

He loved to work with simple apparatus, and his technique was never complicated. He never mistook paraphernalia for science, and he went directly to the end he sought. He had a great fondness for primitive methods, and used to advise his students to learn to cut free-hand sections, and to use some of the oldest methods of staining and imbedding. At one time he had some of his students repeating ancient history in trying to imbed tissues in soap, and to more than one who asked him for advice about staining microscopical preparations he recommended Beale's Carmine; the results were always unsatisfactory, but in the meantime the student had learned something about the historical development of staining methods, and, best of all, had also learned to rely upon himself rather than upon Doctor Brooks. One such student, after laboring for some weeks with Beale's Carmine, saw Doctor Brooks and told him that he could not get satisfactory results. After waiting in vain for some response, he ventured to ask whether Doctor Brooks had ever used the method. Yes, he had. "What did you think of it?" "'Twasn't worth a damn." Not infrequently, when students asked him to suggest some topic for research work, he would recommend some wholly impractical thing, such as the study of siphonophores at Woods Hole or the study of Amphioxus at Beaufort; and such students were left to find their own problem and to work out their own salvation.

Although he would present a subject in his lectures in the clearest and most entertaining manner, he rarely, if ever, attempted to smooth the path of the investigator; the latter was to a very large extent thrown upon his own resources. He

believed so thoroughly in the law of natural selection, as he once said, that he thought it was best for a student to find out for himself, as soon as possible, whether he was fitted for independent investigation or not, and by this rigid discipline the unfit were weeded out from the fit. This was certainly no school for weaklings, but it afforded magnificent training for those who had ability and determination. For those who endured this ordeal he maintained the warmest regard, and his interest and pride in the work of his students was as marked as it was stimulating.

Throughout the greater part of his life he did most of his research work at night; even the preparation and study of microscopical objects were frequently done by lamplight. He was quite proud of a little device of his by means of which he could imbed objects in paraffin by the heat of his student lamp, which served to illuminate his microscope. It was his custom, after his day's work at the university, to spend the evening with his family, frequently in reading aloud or in playing cards, and then, after all others had retired, he began his work. With his feet wrapped up in blankets to keep them warm he would write, or use his microscope, far into the night. In his work at the shore he would work all day, or all night, as the need might require or his inclination prompt. In his last years night work was no longer possible for him, and he turned to music for recreation, having discovered almost by accident that he had a great fondness for music, and that this liking could be gratified by means of an automatic piano. The last time I saw him we sat up until after midnight playing compositions by great musicians.

In spite of the fact that he was, during the course of his life, interested in many things, he was rarely interested in more than one thing at a time; and this sometimes led to an apparent lack of sympathy with the work of some of his students which was more apparent than real. Occasionally, when he was appealed to for some explanation of some published statement of his, he would say, "I have forgotten all about that now." Often when asked a question, he would say, "I don't know," when he knew better than anyone, although, at the time, the subject was out of his mind. To one of his students

who was at work upon a cytological problem, he mildly protested that such work was not morphology; and to one who offered him a thesis on cell-lineage, he remarked, "This university has accepted theses on counting words; I suppose it might accept one on counting cells."

But though he sometimes disagreed with the conclusions of his students, he never attempted to dictate to them. They were treated as absolutely free and independent investigators, and he usually assumed no responsibility for their work or results.

He lived with his students on terms of comradeship. Indeed, between himself and them there existed a real but undemonstrative affection, which was shown on his part, not merely by solicitude for their safety when they were in danger, but by many little kindnesses at the laboratory and in his home. In particular he used to refer with pride and sorrow to those of his students who had died: Rice, Bruce, Humphrey, and Conant. On one of my visits to Baltimore he led me without a word to the tablet which had been placed on the wall of the laboratory in memory of Humphrey and Conant, both of whom lost their lives of yellow fever on their expedition to Jamaica in 1897. We both stood and silently read the tablet, and then as we turned away he said, simply but with emotion, "I thought you would like it." When once relations of comradeship had been established with his students, neither time nor separation changed these relations, and they never needed to be renewed. When attending the International Zoological Congress in Boston, he saw in the hotel lobby a former student whom he had not seen for nine years. He spent no time in renewing acquaintance, but went up to him, as if there had been no break in their associations, and said, "Do you know where I can get a shoestring?" There was a sort of helplessness or lack of worldly wisdom on his part which made his students feel responsible for him, and which increased their affection for him. His interest in his former students was genuine and hearty, though he rarely expressed it to the person concerned. He did not lose his critical judgment in his affection for his students, though he often showed that he was proud of their accomplishments. "One of the joys of

a teacher," he once said, "is to see his students surpass him." On the other hand, his students delighted to honor him; and on the occasion of his promotion to a full professorship, on his fiftieth birthday, at the twenty-fifth anniversary of the founding of the Johns Hopkins University, and at the International Zoological Congress in Boston, they showed him how deep a place he held in their affections. On December 31, 1908, sixty of his former students met at a dinner in Baltimore to pay honor to his memory, and the occasion was one of delightful reminiscence and of grateful recognition of indebtedness to him.

THE CHESAPEAKE ZOOLOGICAL LABORATORY.

In connection with his work as teacher and director must be mentioned the establishment by him of the Chesapeake Zoological Laboratory in 1878. The great influence which his experience at Penikese had upon him has already been mentioned. To a large extent the direction and character of his research work was determined by this experience, and its influence was apparent in all his teaching as well as in his research. We have seen that it led him to organize a second "Penikese" at Cleveland in the summer of 1875, and one of his first acts at the Johns Hopkins University was the organization of the Chesapeake Zoological Laboratory. The stimulating influence which this laboratory had upon the research work of Doctor Brooks is shown by his bibliography, where it may be seen that after the first session of that laboratory his annual output of work was increased at least fourfold. And the importance of the laboratory in the development of the biological department of the Johns Hopkins University and in the general advance of zoology in America may be estimated from the large number of students who worked at the laboratory and the large number of papers which they published. Doctor Brooks expected all of his graduate students to spend a season or more at this laboratory. He rightly estimated this as the most valuable experience a student of zoology could have, for in this way the student became acquainted with animals under natural conditions; he had opportunities of becoming a broadly trained natu-

ralist, and he could find his own problems for work and become an independent investigator.

The Chesapeake Laboratory, unlike the one at Penikese, was not limited to one place; it consisted neither of buildings nor equipment, but of men and ideas. For the first few years of its existence it was located at several different points on Chesapeake Bay; afterwards it was located at Beaufort, North Carolina; then at different places in the Bahama Islands, and finally in Jamaica. In the various expeditions of Brooks and his students to these different places they made not only a thorough biological survey of each region, but they did work of most fundamental and far-reaching importance on the various groups of animals found. Out of these expeditions has grown the beautiful and permanent station of the U. S. Fisheries Bureau at Beaufort, North Carolina, in which Brooks took great interest and pride. It was on these expeditions that his students came to know him most intimately and affectionately. In the memory of each of them is fixed some scene of his enthusiasm over the discovery of a rare specimen or of an unknown stage in some life history; his long vigils full of exciting discoveries; his quiet talks on nature and philosophy, after the day's work was done.

The Chesapeake Zoological Laboratory occupied so large a place in the life and work of Professor Brooks that it seems desirable to reproduce here, in his own words, a more detailed account of the aims and history of that laboratory during its first nine years. The following is taken from a report by Professor Brooks on "The Zoological Work of the Johns Hopkins University, 1878-86," published in the Johns Hopkins University Circulars, Vol. 6, No. 54:

In natural science the policy of the University is to promote the study of life, rather than to accumulate specimens: and since natural laws are best studied in their simplest manifestations, much attention has been given to the investigation of the simpler forms of life, with confidence that this will ultimately contribute to a clearer insight into all vital phenomena.

The oldest forms of life are marine: every great group of animals is represented in the ocean, while many important and instructive groups have no terrestrial representatives; omitting the insects, more than four-fifths of the known species of animals are marine, and the total amount

of animal life in the ocean is incomparably greater than that upon the land. In a word, the ocean is now, as it has been at all stages in the earth's history, the home of life; and it is there, and there only, that we find the living representatives of the oldest fossils, and are thus enabled to study the continuous history of life from its simplest to its most complex manifestations.

