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HENRY FAIRFIELD OSBORN

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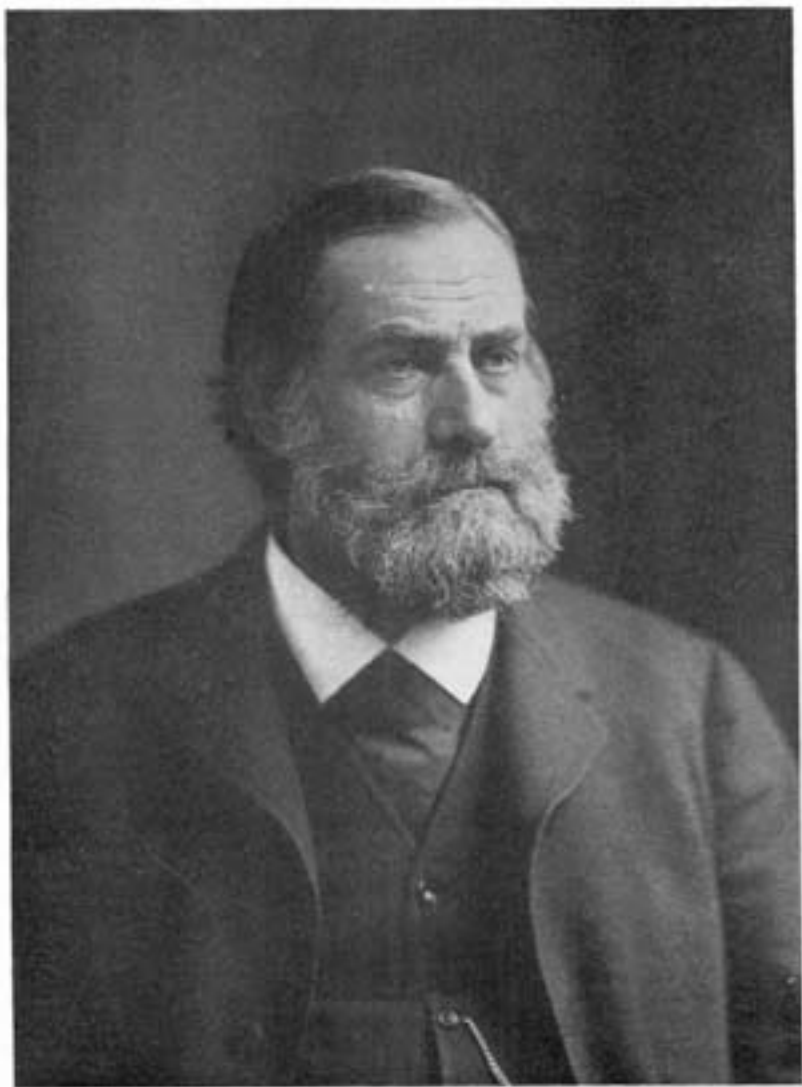


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Joseph Leidy

NATIONAL ACADEMY OF SCIENCES.

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JOSEPH LEIDY.

The name of Joseph Leidy will endure both as the founder of vertebrate palæontology in America and as the last great naturalist of the old, or eighteenth and early nineteenth century type. Among zoölogists he was the last to treat of the whole animal world from the protozoa to man, rendering in every branch contributions of permanent value. From his researches among the minerals, plants, infusorians, entozoa, and mollusks, he ranged into comparative anatomy as well as into his greatest field of research, vertebrate palæontology. In the year 1852 we find him writing upon fossils from the West, the geology of the Badlands, the life history of bees, their anatomy and the physiology of their reproductive organs, as well as entering the discussion of some new fungi with an English microscopist, the specific determination of various parasites, as well as numerous plants, the investigation of some new points in comparative anatomy, the observation of the movements of some new Rhizopods. His encyclopædic knowledge, broad grasp of the whole field of natural history, precision and originality of observation in every field, present a combination of endowments which will never reappear in a single individual.

In vertebrate palæontology, Leidy's favorite field of research, all his great contributions antedate the beginnings of the work of Edward Drinker Cope and Othniel Charles Marsh, the two National Academicians whose names are always associated in our minds with his. His monograph of 1869, "On the Extinct Mammalia of Dakota and Nebraska," is, with the possible exception of Cope's "Tertiary Vertebrata," the most important palæontological work which America has produced.

ANCESTRY AND LIFE.

Descent from patriotic German-American stock enables us to understand the sources of Leidy's fine moral qualities. His remote ancestors, before 1720, were of the German peasantry. While he was chiefly of German extraction, his paternal grand-

mother, Catherine Le Febre Comret, was a sister of Francis Joseph Le Febre, Duke of Dantzic, Marshal under Napoleon I.

Intellectually Leidy inherited the sterling thoroughness generally characteristic of Teutonic science, the indomitable search for knowledge and love for the plain, unvarnished statement of fact, unclouded by speculation. In following up the immediate ancestry of Joseph Leidy we find, both on the father's and mother's side, well-to-do people, tillers of the soil, partly engaged in their own tanning and pottery. We also fail to find among his more remote military forebears any anticipation of his devotion to natural science unless it be that one of his great uncles was a surgeon, and that he was of the same parent stock as the German anatomist, Prof. Franz Leydig, of Wurzburg and Bonn. Leydig was Haeckel's master in embryology; his grandfather was a brother of Joseph Leidy's grandfather. It appears that Leidy's remarkable genius as an observer was not accumulative but was suddenly born with him. Of the many aspects of his character as a man of science we will speak more definitely after reviewing his life and works.

Joseph Leidy was born in Philadelphia on the 9th of September, 1823. His father was a hatter and is described as a man endowed with practical good sense, honest and industrious, but not of any conspicuous mental force nor of very great education. He was of ample means and never deprived his family of the wherewithal for their mental development. He was desirous that his sons should live independent, self-supporting lives, and naturally became concerned when he found Joseph preparing to support himself by teaching rather than by the practice of his profession as a physician. Certain it is that Leidy did not suffer from the financial strain which so many men of science experience in early life.