On the sand flats at the mouth of the Chesapeake Bay, we find, living side by side, animals like Lingula, Amphioxus, Limulus and Balanoglossus, which are the representatives of some of the oldest and most primitive types of animal life; and all attempts to trace out the natural relationships of any group of animals, lead us at once to forms which are found only in the ocean.

The animals which have contributed most extensively to the formation of the earth's crust, the corals and foraminifera and radiolarians, abound in the ocean today, and it is only by studying their life, by observations at the seashore, that we can understand and interpret their geological influence.

Nearly every one of the great generalizations of morphology is based upon the study of marine animals, and most of the problems which are now awaiting a solution must be answered in the same way.

For these reasons our chief aim in zoology and animal morphology has been to provide means for research upon the marine animals of the Atlantic coast, and for nine years, successive parties, composed of instructors, fellows and students in this department, together with instructors and advanced students from other institutions have spent at the seashore all the months in which marine work is practicable. Their time and energy have been devoted to research rather than to the preservation of collections, and the wisdom of this course can be estimated by examination of the accompanying list of publications; all of which are based, either in part or entirely, upon researches which we have carried on at the seashore.

The wisdom of our policy is well illustrated by the fact that the leading naturalist of America, himself the head of one of the largest scientific collections in the world, says in his annual report for 1884,* that the expenses of an immense natural-history collection are so great that it would be far cheaper, with the present facilities and the cost of travel, to supply the student with the necessary funds for valuable researches, than to go on for years spending in salaries of curators and the care of collections, sums of money which, if spent in a different manner, in promoting original investigation in the field or in the laboratory and in providing means for the publication of such original researches, would do far more towards the promotion of natural history than our past methods of spending our resources.

This fact has become widely recognized during the last ten years, as is shown by the establishment of marine laboratories by several of the

* Report of the Museum of Comparative Zoology, Cambridge, Mass.

European institutions of learning; and in the summers of 1883 and 1884 we had with us at our laboratory a young English naturalist (Wm. Bateson) who had been provided by the Royal Society of London with funds for his researches, the results of which have recently been published in England.

The Johns Hopkins University was among the first to recognize and act upon this new departure in zoology, and our little marine station is almost as old as the great Naples laboratory. Briefly stated its history is as follows:

In 1878 a small appropriation was made to enable a party of biologists from the University to spend a few weeks at the seashore in the study of marine zoology. Through the influence of Maj. Gen. Q. A. Gillmore, the Secretary of War permitted us to occupy the vacant building at Fort Wool. Prof. Spencer F. Baird also exerted his influence with the Secretary of War in our behalf, and aided us in many other ways; furnishing us with dredging apparatus and with three small row-boats. The scientific results of our season's work were printed in an illustrated volume, the cost of publishing which was borne by the following citizens of Baltimore: Samuel M. Shoemaker, John W. Garrett, John W. McCoy, Enoch Pratt, P. R. Uhler, T. B. Ferguson, Dr. Geo. Reuling, President Gilman, Professor Martin and others.

In 1879 the appropriation for the maintenance of the laboratory was renewed, and in order to present an opportunity for studying the oyster beds of Maryland, the laboratory was opened in three of the barges of the Maryland Fish Commission at Crisfield, Maryland, a point which proved to be very unfavorable. Maj. T. B. Ferguson, the State Fish Commissioner, not only provided the barges for our accommodation, but he also fitted the steam yacht *Lookout* with dredging apparatus, and rendered us valuable help in dredging and collecting. Through his influence a small steam launch was also detailed from the U. S. Navy for our use.

The next year the Trustees of the University voted to continue the laboratory for three years more, 1880–1–2, and they provided a liberal annual appropriation of $1,000 for current expenses, which was renewed annually in 1883–4–5–6, and was expended in rent, wages, fuel, laboratory supplies, repairs, etc. They also appropriated the sum of $4,500 for permanent outfit, and most of this was used in the purchase of two boats; a Herreshoff steam launch twenty-seven feet long and eight feet beam, and a center-board sloop forty-seven feet long and fourteen feet beam.

After an examination of all the available localities the town of Beaufort, N. C., about four hundred miles south of Baltimore, was selected as the site for the laboratory, and a vacant house, suitable for the accommodation of a small party, was found and rented as a laboratory and lodgings for the party, and it has been occupied during the seasons of 1880–1–2–4–5, and by two students in 1886. As the director was, in 1883, a member of the Maryland Oyster Commission, the outfit of the labora-

tory was that year moved from Beaufort into the Chesapeake Bay, and we occupied a building which we rented from the Normal School at Hampton, Va. As Hampton proved to be a very unfavorable place for our work we returned to Beaufort the next year, and we have accordingly spent five seasons at Beaufort.

During the season of 1886 the zoological students of the University were stationed at three widely separated points of the seacoast. A party of seven under my direction visited the Bahama Islands, two were at Beaufort, and one occupied the University table at the station of the U. S. Fish Commission at Woods Hole.

The party which visited the Bahamas consisted of seven persons, and our expedition occupied two months, about half of this being consumed by the journey.

The season which is most suitable for our work ends in July, and we had hoped to reach the Islands in time for ten or twelve weeks of work there, but the difficulty which I experienced in my attempts to obtain a proper vessel delayed us in Baltimore, and as we met with many delays after we started, we were nearly three weeks in reaching our destination.

We stopped at Beaufort to ship our laboratory outfit and furniture, but the vessel, a schooner of 49 tons, was so small that all the available space was needed for our accommodation, and we were forced to leave part of our outfit behind at Beaufort.

We reached our destination, Green Turtle Key, on June 2d, and remained there until July 1st. The fauna proved to be so rich and varied and so easily accessible that we were able to do good work, notwithstanding the shortness of our stay and the very primitive character of our laboratory. This was a small dwelling house which we rented. It was not very well adapted for our purposes, and we occupied as lodgings the rooms which we used as work rooms.

RECORD OF THE VARIOUS SESSIONS.

For the following brief records of the various sessions of the Chesapeake Zoological Laboratory I am indebted in large part to Prof. E. A. Andrews:

1878: 8 weeks, Ft. Wool, Virginia; 7 members. Brooks studied embryology of Lingula.

1879: June 25—August 8, Crisfield, Maryland; 11 members. Brooks studied the oyster. Three barges served as laboratory and quarters. Swarms of mosquitos led to the abandonment of this locality early in August, and the removal of the laboratory to Ft. Wool, until September 15.

1880: April 23—September 30, Beaufort, North Carolina; 6 members. Laboratory and quarters were in the Gibbs house. A steam launch was bought and the laboratory equipped by means of an appropriation from the University.

1881: May 2—end of August, Beaufort, North Carolina; 12 members. An "Elementary Seaside School" had been announced, with lectures by Brooks and S. F. Clarke; fee for the course, $25.

1882: May 1—end of September, Beaufort, North Carolina; 8 members.

1883: May 1—October 1, Hampton, Virginia. As a member of the Maryland Oyster Commission Brooks was obliged to spend this summer on the Chesapeake. The new machine shop of the Hampton Institute was rented as a laboratory, and a fast sloop was added to the equipment. Wm. Bateson there joined the party to study the development of Balanoglossus.

1884: June 1—September 19, Beaufort, North Carolina; 10 members. The illness of Brooks obliged him to return after a month, leaving the laboratory in charge of H. W. Conn. Bateson, who was again with the party, was also seriously ill.

1885: May 23—September 15, Beaufort, North Carolina; 11 members. Brooks became a licensed pilot to take the steam launch in and out of Beaufort Inlet.

1886: June 2—July 1, Green Turtle Key, Abaco, Bahamas; 7 members. The party left Baltimore, May 1, in a small Bay schooner, chartered by the day, with Brooks as pilot. With head winds, mishaps and a stop at Beaufort to take on laboratory furniture they did not reach their destination until June 2.

1887: March 1—July 1, Nassau, Bahamas; 12 members.

After this session, owing to financial losses on the part of the University, the Chesapeake Zoological Laboratory was temporarily suspended and its outfit dispersed.

1888 and 1889: Brooks, with some of his students, was at Woods Hole, Massachusetts, as naturalist in charge of the U. S. Fish Commission Station.

1891: May 26—September 1, Kingston, Jamaica; 15 members. The Chesapeake Zoological Laboratory was established at Port Henderson, on the harbor opposite Kingston.

1892: A party of three, in charge of Professor Andrews, was located at Alice Town, North Bimini, Bahamas. Brooks did not go.

1893: April 20—July 23, Port Henderson, Jamaica; 7 members. Brooks did not go and Dr. R. P. Bigelow was acting director.

1894: April 7—July 7, Beaufort, North Carolina; 9 members. Brooks was present.

1895: June 6—August 13, Beaufort, North Carolina; 4 members. Doctor Siegerfoos was acting director; Brooks was not present.

1896: April 29—July 30, Port Henderson, Jamaica; 4 members. Dr. F. S. Conant was acting director; Brooks was there for a while.

1897: June–September, Port Antonio, Jamaica; 12 members. Prof. James Ellis Humphrey was acting director. Humphrey died there of yellow fever, August 12; Dr. Franklin Story Conant contracted the fever there, and died on his return to Boston in September.

1898: Beaufort, North Carolina; 6 members. Prof. H. V. Wilson was director. In this and all subsequent years students went, with little or no aid from the University, to the U. S. Fish Commission Station at Beaufort.

1901–1906: Brooks was again at Beaufort in 1901 and 1903, and at the Marine Laboratory of the Carnegie Institution at Dry Tortugas, Florida, in 1905 and 1906.

In twenty years the Chesapeake Zoological Laboratory provided facilities for more than 160 workers, and approximately 200 papers were published as a result of these sessions. In reviewing this enterprise one cannot fail to be impressed with the great results accomplished with small financial outlay. For the purposes which Brooks had in mind the advantages of a laboratory whose equipment could be moved from place to place are most evident, and the need of such laboratories is not yet past. May the Chesapeake Zoological Laboratory, or some other worthy successor, continue this work, so well begun by Brooks!

On these various expeditions Doctor Brooks was interested not merely in zoology, but also in botany and geology, and in the customs, characters, and histories of the people among whom he was living. He took keen interest while in the Bahamas in following the route of Columbus from island to island. He advocated the establishment of a Columbus Biological Station in memory of the great discoverer. He was particularly interested in the Indians found by Columbus on these islands, and he wrote a very interesting popular account of them, and prepared a monograph on their physical anthropology based on a study of a collection of their skulls. His love of the artistic was shown in his vivid pen picture of "Life on a Coral Island" and "Aspects of Nature in the West Indies." The following letter, written to his brother while on his last scientific expedition, describes in his vivid manner a trip which he made into the Everglades:

THE JEFFERSON,
KEY WEST, FLORIDA, March 21, 1906.

DEAR CHARLES: I am in the "hottest place in the U. S." in an overcoat and my thickest underclothing. I am to get off to the Dry Tortugas tomorrow, on an excursion of army officers, after having been ten days on the journey. It has been a pleasant and profitable journey on the whole, but the delays have been very tiresome.

Among other side excursions I have been where very few white men have been—into the Everglades—which I found most interesting and very different from what our geographies lead us to expect. The whole interior of southern Florida is a great lake of pure spring water, covered with wild rice and reeds, and with a hard bottom, with no mud. It is surrounded by a rim of limestone about 30 feet above the level of the lower land, and it overflows in rivers wherever the rim is low. We went up a river, very deep and rapid, for about twenty miles, to the rapids, and we got up the rapids by towing on the overhanging branches to the top, where the big river at once became lost in the great shallow lake. We picked out a tree on a little island about five miles away, and pushed through the tall reeds until we reached it. We climbed the tree, and as far as we could see there was nothing but reeds in all directions. After eating our lunch we pushed back through the reeds and struck our river again; but I could not help wondering what would happen to us if we missed the river. The trip down the rapids, about half a mile, was most exciting, and I was nearly torn out of the canoe by some low branches.

On our way back we visited an alligator farm, where they hatch, from stolen eggs, the little alligators that are sold in our northern cities. They also deal in rattlesnakes and owls and hawks. In one pond they had the biggest American crocodile known. He is 19 feet long, big enough to drown a horse, and he is fed on live hogs. It must be very exciting to rob the nests of alligators and crocodiles. If you ever have the opportunity to visit southern Florida you should do so.

Miami is the prettiest tropical town I have ever seen and well worth a visit.

Yours affectionately, W. K. Brooks.

PRINCIPAL PUBLICATIONS.

As a scientific investigator Brooks showed sound judgment, philosophic insight, and breadth of view. His method of work, like his manner of life, was calm and slow. He was not a prolific writer, and of the one hundred and fifty titles, more or less, which appear in his bibliography, not less than thirty are preliminary notes or republications of other papers. Many of these papers are brief notes or abstracts, so that his total number of important contributions does not exceed one hundred. These were distributed over thirty-five years of his active life, so that he did not average more than three such papers a year. He did practically no research work on vertebrates, and his work on invertebrates was confined almost exclusively to five groups, viz.: pelagic tunicates, mollusks, Molluscoida, higher

Crustacea, and Hydromedusæ. Altogether he published seventeen papers on tunicates, twenty-six on mollusks (fourteen of these on the oyster), three on Molluscoida, fifteen on decapod Crustacea, and sixteen on Hydromedusæ. In addition to these he published five or six general works and about sixty theoretical and popular articles, reviews, etc.

All of his papers, even those which deal with the most detailed and technical subjects, are generally understandable and as little technical as possible. As in his lectures, he took little for granted, began at the beginning, and kept his main topics prominent; moreover, he wrote in an entertaining manner, and his articles contain a certain popular quality while not lacking in scientific accuracy.

His first important paper was on the "Embryology of Salpa," and many of his later works, some of them monumental monographs, were devoted to the anatomy, embryology, and classification of this group of pelagic tunicates. Among these papers the most important are the following: "The development of Salpa," "Origin of the eggs of Salpa," "The anatomy and development of the salpa chain," "Monograph of the genus Salpa," and the "Pelagic Tunicata of the Gulf Stream." His latest work, left unfinished, and for which he had prepared hundreds of beautiful drawings, was a continuation of his great monograph on the genus Salpa. These works on the tunicates are too extensive and complicated to be summarized briefly, but some of his more important conclusions are the following:

1. In his earlier papers Brooks maintained that there is not a regular alternation of generations in the life cycle of salpa, between the solitary individuals and those united into chains, as had been generally held since Chamisso's work on salpa, but that the solitary salpæ are females, and that they produce by budding the chain individuals, which are males. Into each of the chain salpæ, before it is set free, an egg is placed, which comes to maturity in the chain form, and ultimately develops into another solitary individual, thus completing the life cycle. In his later works, as Professor Metcalf has pointed out in a letter to the writer, Doctor Brooks departed in several respects from this early conception. He showed very clearly that the solitary salpa is an immature sexual form, which passes its

germinal cells into the chain individuals, where they reach maturity. Since these germinal cells give rise to both ova and spermatozoa, both solitary and chain forms may be considered potentially bisexual, though the solitary forms never contain mature germ cells.

2. In the formation of the salpa chain a stolon, or stalk, which grows out from the solitary salpa is constricted at intervals, thus giving rise to the members of the chain. The stolon is bilaterally symmetrical, its planes of symmetry coinciding with those of the solitary salpa which bears it, and, at first, the planes of symmetry of every member of the chain coincide with those of the stolon and of the solitary salpa. Very soon, however, a twisting of the chain occurs which leads to the formation of a double row of salpæ, each row with the dorsal surfaces of its members turned outwards, while the ventral surfaces of the two rows are turned toward one another, and the right sides of one row and the left sides of the other are turned toward the base of the stolon.

3. The salpa embryo, which develops from the fertilized egg into the solitary salpa, "is blocked out in follicle cells which form an outline or model of the general features of the embryo. While this process is going on the development of the blastomeres is retarded, so that they are carried into their final positions in the embryo while still in a very rudimentary condition. Finally, when they have reached the places which they are to occupy, they undergo rapid multiplication and growth and build up the tissues of the body directly, while the scaffolding of follicle cells is torn down and used up as food for the true embryonic cells."