Joseph Leidy's mother, Catherine Mellick, was a woman of intellect and education, a descendant of the Mellicks (Moelich), also natives of Rhenish Germany, who founded the celebrated "Old Farm" in New Jersey and later emigrated to Pennsylvania. When Leidy was only a year and a half old his mother died, leaving behind her four children, of whom Joseph was the third. His stepmother, Christiana Mellick, was also an intelligent woman, and gave Joseph his early training until he

was sent to the private school of William Mann, a Methodist clergyman, where he received as good a preparatory training as Philadelphia afforded in that day. At this classical academy, where Latin and Greek formed the principal part of the instruction, Leidy did not distinguish himself in his studies, but showed an intense interest in all branches of natural history, although none of these subjects were included in the curriculum. It was his greatest delight to wander out into the rural districts of Philadelphia in quest of minerals, plants, insects, etc., and occasionally these excursions would tempt him to absent himself from school without leave. He was indifferent to boyish sports and devoted his leisure time to drawing the natural objects which he collected. A note-book has been preserved, dated 1833; it contains a series of careful drawings of snail shells and shows the degree to which Leidy, solely through his own efforts, had cultivated his natural abilities at the age of ten. In later years he became an expert draughtsman, especially of microscopic objects. When at the age of sixteen he left school his father determined that he should be an artist. His mother, however, wished her sons to "learn professions," and, as Leidy later explained, "she being the stronger carried the point."

About this time Leidy spent several months in a wholesale drugstore of a cousin physician and druggist, and soon acquired so accurate a knowledge of drugs that he was recommended to take temporary charge of a retail branch of the business; but from the skill he had already displayed in dissecting, which he had practiced on a few domestic animals, his mother believed that she saw in him the makings of a great physician and she prevailed on his father to allow him to take up the study of medicine. For a year he studied anatomy under a private teacher, Dr. James McClintock, and in 1841 he matriculated at the University of Pennsylvania. Here his chief instructor was Dr. Paul B. Goddard, who in leisure evenings at his own home introduced Leidy to the use of the microscope, which became thereafter one of the greatest pleasures of his life. In 1844 Leidy received the degree of doctor of medicine, after presenting a thesis on "The Comparative Anatomy of the Eye in Vertebrated Animals." He opened an office in Phila-

delphia, and for two years practiced the profession of medicine with little success. With ardent interest he continued to pursue his studies in comparative anatomy, for which his practice left him ample time, and also acted as prosector to the eminent Dr. Horner, professor of anatomy at the university.

Leidy's initial publications appeared, at the age of twenty-two, in the year 1845 in the Proceedings of the Academy of Natural Sciences of Philadelphia and of the Boston Society of Natural History, covering^a new species of fossil shells from New Jersey,^b the microscopic examination of a vertebra of a fossil Zeuglodon,^c the anatomy of the snail *Helix albolabris*, the anatomy of the dart, and several species of American pneumobranchiate mollusks. This last paper, presented before the Boston Society of Natural History, showed so much ability that Leidy was immediately elected a member of the society. At this time, September, 1845, Amos Binney, president of the society, wrote him: "The value of the compliment of your election to membership in the Boston Society of Natural History consists in the wish to encourage you to continue to give some portion of your time to that branch of natural history in which there is no doubt that you may render essential service to science. I mean the comparative anatomy of the lower orders of animals."

On July 29, 1845, Leidy was also elected to membership in the Academy of Natural Sciences of Philadelphia, an important event alike in his history and that of the academy. He published the first of a long series of contributions, and for the succeeding forty-six years he exerted a most active influence on the well-being of the institution in every department, until in the world at large the names of Leidy and the academy became inseparably associated.

This recognition of the originality and breadth of Leidy's

^a Published in Proc. Boston Soc. Nat. Hist., 1845. (See bibliography.)

^b Notes taken on a visit to White Pond, Warren County, New Jersey, [and a list of ten species of fossil shells collected there]. Proc. Acad. Nat. Sci. Philadelphia, vol. 2, 1845, pp. 279-281.

^c[The microscopic examination of a portion of a vertebra of the fossil Zeuglodon shows that it has all the characteristics of recent bone.] Proc. Acad. Nat. Sci. Philadelphia, vol. 2, 1845, p. 292.

observations by the two leading scientific institutions of America truly marked the first turning point in his career. In these days when science has a recognized place in every university and school, and museum collections are available in all the large cities, it is difficult to realize how much the privileges of the academy library, apparatus, and collections, as well as the interest and coöperation of the specialists in its circle of members, could mean to the young scientist. The records of the academy show that Leidy regularly attended the weekly evening meetings from this time on and almost invariably took part in the discussions. Soon after his election as a member Leidy was appointed librarian of the academy, and performed his duties in the conscientious and efficient way in which all his work was done. In later years he served the academy as chairman of the board of curators, and finally as president for two dates.

The six papers which Leidy contributed during the year 1846 cover the anatomy of the sloth and of one of the lemurs, the wings of the locust, the olfactory organs in one of the gastropods, and include also his first two contributions to the knowledge of parasites which infest mammals.

From this early period dates Leidy's first discovery, which in a practical way has contributed more than any other to the welfare of humanity and has resulted finally in the saving of hundreds, even thousands, of lives annually. With his keen powers of observation he noticed in a piece of ham served at his breakfast table numerous minute white specks, which on examination under the microscope he recognized at once as cysts of *Trichina spiralis*, which were known to him from their occurrence in human muscles. In 1835 Richard Owen had described and named *Trichina* as parasitic in the human subject, but up to the time of Leidy's discovery no one had surmised the true source of this dangerous entozoön in man.^a

In the summer of 1846, at the age of twenty-three, Leidy visited Samuel Stehman Haldeman, making collections of animals and plants in the vicinity of his home, reports of which

^a[On the existence of an Entozoön (*Trichina spiralis*) in the superficial part of the extensor muscles of the thigh of a hog.] Proc. Acad. Nat. Sci. Philadelphia, vol. 3, 1846, pp. 107-108.

appear in 1847 as his first contribution to the anatomy of marine vertebrates and invertebrates. It was at this time that through his dissections his attention was drawn to the existence of a fauna and flora within living animals, a subject which he selected for a special contribution in 1853. During the fifties he was a frequent visitor to Newport, Rhode Island, and Narraganset Bay, where much of his work on marine zoölogy was accomplished.

The year 1847 is also noteworthy for the appearance of Leidy's first two contributions to vertebrate palæontology,^a the subjects being a fossil horse of the East and a fossil cameloid of the West (*Poëbrotherium*). This marked the beginning of his interest in palæontology and of those manifold observations and notes on the extinct vertebrates of every region of North America which fill the proceedings and memoirs of the Academy of Natural Sciences. At this time Cope was seven years of age and Marsh sixteen. Although Leidy's labors throughout his life extended over almost every field of zoölogical research, the complete list of his publications shows that the study of vertebrate palæontology absorbed his energies chiefly up to the year 1873, after which his time was again devoted chiefly to microscopic organisms, although he made occasional contributions to palæontology.

In 1847-1848 Leidy definitely decided to abandon the practice of medicine and to devote himself to scientific research and teaching, whatever financial difficulties might arise or as a consequence lie in his path. He therefore accepted an appointment as demonstrator of anatomy in the Franklin Medical College, which he surrendered, however, at the end of one session in order to resume his anatomical work under Dr. Horner at the University of Pennsylvania, and at the same time to deliver privately his first course of lectures on anatomy, human and comparative. His first notable contributions in this field were those of 1847 and 1849 on the evidence of the existence of the intermaxillary bone, confirming the earlier prophecy of Goethe.

^a On the fossil horse of America (*Equus americanus*). Proc. Acad. Nat. Sci. Philadelphia, vol. 3, 1847, pp. 262-266.

On a new genus and species of fossil Ruminantia (*Poëbrotherium wilsoni*). Proc. Acad. Nat. Sci. Philadelphia, vol. 3, 1847, pp. 322-326.

Several contributions to human anatomy appear about this period (1848-1849), which prepared him, at the age of twenty-seven, for the editorship of the first American edition of Quain's "Human Anatomy."

The summer of 1848 was spent abroad, Dr. Horner having invited his young assistant to accompany him. In London, Paris, Vienna, and other large cities, he visited the museums and hospitals and made the acquaintance of eminent anatomists and physiologists, among others Owen, Darwin, Majendie, Milne Edwards, and Johannes Müller. Leidy sailed for London on a packet ship, and soon after arrival he wrote a letter to Richard Owen in which he used the following appropriate expression: "Looking upon you as the Cuvier of England." Owen extended to him every courtesy. He dined with Owen and met Charles Darwin just before returning to America. In Paris he found himself in the midst of the rebellion of 1848, and in a long letter to his mother, describing the exciting events, he writes: "I got between the fires."

With his vision greatly broadened by this experience, Leidy returned to his work with increased energy. He delivered a course of lectures on microscopic anatomy, published the new edition of Quain's "Human Anatomy," and began a course of lectures on physiology at the Medical Institute of Philadelphia.

Indicating that he was a pioneer in this country in his special field of microscopy is a letter received in 1852 from the Italian anatomist, Corti: "I have not been aware of any one else in America interested in microscopic anatomy, and write to interest you in my investigation of the organ of hearing."^a

After a short time overwork threatened Leidy with serious illness, and he was obliged to suspend his teaching, as well as his investigations, for some months. In the spring of 1850, at the age of twenty-seven, a second opportunity to travel abroad presented itself. Dr. George B. Wood, who had just been appointed professor of the practice of medicine in the University of Philadelphia, and who wished to make a collection in Europe of specimens, models, and drawings for his lectures, persuaded Leidy to accompany him.

^a This was the only work that Corti published, as he relinquished scientific pursuits and entered the field of Italian diplomacy.

In the meantime an intimacy had sprung up with Spencer F. Baird. In 1853 Leidy wrote to Baird: "I am desirous of making a special library of vertebrate palæontology so far as my means will permit." In 1852 Leidy had arranged to accompany an expedition to the West to collect fossils. He particularly desired to enter the field, as he wished to make certain geological observations. We must consider it a great loss to science that he was unable to carry out his plan. As he was about to start Dr. Horner, professor of anatomy at the University of Philadelphia, became so seriously ill that Leidy was informed by his friends it was absolutely essential for him to remain as a substitute for Dr. Horner's course of lectures, as in the event of his death he would in all probability be called to the chair. Baird wrote to him: "Do not leave Philadelphia until you have settled the professorship," and added, "Do not worry about the fossil bones; they will all be sent to you anyhow."

It is characteristic of the dogmatic influences of the times that the rival candidate for the chair of anatomy was using Leidy's scientific researches as a weapon in opposing him. He writes to Baird: "All those things which you would think would recommend me to the trustees my opponent is using against me. I am shamefully abused as being an atheist, an infidel. It has been positively asserted that I seek to make *proselytes to infidelity*, and that in my writings I have tried to prove that geology overthrows the Mosaic account of the creation. You may judge of my feelings."

Aided by warm letters of recommendation from Wyman, Dana, and Henry, Leidy, although only thirty years of age, received the professorship of anatomy in 1853. Dana referred to him as the most eminent comparative anatomist in the country. Wyman wrote: "It may be added that Dr. Leidy is eminently distinguished as a man of science, with an ardent love of nature, with untiring industry, with quiet and accurate powers of observation. He combines a highly philosophical mind and great fidelity as a searcher after truth." Joseph Henry wrote: "If the regents, or rather the trustees, should be so blind to the best interests of the institution as to place some favorite over your head, they will repent it. If you con-

tinue to grow as you have begun, places of honor will be forced upon you."

At the age of forty, in August, 1864, Leidy married Anna Harden, of Louisville, Kentucky. They had no children.

When, in 1867, the Academy of Natural Sciences of Philadelphia was planning the erection of a new building, more ample accommodations for its growing museum and library, Leidy was appointed a member of the board of trustees of the building. The administrative duties connected with this post were little to his taste, and so far as possible he left all decisions to other members of the board, whom he considered more practical than himself.