4. The salpa embryo is connected by a placenta with one of the members of the chain, and is nourished by placenta cells which migrate from the placenta into the embryo. The placenta is thus an organ which nourishes the embryo, not by the transfusion of blood, but by means of giant cells which in the placenta receive nourishment from the blood of the parent, and then migrate into the embryo, there to break down and supply food to the embryo.

But Brooks' work on salpa is not merely a description of the anatomy, embryology, and classification of these interesting

tunicates, for it deals in original and philosophical manner with such problems as the origin of chordates, the origin of pelagic animals, the discovery of the ocean bottom, and the effects of this upon the evolution of life.

Another major line of his work was on the anatomy and embryology of the Mollusca. One of his first papers was on "An organ of special sense in the lamellibranchiate genus Yoldia," this sense organ being a long retractile tentacle, half way between the siphon and the lower edge of the mantle on the right side. This paper was soon followed by one on "The embryology of the fresh-water mussels," in which the entire development of *Anodonta implicata* is described in brief outlines, and the conclusion is reached that the larva, or glochidium, is a specially modified stage, adapted to a special purpose, and having no bearing on the question of the origin of the group. Both of these papers are brief abstracts of three pages each, and they were read at the meetings of the American Association for the Advancement of Science in 1874 and 1875. In a paper "On the affinities of the Mollusca and Molluscoida" (1876) he concluded that Brachiopoda have been derived from Vermes, Polyzoa from Brachiopoda, and the Molluscan Veliger (the prototype of the Mollusca) from Polyzoa. The Lamellibranchiata he held to be a side branch, and not ancestral to the group of mollusks as a whole. Later (1879), in his paper on "The development of Lingula and the systematic position of the Brachiopoda," he held that the Rotifera, Polyzoa, and Veliger were three branches which early diverged from the vermian stem. The Brachiopoda he held to be the most highly specialized members of the polyzoan branch, the Mollusca the most highly specialized of the Veliger branch. For these three branches he proposed the name Trochifera.

In his "Observations upon the early stages in the development of the fresh-water pulmonates" (1879) he observed the rhythmical nature of the process of cleavage, the formation of the ectoderm from the clear cells at the animal pole of the egg, the formation of the endoderm from the macromeres at the vegetative pole, and the lack of a continuous mesodermal layer in the embryo. He devoted particular attention to the fate of

the blastopore and the origin of the digestive tract; but since his observations were made exclusively on living material, he fell into several errors, mistaking the shell gland for the mouth, which he maintained appeared opposite the original position of the blastopore, and concluding that the macromeres fuse together, and afterwards bud out cells which form the alimentary canal. In the main the same remarks apply to his "Preliminary observations on the development of the prosobranchiate gasteropods," which appeared in the same year (1879). In this paper, and in a subsequent one on the "Acquisition and loss of a food yolk in molluscan eggs," he devoted much attention to what is now known as the yolk lobe, or polar lobe, which he regarded as a "food yolk." This he believed to be in process of being lost in some cases, as, *e. g.*, the oyster, while it was being acquired in others. It is needless to say that this explanation of this problematical yolk lobe is no longer found to be satisfactory. In a brief paper on the "Development of the digestive tract in molluscs" (1879) he reiterates his mistaken view that in gasteropods and lamellibranchs the blastopore is converted into the shell gland, and that the mouth forms at the opposite side of the embryo. With the exception of a single paper, published in collaboration with one of his students in the last year of his life, this list comprises all of his publications on the gasteropods. The paper just mentioned is entitled "The origin of the lung in Ampullaria" (1908), and is based upon the study of material which he obtained on his trip into the Everglades in 1906 (see p. 53). In brief, the conclusion of this paper is that the lung of this prosobranch has no ancestral connection with the lungs of pulmonates. "The gills, the lung, and the osphradium of Ampullaria arise simultaneously, or nearly so, and they must be regarded as a series of homologous organs specialized among themselves in different directions."

During the second session of the Chesapeake Zoological Laboratory material was collected for a study of the later stages in the development of the squid, *Loligo pealii,* which resulted in the publication of two papers, one "The development of the squid," the other "The homology of the cephalopod siphon and arms." The most important conclusions of

these papers are: (1) That the embryonic record of the Cephalopoda "has been simplified to a degree which is without parallel in the animal kingdom, and it is hardly too much to say that the ontogenetic process furnishes us with no knowledge whatever of the phylogeny of the group;" (2) that the yolk sac of the cephalopod embryo is the homologue of the gasteropod foot; (3) "that if the epipodal folds of the gasteropod are regarded as homologous with the cephalopod siphon, the arms of the cephalopod must be regarded as independently acquired structures; whereas if we regard the arms as modifications of the epipodal folds, we must consider the four siphon folds as independently acquired structures;" and (4) "the common ancestor of the gasteropods and cephalopods must have been an unspecialized form, and we cannot expect any valuable results to follow from the attempt to compare any part of the body of a cephalopod with structures which, like the epipodal folds, are not common to the Gasteropoda, but somewhat exceptional."

All his other publications on the Mollusca, fourteen in number, deal with the development and propagation of the oyster. In 1878, during the first session of the Chesapeake Zoological Laboratory, he attempted to find young oysters in the gills of the female, as had been described in the case of the European oyster, but without success. In May, 1879, he went to Crisfield, Maryland, the center of the oyster industry on the Chesapeake, and settled down to study the problem of the development of the oyster. "On Monday, the 21st," he says, "I opened a dozen fresh oysters, and found three females, with their ovaries filled with ripe ova, and one male, with ripe spermatozoa. I mixed the contents of the reproductive organs of these four oysters, and within two hours after the commencement of my first experiment I learned by the microscope that the attempt at artificial fertilization was successful, and that nearly all of my eggs had started on their long path toward the adult form. . . . I have accumulated enough evidence to show, beyond the possibility of doubt, that so far as the oysters of the Chesapeake Bay, during the summer of 1879, are concerned, the eggs are fertilized outside the body of the parent, and that during the period which the European oyster passes

inside the mantle cavity of its parent, the young of our oyster swim at large in the open ocean."

This was the beginning of his many publications and his years of labor on the development and propagation of the oyster. His first paper on "The development of the American oyster" was very favorably received, and was republished in whole or in part in many American and foreign journals. In recognition of the importance of this work, he was awarded a medal by the Société d'Acclimatation of Paris. In 1882 the General Assembly of Maryland established a commission to consider ways and means to "Perpetuate the oyster beds of the Chesapeake," and Doctor Brooks was appointed chairman of this commission by the governor. The university released him from active duties, in order that he might devote his entire time for eighteen months to the study of the economic aspects of the oyster problem. A laboratory was established at Hampton, Virginia, where experiments were carried out on the propagation of oysters, and extensive surveys of oyster beds were made. The report of this work was published in 1884, in a quarto of 183 pages, 7 maps, and 13 plates. The legislature paid little attention to the recommendations of this report, and Doctor Brooks undertook by public lectures and newspaper articles to arouse public interest in the subject. To this end he published in 1891 a popular work on this subject, entitled "The Oyster," which was republished in a second edition in 1905. His absorption in this work was so complete that he talked oysters in season and out of season. The story is current that at a university reception a society woman attempted to engage him in small talk; he listened mutely for a while, and then was heard to say suddenly, and with animation, "Madam, the Maryland oyster is being exterminated."

Finally, in 1906, the legislature of Maryland passed a law for the protection and propagation of oysters along substantially the lines advocated by Doctor Brooks, and the satisfaction which he felt in this happy culmination of his long campaign was very great.

A third line of work to which he devoted much attention was the embryology and larval history of the higher Crus-

tacea,* and altogether about fifteen papers dealing with these subjects were published during a period of fifteen years, from 1879 to 1892, his first contribution on the larval stages of *Squilla empusa* representing some of the "Scientific Results of the Chesapeake Zoological Laboratory" for 1878. At Beaufort, in 1880, his interest in this subject deepened, for he saw in the structure and metamorphosis of these animals a means of attacking several larger problems, such as the laws of larval development, the analysis of secondary adaptations, and the meaning of metamerism in both lower and higher animals.

The works by which Professor Brooks will be best known to all future students of crustacean zoology are undoubtedly his large monograph on "Lucifer: a study in morphology," published in the Philosophical Transactions of the Royal Society of London for 1882, and his "Report on the Stomatopoda," which appeared as part of the sixteenth volume of the Scientific Results of the Challenger Expedition in 1886. Not only did he discover that the shrimp, Lucifer, emerged from the egg as a true Nauplius, but, what was even more novel, that the egg itself underwent a total and regular segmentation, and gave rise to a gastrula of the invaginate type. After tracing the metamorphosis through nine distinct stages, and making exhaustive comparisons, he concludes that the highly peculiar segmentation and gastrulation are secondary, but that the three-jointed Nauplius represents a true ancestral form, "and nothing but the supposed necessity of believing that the primitive Crustacea had a large number of somites and appendages opposes this view." He shows that the serial and bilateral homology, so evident in the Crustacea, cannot be explained by supposing that the ancestors of the Crustacea represented a community of independent parts. In his Report on the Stomatopoda he considers this subject again, and concludes that serial homology may be due "to heredity from the same part of the developing egg, rather than from a remote ancestor." The report on the Stomatopoda is distinguished by the great ingenuity and mastery shown in classifying all of the

*For assistance in preparing this abstract of Brooks' work on the Crustacea, the writer is indebted to Prof. F. H. Herrick.

known larvæ of this sub-order and in tracing them to their proper genera, for he had no living material to work with, excepting the two species—*Squilla empusa* and *Lysiosquilla excavatrix*—which he had studied from the southern coast of the United States.

During the period from 1880 to 1883, Professor Brooks undoubtedly contemplated the preparation of a work on the higher Crustacea, of greater scope than anything which he later produced, and this was only partially fulfilled in the publication, in collaboration with F. H. Herrick, of "The embryology and metamorphosis of the Macrura," in the Memoirs of the National Academy of Sciences for 1892. Moreover, it should not be overlooked that one of his most notable papers, in which he described how a Stomatopod—*Gonodactylus chiragra*—was reared, for the first time, from the egg, and in which he traced all its successive stages in the living state, appeared as Chapter III of the latter work.

Another group of animals to which Professor Brooks devoted a large amount of attention is that of the Hydromedusæ. In the study and drawing of these beautiful and delicate forms he combined the enthusiasm of the naturalist and that of the artist. From 1880 to 1886 he published seven papers on the Medusæ, chiefly of the Beaufort region, culminating in his monograph on "The life-history of the Hydro-medusæ: A discussion of the origin of the Medusæ and of the significance of metagenesis" (Memoirs Boston Society Nat. Hist., Vol. 3, 67 pp., 8 plates). This work contains an account of his observations on the life-history of a Narcomedusa, a Trachomedusa, an Anthomedusa, and a Leptomedusa, the four species selected for study being "among the most abundant and characteristic of our Southern coast, yet none of them have been well studied." This is one of the most beautiful, complete, and satisfactory papers which Doctor Brooks wrote; the observations are beautifully recorded, the evidences from his own work and that of others are completely marshalled, and his conclusions give the satisfaction which comes from a broad outlook, an intimate knowledge and a logical presentation of a great subject. In brief, his conclusion as to the origin of the Medusæ and the significance of metagenesis are these: (1) The remote ancestor

of the Hydromedusæ was a solitary swimming hydra, or actinula, with no medusa stage, but probably with power to multiply by budding; (2) this became more highly organized, better fitted for swimming life, until it was converted into a medusa, with swimming bell and sense organs, developing directly from the egg, but exhibiting during growth the stages through which the race had passed; (3) after this the larva derived some advantage in becoming attached, either as a parasite or semi-parasite, and in this condition it budded off other larvæ, all of which became medusæ; (4) the sessile life of the larva was so advantageous that it was perpetuated by natural selection and the primary larva lost its tendency to become a medusa, and remained a sessile hydra, budding off larvæ which became medusæ; (5) the primary larva acquired power to produce other larvæ, which remained permanently in the hydra state; and (6) finally, the communities thus formed became polymorphic by division of labor, and the sessile habit became so advantageous that the free medusæ became degraded into medusa buds on the bodies of the sessile hydras, or on the blastostyles. Following this monograph, he published six shorter papers on Hydromedusæ, the last appearing only one year before his death. A monograph on American jelly fishes, which he had worked upon for many years, was never completed, though many of the drawings and descriptions were used in some of the other papers named.

He wrote but one text-book, his "Handbook of Invertebrate Zoology," 1882, but this was so excellent that it has been a model for many subsequent books on that subject, and it is probable that if it had been handled by a larger publishing house its success would have been much greater. He was also the author of many scientific articles of a popular sort, in which kind of writing he showed unusual ability. He was inclined to look upon various human problems, such as the education and political position of woman, from the standpoint of zoology, and his popular discussions of the possible improvement of the human race, of instinct and intelligence, of heredity and variation, etc., were both novel and suggestive.

His chief interest was always on the philosophical side of biology, and into this he put a large part of his life work.

Even the special researches, some of which have been named above, were permeated by philosophical inquiry, and most of his books and later contributions were devoted to the deeper philosophical meanings of vital phenomena.

As a boy he had read the works of Darwin, and had been immensely impressed by them, and to the last he yielded to no one in his admiration and reverence for that great master. Probably no other disciple of Darwin was more thoroughly acquainted with his works, and very frequently when criticisms of Darwinism appeared he would point out the fact that the critic did not understand what Darwinism is, or that Darwin had already met and answered the objection raised.

One of his earliest papers, entitled "A provisional hypothesis of pangenesis," which he read before the American Association for the Advancement of Science in 1876, contained the germ of many of his later theories and speculations. This germ is the hypothesis that, whereas fully established peculiarities are transmitted by asexual reproduction as well as by the ovum, new characteristics are transmitted only through gemmules, which are stored in the reproductive glands of the male, and are transmitted to the egg in fertilization. Gemmules from the body of the female may pass into the ova, but there is here no organ for the aggregation and transmission of them. "The male element is thus the originating, the female the perpetuating factor in the reproductive process. The female is conservative, the male progressive."

This speculation, which he sought to support by many observations, became the basis of a volume of 336 pages, entitled "The law of heredity," which he published in 1883. This volume, however, contained much of value besides the speculation named. In some respects it anticipated the Germ-plasm theory of Weismann and the Mutation theory of De Vries, and it won the highest commendation from Huxley and other leaders in biology. Like many other profound thinkers on the subject of heredity, he recognized that no hypothesis of epigenesis offers a satisfactory explanation of heredity, and that there is no escape from some form of the evolution hypothesis. The form which he adopts is Darwin's hypothesis of pangenesis, with the modification suggested above. He points out that it is not

necessary to assume that the germ is as complicated as the adult, since under certain conditions the descendants of a single cell may become modified in several divergent directions. He maintains that Darwin's hypothesis may be so simplified that the gemmules may be few in number, simple in their properties, and not infinitely small. Nevertheless, this theory requires us to believe that the egg of one of the higher animals is complex beyond our powers of conception. It is interesting to note that he discusses (p. 131) those cases in which a hybrid resembles one parent or the other, but not both (what we now know as Mendelian inheritance), and he suggests a possible explanation by means of his hypothesis of pangenesis. In similar manner he discusses saltatory evolution (pp. 157, 296), and agrees with Huxley, Galton, and Mivart that nature does make considerable jumps (mutations), especially in the case of domesticated animals and cultivated plants. As instances of this kind he cites the sudden appearance of spike-horned bucks in the species *Cervus virginianus,* the ancon ram, the japanned peacock, and several similar cases among plants, and he "points out that our view of the cause of variation implies that any particular change should in itself be a fruitful source of still greater modifications, so that as soon as a tendency to vary becomes established it will continue to increase until an equilibrium is again established by the natural selection of those modifications which are adapted to the environment."