In 1874 Leidy was offered the Hershey Professorship at Harvard. In 1875 he again went abroad, and during his visit to London he met Mrs. Huxley, Huxley himself being at the time in Edinburgh lecturing. The day following his call Leidy received a letter from Huxley, in which he expressed regret, and wrote in his characteristic way: "Mrs. Huxley once saw an iceberg, which I in all my travels never had a chance of, and I am really in despair missing all chance of seeing you. If she has also the power of boasting that she met you and I have not . . . my life will not be worth living. For domestic reasons if for no other, therefore, let me have the pleasure of seeing you."

In 1880 an invitation to lecture and supervise the studies of the graduate students of Princeton University was considered and declined.

Some of the most interesting episodes in Leidy's life may be considered in connection with his two chief lines of investigation, the protozoa and fossil vertebrates. His character and intellectual predispositions are constantly reflected in his work. His knowledge of the general facts of natural history was vast. While lecturing at Swarthmore the students would delight in trying to bring to his notice some natural object with which he might prove to be unacquainted, but they never succeeded in finding him unprepared. In scientific discussion he seemed to have an intimate and first-hand knowledge of every speciality, in addition to being a master of anatomy, invertebrate zoölogy, and palæontology. Although he did not claim to be a miner-

alogist his knowledge of minerals and precious stones was vast. He lectured at Swarthmore for years on minerals, and his collection of minerals, sold to the Smithsonian Institution after his death, reflected his keen powers of observation and judgment. He made one of the first collections of gems arranged in this country, to which he added from time to time until a few years before his death it was disposed of in Boston; some of these gems are now in the collection of the American Museum of Natural History of New York.^a

Botanical studies continued to attract him. He once expressed regret at not having time to prepare a monograph on the "grasses," which interested him particularly.

Leidy's life continued to be characterized by unabated vigor and constant industry. Year after year the Proceedings of the Academy of Natural Sciences contained numerous short communications, with studies of parasitism and palæontology taking the most prominent place. In 1881 Leidy was unanimously elected president of the Academy of Natural Sciences of Philadelphia—an office which he held until his death, in 1891. When, in 1884, after almost twenty years of preparation, the University of Pennsylvania established a department of biology, Leidy was made its director, and was also appointed to fill the chair of zoölogy and comparative anatomy. In the following year the Wagner Free Institute of Science of Philadelphia elected him its president. Thus the prophet was honored in his own country, and Philadelphia may look back with satisfaction to her generous and timely recognition of the greatness of her son.

Accompanied by his wife, Leidy visited Europe for the last time in 1889. He returned home little refreshed and his strength began to fail soon afterward. Nevertheless he continued his teaching and the performance of his many duties until the week before his death.

Leidy passed away on April 30, 1891, in his sixty-eighth year, having continued his studies almost to the very last. The amount of work accomplished by him in his productive period of forty-six years (1845-1891) is extraordinary. His pub-

^a See Memoir of Joseph Leidy by Persifer Frazer, *American Geologist*, January, 1892.

lished writings of various lengths exceed 600 titles. Although an indefatigable worker, he was devoid of personal ambition, and seems to have sought positions not for the distinction they might bring to him, but only for the opportunity which they might afford for the pursuit of his scientific studies. He frequently placed others before himself. When invited to make the opening address of the American Museum of Natural History in New York, he declined, advising the trustees to ask Professor Marsh in his stead. To Meek and Hayden, who wrote to him in 1859 regarding credit for a geological observation, he replied: "I am too little ambitious to give myself any trouble about such a case as that you mention. Even should any one pass unnoticed more important things I may have done, I shall feel no regret about the matter."

He cared as little for money as for position, his tastes being extremely simple. He was simple and unassuming in habit from first to last and unaffected by the honors which came to him from every part of the world. The tributes paid to Leidy at the time of his death enable us to realize in what high esteem he was held as a man. It is said that he never made an enemy; the testimony of all with whom he came in contact is that he was as lovable as he was great in character. A love of peace was one of the essential characteristics of his nature, combined with a strong passion for truth and love of the beautiful. He disliked controversy exceedingly and was reserved on all matters relating to his personal beliefs, such as religion. The Unitarian Church appealed to him most strongly. To quote from his own words: "I have always had an antipathy to enter into a discussion of religious opinions, and when persons, curious to know mine, have questioned me, to avoid discussion, I have the last few years referred them to the admirable work of John Fiske [Cosmic Philosophy]. . . . Through life I have been conscious of having been a devoted worshiper (again to quote Mr. Fiske) 'of an ever-present God, without whom not a sparrow falls to the ground'; and I have often felt annoyed at the implied reproach of infidelity from the self-sufficient who consider that they fulfill all religious duty in lip service to the same Deity." It has been alleged that he resembled Darwin in a lack of appreciation of poetry, but

this appears to have arisen from a misunderstanding. Among his favorite writers were Longfellow and Holmes. "The Chambered Nautilus" of the latter had an especial charm for him. He was fond of art, and his own artistic skill was coupled with a keen delight in beauty of form and color.

CONTRIBUTIONS TO ANATOMY.

In 1854, the year after his appointment as professor, Leidy was selected to represent the University of Pennsylvania at the meeting of the American Medical Association in St. Louis.

After his appointment he came to be regarded as one of the leading authorities on anatomy in America. His elementary treatises on human anatomy,^a published in 1861, and republished in a large and revised edition in 1889, was for many years a classic text book for students of medicine, and even now repays study, though out of date in many of its statements. It is conspicuous for clearness, simplicity, and accuracy—features which characterized all of Leidy's writings.

During the Civil War Leidy volunteered as surgeon to the Satterlee Military Hospital, which was established in West Philadelphia. The task of superintending and reporting on the autopsies was assigned to him, and in the medical and surgical history of the war, published between 1870 and 1879, are contained the accounts of sixty autopsies performed by Leidy. Although he continued to hold the professorship of anatomy throughout his life and performed the duties connected with it in a more than creditable manner, his interests gradually drew him farther and farther from the subject of anatomy. After his report to the Surgeon General of the Army he wrote only one more paper directly connected with the science of medicine. As in his school days, it became his pastime to study almost every branch of natural history, and all his leisure was devoted to varied researches, which in retrospect seem to constitute the most voluminous portions of his work.

^a An Elementary Treatise on Human Anatomy. J. B. Lippincott Co., Philadelphia, 1861. Second edition, rewritten. J. B. Lippincott Co., Philadelphia, 1889.

CONTRIBUTIONS TO MICROSCOPY.

Leidy's studies in helminthology continued to the last and gave him a very great reputation; specimens chiefly of parasitic worms were sent to him for determination from all parts of the United States. Some time previous to his death he had in contemplation the publication of a work upon helminthology and parasitology. In the early years of his researches in this field he was the only American naturalist who devoted any considerable time to these studies. Leidy's plan of publication was never carried out, but we are indebted to Joseph Leidy, Jr., a nephew of the great anatomist, for bringing together, in the Smithsonian Miscellaneous Collections,^a all of Leidy's published researches in this field, beginning in September, 1846, and continuing until 1891, the last year of his life. In 1853 Leidy published his first memoir in this field, entitled "A flora and fauna within living animals,"^b a volume beautifully illustrated by ten plates from Leidy's own drawings.

His first materials for the study of the Protozoa had been gathered in the East, in the pools and streams in the neighborhood of Philadelphia. During the years 1872-1873 he spent his summers in the region of Fort Bridger, Wyoming, and when obliged for a time to abandon the subject of vertebrate palæontology, he turned again to that division of the Protozoa known as Rhizopods.

Dr. F. V. Hayden, director of the United States Geological Survey of the Territories, encouraged these researches and showed a very broad appreciation of the scope of the survey in publishing "Freshwater Rhizopods of North America" as volume 12 (1879) of the survey monographs. In introducing this monograph, Leidy observes: "During the last four years

^a Researches in Helminthology and Parasitology by Joseph Leidy, M. D., LL. D., professor of human and comparative anatomy and zoölogy in the University of Pennsylvania, president of the Academy of Natural Sciences, and of the faculty of the Wagner Free Institute of Science, Philadelphia, with a bibliography of his contributions to science. Arranged and edited by Joseph Leidy, Jr., M. D. Smithsonian Misc. Coll., part of vol. 46, 1904, 281 pages.

^b A flora and fauna within living animals. Smithsonian Contr. Knowl., vol. 5, 1853, pp. 68, 10 plates.

I have studied one important class—the Rhizopods as they occur in all fresh waters of the country from the Atlantic border to an altitude of 10,000 feet in the Rocky Mountains. The marine forms of Rhizopods, in all times, have extensively contributed to the construction of stratified rocks. The determination of the living fresh-water forms may serve as a guide to the discovery and determination of fossil forms in the vast lacustrine formations in the interior of our continent.” The volume is beautifully illustrated with forty-eight large plates in color from Leidy’s exquisite drawings. The work illustrates the simplicity of Leidy’s methods when he observes that all his observations were carried on with a small microscope costing only \$50, and that the total expense to which he put the Geological Survey during his explorations in the West amounted to \$222. The spell which the work cast about him is shown in his concluding remarks: “I may perhaps continue in the same field or research and give to the reader further results, but cannot promise to do so; for though the subject has proved to me an unceasing source of pleasure, I see before me so many wonderful things in other fields that a strong impulse disposes me to leap the hedges to examine them.” This culminated Leidy’s study of this group, begun in his student days, when he had observed for the first time the amoeboid motions of the white blood corpuscles.

One of his most important observations in the field of microscopy was presented in a brief note of May 5, 1886, under the title, “Remarks on parasites and scorpions.”^a Leidy described three specimens of worms obtained from an anemic cat, presumed to be specimens of *Ankylostoma duodenale*, which was sent to him by Dr. Belfield, of Chicago, for determination. He remarked:

On superficial examination I supposed the worms might belong to *Strongylus tubiformis*, a closely related parasite infesting the cat. The specimens, however, exhibit the same structure of the mouth as is described in the *Ankylostoma duodenale* of man. . . . [Description follows.]

The finding of this parasite in the cat in this country renders it

^a Remarks on parasites and scorpions. Trans. Col. Phys. Philadelphia, 3d ser., vol. 8, 1886, pp. 441-443.

probable that it may also infest man with us, and is probably one of the previously unrecognized causes of pernicious anemia.

This communication was made by Leidy to the College of Physicians of Philadelphia before the full significance was recognized of the presence of the hookworm in man as a cause of anemia—a subject subsequently developed through the investigations of Dr. C. Wardell Stiles as of the first importance in medicine.^a

Leidy, in alluding to the work of Dr. John K. Mitchell on the fungus origin of malaria, denied this origin and treated Mitchell's work as speculative, in which position he was correct. It is doubtful whether he entertained the idea that malaria could not be or was not of parasitic origin, because the etiology was not then known, and it would have savored too much of dogmatism. He remarks: "The production of certain diseases, however, through the agency of entophyta, is no longer a subject of doubt, as in the case of Muscardine in the silk-worm, the Mycoderm of *Porriago favosa* in man, etc.; but that malarial and epidemic fevers have their origin in cryptogamic vegetables and spores requires yet a single proof.^b If such were the case, these minute vegetables and spores, conveyed through the air and introduced into the body in respiration, could be detected^c (p. 14).

Leidy had a marked interest in the problem of "spontaneous generation"; his work covered a long period at intervals of patient research work; his conclusions were referred to in the text and in the footnotes appended to the introduction of "A flora and fauna within living animals" (1853). He made an extended reference to further investigations in his address before the medical students of the university in a lecture published in 1858 and 1859.

^a "The worms from the cat were not *A. duodenale* of man, but apparently *A. caninum*, which is very common in dogs." C. W. Stiles, letter to H. F. Osborn.

^b See "an ingenious little work by my distinguished friend, Dr. J. K. Mitchell, 'On the cryptogamous origin of malarious and epidemic fevers.'"