With regard to the determination of sex, he concludes that "sex is not determined by any constant law; that in certain animals and plants the sex is determined by certain conditions, while in other groups it is determined by quite different conditions" (p. 317). These are only a few of the subjects of present-day interest which are discussed in this book, and which he attempts to explain by his modified hypothesis of pangenesis, and although this hypothesis has no defenders at present, the book is still stimulating and suggestive.

It is interesting, and to many of his followers saddening, to see how far Brooks wandered in later life from the study of the physical phenomena of heredity and variation into metaphysical speculation. In two papers written in the last

years of his life, one of them entitled "Heredity and variation, logical and biological" (1906) and the other his address before the Seventh International Zoological Congress in 1907, entitled "Are heredity and variation facts?" he concludes that these terms "represent only imperfect mental concepts, and not facts, and that neither heredity, nor variation nor species can reside in germ cells, nor in chromatin, nor in gemmules. The gradual disappearance of attempts to invent evolutionary hypotheses to account for individual development or ontogeny, and the return to a more epigenetic standpoint . . . seems to me a notable reformation. Ancestral development is as epigenetic as individual development. The being of an individual is not in itself, but in reciprocal interrelations between it and its environment. If these things are true, is it not time to have done once for all with the pre-Darwinian metaphysical notion of species as something which resides in germ cells and is handed down by a substance of heredity?"

This brings us to a consideration of his philosophical and metaphysical writings to which the last ten years of his life were devoted almost exclusively. The publications of this period include some eighteen or twenty papers on philosophical subjects, culminating in the book into which he put the best efforts of his life, and by which he hoped to be longest remembered, viz.: "The foundations of zoology" (1899). This book consists of a series of lectures which were originally delivered at Columbia University, and were published in the Biological Series of that institution. It deals with many subjects fundamental not only to zoology, but to science and philosophy in general. The keynote of this book is found in the following extracts from the introductory lecture: "I shall try to show that life is response to the order of nature—in fact, this thesis is the text of most of the lectures; but if it be admitted, it follows that biology is the study of response, and the study of that order of nature to which response is made is as well within its province as the study of the living organism which responds." Among such responses to the order of nature are various forms of adaptation, correlation, instinct, intelligence, volition, and responsibility, and the question arises as to whether such responses are mechanical. "I am myself unable

to discover, in the present status of biology, any demonstration of error in the assertion that life is different from matter and motion," but "I cannot find any contradiction between anything we find in our nature and the ultimate reduction of all nature, including all the phenomena of life and of mind, to mechanical principles; for most students of the principles of science agree that natural knowledge is no more than the discovery of the order of nature. . . . Order is no explanation, but a thing to be explained." "It is a hard thing," says Berkeley, "to suppose that right deductions from true principles should ever end in consequences which cannot be maintained." To which Brooks responds: "In my opinion there is nothing in the prevalence of mechanical conceptions of life and mind, or in the unlimited extension of these conceptions, to show that this hard thing to suppose is true."

It is as impossible to summarize this book as it would be to summarize the Book of Proverbs, or the Meditations of Marcus Aurelius. It is, indeed, a compilation of many meditations which appear to have been written down at many different times, and afterwards joined together with more or less care. The result is a book which contains more pithy, quotable sentences than can be found in any other book dealing with biology with which I am acquainted, but at the same time it is a book which is difficult to analyze, and in places difficult to understand. The titles of the chapters will, in a general way, give the trend of the book; these are: "Huxley and the problem of the naturalist," "Nature and nurture," "Lamarck," "Migration in its bearing on Lamarckism," "Zoology and the philosophy of evolution," "A note on the views of Galton and Weismann on inheritance," "Galton and the statistical study of inheritance," "Darwin and the Origin of Species," "Natural selection and the antiquity of life," "Natural selection and natural theology," "Paley and the argument from contrivance," "The mechanism of nature," "Louis Agassiz and George Berkeley." In the course of these lectures very many important facts and observations on the topics suggested are introduced, and the book is of value from this more usual standpoint of science, but attention is chiefly directed to the underlying philosophical significance of these phenomena. On the whole his chief

points of view may be summarized in his oft-quoted remark of Aristotle, that the "essence of a living thing is not what it is made of nor what it does, but why it does it;" or, as he expresses it elsewhere, "the essence of a living thing is not protoplasm, but purpose;" and in the further statements which he draws from Berkeley, that "nature is a language," that "phenomena are appearances," and that "natural laws are not arbitrary nor necessary, but natural, *i. e.*, neither less nor more than one who has the data has every reason to expect." His system of philosophy was profoundly influenced by the writings of George Berkeley; his language resembles in its force and beauty the essays of Huxley, but his application of these to the foundations of science is his own.

On his fiftieth birthday, March 25, 1898, his former students united in presenting to him an oil portrait of himself (see page 71), together with a congratulatory address, and at the end of his book on the "Foundations of Zoology" he added on this date the following note:

> For you who have, at this time, for my encouragement, called yourselves my students, I have written this book which has been my own so long that I should part with it with regret, did I not hope that, as you study the great works to which I have directed you, you may still call me teacher. If you are indeed my students, you are not afraid of hard work, so in this day of light literature, when even learning must be made easy, you must be my readers, and you must do double duty; for I take the liberty of a teacher with his pupils, and ask that, after you have read the book, you will some day read it again; since I hope that what may seem obscure, may, on review, be found consistent and intelligible.

Much that he has written still seems to me obscure, although I have read it more than once, but I bear in mind his parting request, and in the meantime profit by that which I do understand, and am charmed by the classical and almost poetical diction in which it is written. Whatever one may be inclined to say of his conclusions and theories, it cannot be denied that in an age when biological investigators have been content with discovering phenomena, he attempted to go back of phenomena to their real meaning and significance and to point out the relationship of these newly-discovered phenomena to the great cur-

rent of philosophy which has flowed down to us from the remote past.

In his review of this book, under the caption "A sage in science," David Starr Jordan said:

> Brooks' lectures on the Foundations of Biology constitute a book that will live as a permanent addition to the common sense of science. It belongs to literature as well as to science. It belongs to philosophy as much as to either, for it is full of that fundamental wisdom about realities which alone is worthy of the name of philosophy. Writers of literature have been divided into those with quotable sentences, such as Emerson and Thoreau, and those whose style runs along without break in the elucidation of matter in hand, as Hawthorne and Irving. To the former class Brooks certainly belongs. His lectures are full of nuggets of wisdom, products of deep thought as well as of careful observation. There is not an idea fundamental to biology that is not touched and made luminous by some of these sagacious paragraphs. Whether it be to show the significance of some unappreciated fact, or to illustrate the true meaning of some complex argument, or to brush away the fine-spun rubbish of theory, the hand of the master is seen in every line. . . . The stones which Doctor Brooks has chosen as "Foundations of Zoology" will remain for centuries, most of them as long as human wisdom shall endure. The volume is a permanent contribution to human knowledge, the worthy crown of a life of wise thought as well as of hard work and patient investigation. The biologists of America have long since recognized Doctor Brooks as a master, and this volume, the modern and scientific sequel to Agassiz's "Essay on Classification," places him in the line of succession from the great interpreter of nature, whose pupil and friend he was.

HONORS, DEGREES, OFFICIAL POSITIONS.

His abilities received early and generous recognition. Apart from his university advancement he received many honors. The honorary degree of LL. D. was conferred upon him by Williams College in 1893, by Hobart College in 1899, and by the University of Pennsylvania at the Franklin Bicentenary in 1906. In 1884, at the age of thirty-six, he was made a member of the National Academy of Sciences. He was chosen a member of the American Philosophical Society in 1886, and a Councillor of the Society in 1906; an Associate Fellow of the American Academy of Arts and Sciences in 1892; resident member of the Boston Society of Natural History in 1875, and corresponding member in 1877; corresponding member of

the Academy of Natural Sciences of Philadelphia in 1887; honorary member of the New York Academy of Sciences in 1898. He was also a member of the American Society of Zoologists, the New York Geographical Society, the Society of American Wars. He was a fellow of the American Association for the Advancement of Science, and of the Royal Microscopical Society.