^c "A flora and fauna within living animals." Accepted for publication December, 1851. Smithsonian Contr. Knowl., vol. 5, Art. 2, April, 1853, pp. 67, 10 plates.

Prof. Henry B. Ward^a gives the following estimate of the value of Leidy's work on the lower organisms:

His contributions to comparative anatomy among invertebrate groups are no less important; both among insects and mollusks he contributed investigations which form the basis of our present knowledge of these groups. It was, however, among the lower forms that his work was particularly noteworthy. Here he entered upon fields comparatively unbroken and achieved results of the highest permanent value. His work on Protozoa is well shown in a magnificent monograph^b whose artistic and accurate figures were all the work of his own pencil. All his observations were made with wonderful precision in view of the simple instrument at his command. Thus, for instance, he noted in 1849 and in 1851^c that the Gregarinida are provided with muscle fibers, a view which was denied by European observers until thirty years later it was confirmed by the younger Van Beneden.

In some respects his most striking work was done in the field of helminthology. Among his very first papers was one in 1846 on an entozoan from the pig, in which he announced that he had discovered a minute encysted worm, which he regarded as *Trichina spiralis*, heretofore considered as peculiar to the human species. This observation attracted the attention of Leuckart, who in his monograph gives due credit to Leidy, and suggested that trichinosis in man might be due to the eating of raw pork containing the parasite (pp. 273-274).

A series of helminthological contributions ran from 1850 to 1856, culminating in his Synopsis,^d which is the only paper of its kind that has yet appeared in this country (p. 274).

Prof. Gary N. Calkins writes:

There is really not much that I can add to what he [Ward] has given except a word of appreciation for his splendid work as a pioneer on American Protozoa. His monograph on the rhizopods is a splendid production and will stand as a classic. It well illustrates his powers of careful observation, keen insight into the structures, and their bearings on the vital activities of these forms. Not only rhizopods, but many other types of Protozoa as well, are carefully noted and affinities made out. On the whole, Leidy's work is to be classed as taxonomic rather than biologic. His particular genius here seemed to be morpho-

^a Ward, Henry B.: Notices Biographiques, VIII. Joseph Leidy, M. D., LL. D. Archives de Parasitologie, tome 3, 1900, pp. 269-279.

^b Fresh-water rhizopods of North America. Rept. U. S. Geol. Survey Territories, vol. 12, 1879, pp. xii and 324, 48 pls.

^c Proc. Acad. Nat. Sci. Philadelphia, vol. 4, pp. 226-233; and vol. 5, pp. 205-210.

^d A synopsis of Entozoa and some of the ectocongeners. Proc. Acad. Nat. Sci. Philadelphia, vol. 8, 1856, pp. 42-50.

logical, his quick eye noting any differences which might indicate novel types. It may be stated that Leidy was undoubtedly the foremost student of Protozoa in this country at his time—a fact which illustrates his wonderful breadth of view and keen interest in all things pertaining to natural history.^a

To his helminthological work numerous references have already been made. He brought together a vast amount of material and the studies made on this were communicated to the world mostly in the form of brief articles rather than finished contributions. Nevertheless, his keen insight into comparative anatomy led him to outline many natural genera, such as *Clinostomum*, to which the newer generation of students are just returning as natural subdivisions. While these observations were made with great keenness of perception, it must still be confessed that they were often expressed in quite too brief form for clear general understanding. In this he only followed the plan of his European contemporaries, and while his ideas are distinct with the specimen itself in view, it is undoubtedly true, as in the case of many other great workers of the past generation, that the original specimens must be worked over more fully to establish their actual taxonomic position. It is sad to record that his helminthological work was left unfinished. In the five volumes of *Leidyana* presented to the Philadelphia Academy by Dr. Nolan are included four volumes of drawings and notes which are a veritable mine of helminthological information. An unfinished monograph of the Gregarines is indicated by the 176 unpublished illustrations of these forms from twenty-one hosts which occur among these drawings; and the wide range of other helminthological work shows well that his project of a monograph on parasites would have given the world a work the loss of which we may well mourn. But though unfinished, his contributions will form the basis of American work in the future as they have furnished in some directions even to the world the foundation for past work in this department. Leidy's reputation as a helminthologist was certainly cosmopolitan, as is clearly evinced by the numerous references to his contributions in the works of Cobbold, Diesing, and of that master of helminthology, Rudolph Leuckart (pp. 276-277).

Dr. C. W. Stiles gives the following estimate of Leidy's work:^b

Our estimate of Leidy's work on parasites must vary with our point of view. If we belong to the class of students who try to judge the work of a broad general zoölogist of 1880-1890 from the point of view of a specialist of 1910, we must conclude that Leidy's results were inferior. If we belong to the class of students who recall that all efforts

^a Letter to Professor Osborn, April 30, 1912.

^b Letter to Professor Osborn, May 18, 1912.

should be judged in connection with their period, we must conclude that Leidy was not only the American pioneer, but a brilliant pioneer in this field of zoölogy.

From a viewpoint of public health, his discovery of *Trichinella spiralis* in swine seems to be his most important practical contribution to helminthology. In addition, his systematic work had considerable value which for years was overlooked.

His other great public-health contribution seems to me to be his observation on flies as apparent spreaders of disease. It concerned flies in hospital wards during the war, 1861-1865, as spreaders of infection to wounds.

Leidy, in 1879, reached a stage in the classification of parasitic amœbæ which the rest of the world did not reach until years later. He recognized that parasitic amœbæ, like the amœbæ of the water-roach, should be separated from the free living forms, but I do not recall any modern author on amœbiasis who has seen this historical point.

- Insects and protozoa as possible disease-carriers were constantly in Leidy's mind. Dr. Frank E. Lutz contributes^a the following interesting notes gathered from twenty-three of Leidy's contributions on insects:

In most of Leidy's best work insects play the incidental rôle of hosts of the micro-animals and plants he was really investigating. He apparently was much interested in them as objects for observation, as is shown by the numerous short notes he presented before the Academy of Natural Sciences, but he wrote no important paper on a purely entomological subject. In 1846 he published two short but interesting notes on the anatomy of certain Orthoptera, and in 1852 made the suggestion that the disappearance of tracheæ from the repletes of the honey-ant prevented the digestion of the "stored" honey. In the same year he worked with Langstroth on the question of the fertilization of the eggs of the honey-bee, advocating the now accepted idea that spermatozoa are stored for some time in the spermatheca of the queen. In 1853 he discussed the cause of malaria and wrongly concluded that it is not of parasitic origin; but in 1871 he suspected the carrying of smallpox and gangrene by flies, proving that they do carry spores of the fungus *Peallus impudicus*.

CONTRIBUTIONS TO PALÆONTOLOGY.

Sir Charles Lyell's "Principles of Geology," published in 1839, appears to have exerted a direct influence upon Leidy, as upon Darwin and many others, in arousing his interest in ge-

^a Letter to Professor Osborn, April 29, 1912.

ology. After Lyell had visited young Leidy in his home in Philadelphia he wrote to him in 1883: "Give serious attention and devote your time to palæontology." It is a piece of interesting history that in Leidy's address many years afterward to Sir William Flower, acknowledging the award of the Lyell Medal by the council of the Geological Society of London, he says: "I must add that I feel as if Sir Charles himself was expressing satisfaction in consideration of my having complied with his wish, when thirty years ago in my own home here he said he hoped I would devote my time to palæontology instead of to medicine."

Leidy's observations in palæontology were first directed to specimens found in a cave in Mississippi near Natchez, supposed to include fossil human bones, in 1845; and presented at a meeting of the Academy of Natural Sciences. The untrodden field of palæontology opened before him as his greatest opportunity. A number of stray memoirs, notable among them those of Vice-President Thomas Jefferson and Dr. Harlan, upon the extinct sloth of America, the *Megalonyx jeffersoni*, had already been published, but no systematic work or connected statement covering the remarkable extinct fauna of the eastern coast of our continent had as yet been attempted. From the scanty materials in the academy and from scattered specimens sent to him by amateur collectors, Leidy, in the year 1847, at the age of twenty-four, published his first important paper on the fossil horse of America, in which he proved beyond a doubt that the horse, though extinct at the time of the discovery of America, had existed on this continent in prehistoric times. This had been preceded by several palæontological notes—*e. g.*, November 18, 1845. We find him inquiring into the causes which may have brought about the extinction of the horses on our continent, and his inquiry was formulated as follows: "At present their existence is being fully confirmed; it is probably as much a wonder to naturalists as was the first sight of the horses of the Spaniards to the aboriginal inhabitants of the country, for it is very remarkable that the genus *Equus* should have so entirely passed away from the vast pastures of the western world, in future ages to be replaced by a foreign species to which the country has proved so well

adapted. It is impossible in the present state of our knowledge to conceive what could have been the circumstances which have been so universally destructive to the genus on one continent and so partial in its influence upon another." Twelve years later we find much the same proposition stated in the following words in Darwin's "Origin of Species": "For seeing that the horse since its introduction into South America has run wild over the whole country and has increased in numbers at an unparalleled rate, I asked myself what could so recently have exterminated the former horse under conditions of life apparently so favorable."^a

Leidy's wide and accurate knowledge of human and comparative anatomy, together with his extraordinary power of detecting resemblances, enabled him to make remarkable deductions from even the fragmentary materials which were submitted to him. In the year 1847 he described the first cameloid (*Poëbrotherium*) from the Oligocene of the Western Territories.

In 1848 there are two notices of western forms, and from this time on until 1870 all the great materials from the West came into Leidy's hands, affording him the unparalleled opportunity of laying the foundations of American palæontology. As early as 1846 there had appeared in the American Journal of Arts and Sciences the description by Hiram A. Prout of part of a jaw which the author referred to "*Palæotherium*," from the *Mauvaises Terres*, near the White River, Nebraska. This jaw subsequently was referred to Leidy and he distinguished it as *Titanotherium*. It has become the type of the titanotheres, one of the most important families of mammals which Leidy discovered. These early papers on the mammals of Nebraska proved to be of the greatest importance, because they served to draw the attention of scientists to the exploration of the rich fossil beds of the West. The history of early exploration is given in Leidy's memoir of 1869. The first bones were collected by amateur collectors and sent to the Academy of Natural Sciences. The first systematic scientific collections were made by Dr. John Evans (1849) and by Thad-

^a See Angelo Heilprin's manuscript memoir, "Dr. Leidy's work in geology and palæontology."

deus Culbertson (1850); the latter, at the instigation of Spencer F. Baird, immediately sent the fossils to Leidy for study and description, remarking that he was the only anatomist qualified to make the determination. Leidy's observations on this collection were presented in a series of notices in the Proceedings of the Academy. Leidy described and figured the forms mentioned in his "Description of the Remains of Extinct Mammalia and Chelonia from Nebraska Territory," published in 1852, and his final report was in "The Ancient Fauna of Nebraska, a Description of Extinct Mammalia and Chelonia from the Mauvaises Terres of Nebraska," published in 1854. In this the oreodonts, rhinoceroses, elotheres, and horses, as well as the titanotheres (*Palæotherium*) and Testudinata, chiefly of the Lower Oligocene, but referred to the Eocene, were first described. It was in the same year, 1852, that Leidy had arranged to accompany an expedition to the West to collect fossils; he particularly desired to go in order to make his own observations on the occurrence of the fossil remains, and it must always be deplored as a great loss to science that he was unable to carry out these plans. His mind was now concentrated upon vertebrate palæontology. One by one he thoroughly established the distinction of the New World from the Old World forms, first in the Oligocene, then, as the field of exploration broadened, in the Miocene and Pliocene areas. In the meantime the mammals of the eastern Pleistocene were successively treated in short but clear descriptions, always accompanied by close comparisons with the living and extinct forms of the Old World. "The Ancient Fauna of Nebraska," accepted for publication by the Smithsonian Institution in 1852, appeared in 1854. This was his last synthetic contribution to the western mammals prior to the publication of his great memoir of 1869. In the meantime Leidy's work, "A Memoir on the Extinct Sloth Tribe of North America," was prepared in 1853 and published in 1855. This was a companion to his other important works, "A Memoir on the Extinct Dicotylinae of North America," presented to the Philosophical Society in 1852 and published in 1853 also to his memoir "On the Extinct Species of American Ox," completed in 1852 and published in 1853 by the Smithsonian Institution.