As a result of his investigations on the development of the oyster, he was appointed by the governor of Maryland to be chairman of the Oyster Commission of that State; and he was also made Member Protector, Classe Peche et Pissiculture d'Exposition universelle d'Anvers; he also received the medal of the Société d'Acclimatation of Paris for his oyster work. A Challenger medal was given him for his work on the Challenger Reports; and he received a medal at the St. Louis Exposition of 1904, where he gave one of the principal addresses. He was Lowell Lecturer in Boston in 1901; one of the speakers at the American Museum of Natural History on the occasion of the unveiling of busts of American men of science during Convocation Week, 1906; and he gave one of the principal addresses at the Seventh International Zoological Congress in Boston, in 1907.

For nearly twenty years he was a trustee of the Marine Biological Laboratory at Woods Hole, Massachusetts; and in 1888 he was Scientific Director of the U. S. Fish Commission Station at Woods Hole. He was editor of the Results of the Chesapeake Zoological Laboratory; co-editor, with Professor Martin, of the Studies from the Biological Laboratory of the Johns Hopkins University; editor of the Memoirs from the Biological Laboratory, and a member of the board of editors of the Journal of Experimental Zoology.

All of these honors he prized highly, though modestly, and he rarely mentioned them except in facetious vein. It was characteristic of him, however, that he not infrequently mentioned with pride the fact that he held a U. S. Inspector's Certificate, licensing him as a pilot.

PERSONALITY.

Professor Brooks was a man of strongly marked individuality. In personal appearance he was short and stout, with straight dark brown hair and heavy dark brown moustache and eyebrows. While in Cambridge, and during the earlier years of his residence in Baltimore, he wore a full bushy beard. He sometimes allowed his hair to grow long, apparently because he disliked to take the time to have it cut. He used to say jocosely that he envied the man who did not need to have his hair cut, and who never wore a collar or necktie. He was generally careless, or rather thoughtless, of dress, and mere conventionalities counted for little with him. His best known portrait is the one painted by Thomas C. Corner, and presented to him by some fifty of his former pupils on his fiftieth birthday, March 25, 1898, a photographic copy of which appears on the opposite page. This portrait was afterwards loaned to the Johns Hopkins University, and it now hangs among the portraits of other distinguished professors of the university in McCoy Hall. It represents him in characteristic attitude, sedentary, meditative, careless of dress, and with that peculiar uplift of the eyes which with him usually preceded speech.

He was slow and deliberate in his movements and speech, and undemonstrative in manner. In general he talked little, and in a low tone. When he had occasion to speak more loudly his voice assumed a rather high and piping quality. With him talking meant expressing ideas, not merely passing the time, and if he had no answer ready when a question was asked him he usually gave no answer until he was ready—it might be several days later—when he would answer as naturally as if the question had been asked only a moment before. These characteristics made him appear somewhat unique and picturesque, and gave rise to many charming anecdotes about him which his students and friends relate with merriment, but real affection.

In spite of his quiet reserve he was usually a very companionable man, and his company was sought and prized by his friends. On his part he was fond of his friends and neighbors, though he was often silent and absorbed in thought. At

such times he would occasionally interrupt his quiet reflections by some thoughtful and unexpected remark, such as, "The term supernatural is due to a misconception of nature; nature is everything that is."

His humor was quiet but genuine; he enjoyed a good joke, and would sometimes relate humorous stories, but never any of questionable propriety. His laugh was never loud, and his amusement was shown by a quiet chuckle and twinkling eyes. In particular he enjoyed telling of odd and interesting persons whom he had known, and of the amusing behavior of animal pets. For a puppy that destroyed a copy of Shakespeare he professed a high regard, but one that chewed up cheap novels was a worthless rascal.

His love of animals was deep seated, and between him and his pets there was genuine companionship. In particular his great dog "Tige" was his constant companion for many years. This "noble dog," as Prof. William James has called him, was seven-eighths St. Bernard and one-eighth mastiff, and weighed nearly 100 pounds. He lived with his master during his life at Cambridge, and later accompanied him to Baltimore, and many who knew Doctor Brooks in those days remember how nearly inseparable he and his dog were. On one occasion, when Professor Brooks was living in the country near Baltimore, he took an early train to the city, and put "Tige" in the baggage car. Before the train started "Tige" jumped out, and then, missing his master, he raced after the train and kept within sight for two and one-half miles, when he was lost to view; but he appeared at the laboratory several hours later, and quietly laid down at his master's feet. The affection which Brooks had for this dog was very great, and after "Tige's" death he was often mentioned as if he had been a dear human companion.

For another favorite dog which had been lost in transit between Baltimore and North Carolina, Brooks employed a man to make careful search over the entire line of travel, not because the dog was of commercial value, but because of his affection for him. His attitude toward all animals and plants is beautifully expressed in his introductory lecture on the "Foundations of Zoology," p. 17: "As for myself, I try to treat

all living things, plants as well as animals, as if they may have some small part of a sensitive life like my own, although I know nothing about the presence or absence of sense in most living things; and am no more prepared to make a negative than a positive statement."

Professor Brooks was interested in the welfare and practical needs of his fellow-men. In 1879 he gave part of an elementary course in biology for the teachers of the Baltimore schools. In 1882 he lectured before the employees of the Baltimore and Ohio Railroad on "Methods of locomotion in animals." He was also instrumental in establishing a public aquarium in Druid Hill Park. But his principal work of a practical character was on oyster and fish culture. By lectures, newspaper articles, and books he sought to arouse public interest in the great possibilities for public good which lay in these "harvests of the seas."

His sense of honor and justice was highly developed and his indignation was aroused when any case of injustice or abuse of power came to his notice. In particular he respected the rights of servants and the poorly educated, and he resented any infringement of these rights. While at Nassau, a merchant of the town tried to compel Doctor Brooks to pay him the wages of a negro servant of the laboratory. Doctor Brooks refused to do this unjust act, as he regarded it, and he resisted all pressure which was brought to bear to compel him to do this, even at the risk of being unable to sail on the steamer on which he had engaged passage. With a sense of obligation, unusual and perhaps exaggerated, he held that the university which employed him was entitled to all that he might earn by outside work; fortunately for him his university recognized no such obligation.

He was occasionally very happy in the use of scriptural language, illustrations, and quotations. He acquired his familiarity with the Bible in his grandfather's family, where it was read daily. His familiarity with the scriptures was often shown in his writings and conversation. On one occasion, in a discussion of Weismann's essay on "Life and Death," in which, as is well known, Weismann claims that death is not a necessary and primary characteristic of living things, but one

which has been acquired, one of the students asked whether such a view was not contrary to religious teaching. Professor Brooks at once replied: "As I remember it, St. Paul teaches that death was not an original corollary of life, for he says 'by sin came death.'"

His nature and cast of mind was strongly reverential, and he could be said to be religious in the higher sense, although he long ago ceased to attend church or to take any interest in the doings or affairs of religious bodies. A few years before his death he talked with the writer upon the subject of immortality, and maintained that faith in immortality was in no sense unscientific. His attitude on these things may be inferred from the following extracts from the "Foundations of Zoology":

> If any believe they have evidence of a power outside nature to which both its origin and its maintenance from day to day are due, physical science tells them nothing inconsistent with this belief. If failure to find any sustaining virtue in matter and motion is evidence of an external sustaining power, physical science affords this evidence; but no one who admits this can hope to escape calumny; although it seems clear that the man of science is right, . . . for refusing to admit that he knows the laws of physical nature in any way except as observed order.
>
> Many will, no doubt, receive with incredulity the assertion that the ultimate establishment of mechanical conceptions of life has no bearing, either positively or negatively, upon the validity of such beliefs as the doctrine of immortality, for example. The opinion that life may be deducible from the properties of protoplasm has, by almost universal consent, been held to involve the admission that the destruction of the living organism is, of *necessity*, the annihilation of life. Yet it seems clear that this deduction is utterly baseless and unscientific; . . . if it be admitted that we find in nature no reason why events should occur together except the fact that they do, is it not clear that we can give no reason why life and protoplasm should be associated except the fact that they are? And is it not equally clear that this is no reason why they may not exist separately?

During his first years at the Johns Hopkins University he and other members of the biological department boarded at "Brightside," on the shore of Lake Roland, seven miles from Baltimore. Here he met his future wife, Amelia Katharine Schultz, to whom he was married June 13, 1878. In after years Mrs. Posey, owner of "Brightside," bequeathed this

beautiful estate to her favorite niece, Mrs. Brooks. Here Doctor Brooks and his family lived a happy life, with books, greenhouse, garden, and trees; and here Doctor and Mrs. Brooks entertained repeatedly the graduate students of the biological department. All of these students remember Doctor Brooks' devotion to Mrs. Brooks and the children. His interest in the education of his children and his pride in their achievements were so great that he not infrequently spoke of these things to his students, and his complete devotion to Mrs. Brooks was both touching and beautiful. For several years before her death Mrs. Brooks was an invalid, and Professor Brooks frequently spent days and nights at her bedside reading to her and attempting to ease her suffering, and no other work or duty was allowed to interfere with this service of love. Mrs. Brooks was a woman of simple and charming personality, and one of the most delightful memories which zoological students have of their life in Baltimore is of the pleasant evenings spent with Professor and Mrs. Brooks at their home, when biological classics were read and discussed, when the various biological expeditions were talked of, and in lighter vein, when the sayings of the children were told, the animal pets shown, and the home-grown orchids exhibited. No one who experienced it can ever forget the simple and cordial hospitality of Professor and Mrs. Brooks, nor the sense of deep and abiding happiness which these glimpses of their home life gave.

Professor Brooks was a man of wide culture, though his absorption in his work was so great that many knew him only as a naturalist. He read widely, and wrote with much attention to his style. He knew well the world's best literature and art, and in his later years he found that he had a strong liking for music, especially the great compositions of Beethoven, Mozart, Wagner, and Bach.

One of his strongest characteristics was his judicial and philosophical temper. When he was once asked if he did not fear that someone would anticipate him in his great work on Salpa, on which he had worked for many years, he said: "I long since ceased to be troubled by such thoughts, for if another should publish on this or any other subject before I do, his work would probably be better or worse than mine. If it

was better, I should be glad to be saved the mortification of having published poorer work; if worse, it would only afford additional material for my paper." His mind was too large for little things, too sane for foolish ones. He was remarkably original and suggestive in his methods of thought, and in his views of scientific, social, and philosophical problems he was as artless and direct as a child. He was critical, yet tolerant; modest, but dignified; loyal to his friends, his university, and his ideals; independent in thought and action, and not easily moved from a position he had once taken. He was kind and gentle; and neither in his publications nor in his relations with students did he ever deal in scorn, irony, nor invective. President Remsen said that he had been called the most lovable man in his faculty.

What is the secret of his remarkable influence over others, which his students and associates recognize? By general consent it is attributed not merely to his greatness as an investigator and teacher, but also to his character as a man. In his life there was nothing either to be concealed or explained. He was "a man in whom there was no guile;" a man of such transparent simplicity and sincerity, of such single-hearted devotion to science, so simple-minded, natural, kind, gentle, pure in thought and deed, that his *life* as well as his *work* has left an indelible impression upon all who knew him.

SICKNESS, DEATH, AND BURIAL.

A congenital defect of the heart had caused him to lead a less active life physically than do most men, and to this trouble other bodily ills were added as life advanced. He bore all these ills with fortitude and patience, and many of his friends did not know how serious his condition was. Professor Andrews, who was closely associated with him, says:

In 1908 difficulty in breathing added to his burdens and his machinery was most seriously out of order. He continued to come to his lectures and worked earnestly to complete a final paper on salpa, for which the drawings were finished and which he planned to write out in the summer. This, he said, would probably be his last piece of serious microscopic research, since trouble with his eyes made the employment of immersion lenses too difficult; and his mind was eager to digest the facts of his long experience and the recent work of others. But his strength

was not equal to the task. Sudden attacks confined him to his home, but yet his will brought him back to his laboratory, till one last day, February 12. After preparatory rest, driven by his conscientiousness, he forced himself to attend an oral examination of a candidate for the degree of Ph. D. Then walking to the train that brought him home, he was there overcome by a serious collapse. He was persuaded to go to the hospital and, after most severe attacks there, rallied; but in nine long months that followed he scarcely left his wheel-chair.

When he returned to his home he got such comfort as might be from the advent of spring, the passing of summer and the long lingering of autumn, amidst scenes so familiar and dear. Despite his critical state he was deeply interested in such news as came to him from the University. His last official act was a strong, successful plea for another when his own interests might well have absorbed his attention. His was real friendship growing out of his own wide sympathies.

While having some strength to correct the proofs of papers in press, he felt most keenly his inability to put his last work upon paper, and till this work was done he would not deem it right to retire or seek a pension.

Professor Brooks once told the writer of this memoir that he proposed to retire from his professorship when he had reached the age of sixty, and thereafter devote himself entirely to philosophical and scientific work. He reached the age of sixty in March, 1908, but how different was his realization from his plan. His retirement was not to the scholarly leisure for which he longed, but to pain, weakness, and mortal sickness. For nine months he struggled against a complication of organic heart trouble and kidney disease; he was unable to walk or lie down, but lived in a reclining chair. For a month before his death he was often in a semi-comatose condition, and for the last three or four days was unconscious. The end came at last at sunrise on Thursday, November 12, 1908.

The autopsy revealed chronic diffuse nephritis, arteriosclerosis, congenital malformation of the heart with open septum ventriculorum, cardiac hypertrophy, atrophy of the olfactory lobes, and atrophy of the cerebral cortex. The heart was enormously enlarged, and with the opening in the septum between the two ventricles it is surprising that he lived as long as he did. He had for years expected death at any time, and at forty congratulated himself on having lived so much longer than any one acquainted with his condition could have expected. It is the opinion of experts that the explanation of his living to such

a comparatively good old age, was due to the fact that the heart lesion was very well guarded by muscular tissue, so that it did not increase during life. Had it been otherwise, it would have been out of the question for him to have survived so long.

His funeral was held on November 16th, at Towson, Maryland. After preliminary services in Trinity Church, his body was followed by his colleagues, students, and friends to its last resting place "on the brow of a hill overlooking a broad valley, in the cemetery of the county seat of Baltimore county."

A meeting commemorative of Professor Brooks was held at McCoy Hall, Johns Hopkins University, on Sunday afternoon, December 6, 1908. President Remsen presided, and spoke of Doctor Brooks' early connection with the university, and of his career as an investigator, a teacher, a colleague, and a man. Addresses were delivered by Prof. B. L. Gildersleeve, Dr. H. M. Hurd, Prof. W. H. Howell, Prof. E. A. Andrews, and Dr. Caswell Grave. These addresses, together with a letter from Prof. William Hand Browne, and a biographical sketch of Professor Brooks by Doctor Andrews, were published in the Johns Hopkins University Circular for January, 1909.

A memorial dinner, attended by former students and biological associates of Professor Brooks, was held in McCoy Hall, Johns Hopkins University, on the evening of December 31, 1908. About sixty persons were present, and short addresses were made by Profs. S. F. Clarke, of Williams College; E. A. Birge, of the University of Wisconsin; E. B. Wilson and T. H. Morgan, of Columbia University; H. W. Conn, of Wesleyan University; H. H. Donaldson, of the Wistar Institute; C. F. Hodge, of Clark University; F. H. Herrick, of Western Reserve University; M. M. Metcalf, of Oberlin College; J. P. McMurrich, of the University of Toronto; H. V. Wilson, of the University of North Carolina; R. G. Harrison, of Yale University; E. G. Conklin, of Princeton University, and W. H. Howell and E. A. Andrews, of Johns Hopkins University.

At this dinner it was decided to publish a memorial volume to Professor Brooks, to consist in the main of original scientific papers contributed by his pupils. Since Doctor Brooks was one of the editors of the Journal of Experimental Zoology,

it was decided to publish this memorial as a volume in that series; and it is now in course of preparation. In what better way may the memory of a great scientist and teacher be honored than by carrying forward the torch which has fallen from his hand?

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