Dr. F. V. Hayden's explorations in the Judith and Mussel-shell rivers of Missouri in 1855 yielded to Leidy the first knowledge of the Upper Cretaceous reptilian fauna, including the Crocodilia, the Iguanodontia, and carnivorous dinosaurs. The first comprehensive account of these animals was Leidy's memoir, "Extinct Vertebrata from the Judith River and Great Lignite Formations of Nebraska," published by the American Philosophical Society in 1860. It will be observed that at this time the whole western territory was comprised within Nebraska. Leidy's comprehensive review of eastern and western mammals was completely paralleled by his equally comprehensive examination of the eastern and western reptiles. In 1857 he began his monographic revision of the Cretaceous reptiles of the United States, which comprehended those of New Jersey, Maryland, Delaware, North Carolina, Georgia, Alabama, Mississippi, and Nebraska. The last embraces not only the Judith River forms, first described, but from other parts of the West, adding the mosasaurs, plesiosaurs, and many new types of Crocodilia and Testudinata to his previous description. The mosasaurs carried his work into the Middle Cretaceous. It is interesting to note that the commission to which this memoir was referred by the Smithsonian Institution included Louis Agassiz and Edward D. Cope, the latter destined to soon succeed Leidy in both the reptilian and mammalian field. While extremely valuable for its exact description, this memoir on the "Cretaceous Reptiles of the United States," published in 1865, was rather a synthesis of all existing knowledge and an exact description and determination of a very fragmentary series of types than an attempt at classification or determination of the relationships and habits of the animals described; in fact, the material was far too fragmentary to admit of philosophic work. Even in the hands of Owen the classification of the extinct Reptilia was in a rudimentary stage. Nevertheless, this memoir, taken with that on the reptiles of the Judith River, constitutes the foundation of the reptilian palæontology of America. Brief reference should also be made to Leidy's work on the eastern saurians, such as *Bathygnathus*? (1853) and "Descriptions of some remains of fishes from the Car-

boniferous and Devonian formations of the United States," published in 1856 by the Academy of Natural Sciences.

It is important to note that in all these treatises, although not having visited the territory described, Leidy made a serious effort in conjunction with the geological work of Dr. F. V. Hayden to determine the geological levels of the forms described.

Leidy's grandest contribution to palæontology is his memoir of 1869, entitled "The Extinct Mammalian Fauna of Dakota and Nebraska." This not only covers all his own researches on the western forms, but embraces a complete synopsis on the mammalian palæontology of North America up to the year of publication, which is absolutely invaluable to the student of the history of the subject. This synopsis of early palæontology in this country is a priceless repertoire of the first period of mammalian palæontology in America, what may be called the pre-Darwinian Period. The illustrations in thirty lithographic plates, executed under Dr. Leidy's direction, are masterpieces of accuracy and have served for all subsequent determinations. The materials for the work had been accumulating for twenty-three years; those of the synopsis of the mammalian remains of North America had been accumulating for a century and a half. The preparation of the work occupied Leidy, with various interruptions, for a period of seven years. In the preface we once more observe Leidy's regard for fact rather than theory:

The present work is intended as a record of facts, in palæontology, as the authors have been able to view them—a contribution to the great inventory of nature. No attempt has been made at generalizations or theories which might attract the momentary attention and admiration of the scientific community. We give this premonition at the outset, to prevent disappointment in those who might be expectant of more important results than we have obtained from the great amount of material at our command. We have endeavored to see and represent things correctly, nothing more, though we apprehend we have not been able to avoid the average amount of errors usual under such circumstances.

The geological introduction by Dr. F. V. Hayden illustrates the extremely rudimentary knowledge of geological succession

which prevailed at that time, the Tertiary rocks being divided into four groups as follows:

- Loup River beds, 300-400 feet.....Pliocene
- White River group, 1,000 or more feet.....Miocene
- Wind River deposits, 1,500-2,000 feet.....(?)
- Fort Union or Great Lignite group, 2,000 feet.....(?)

Leidy himself, however, made a remarkably accurate presentation of the vertical range of species (p. 20). His subdivisions, A, B, C, D, E, and F, have been used largely by Matthew (1899).^a Matthew's identification of the Hayden and Leidy stratification is as follows:

- F = Loup Fork = Upper Miocene
- E = Ticholeptus Zone = Middle Miocene
- D = Lower Miocene
- C = Leptauchenia Zone or Protoceras Zone = Upper Oligocene
- B = Oreodon Zone = Middle Oligocene
- A = Titanotherium Zone = Lower Oligocene

At the time, the deposits in Nebraska and Dakota were all considered of lacustrine origin, and Leidy shows his sagacity in pointing out the absence of the remains of birds and fishes, and the fact that the single reptile known is a land turtle. It is now believed that these deposits are flood-plain—an interpretation which accounts for the absence of aquatic forms. Leidy returns to this subject in his concluding remarks:

. . . In this view of the formations we are led to inquire why they exhibit no traces of fishes or aquatic mollusca mingled with the multitude of relics of terrestrial mammals. Even remains of the latter of decided aquatic habit are absent. With the exception of the marsh-loving rhinoceros and the beaver, no amphibious mammals have been discovered; not even the hippopotamus, whose remains are frequent in contemporaneous formations of Europe and Asia.

The constitution of the skeletons of most fresh-water fishes, though comparatively unfavorable to their preservation as fossils, can hardly be admitted as a sufficient reason for the total absence of their remains

^a A Provisional Classification of the Fresh-water Tertiary of the West. Bull. American Mus. Nat. Hist., vol. 12, Art. 3, March 31, 1899, pp. 19-75.

in the formations in question. The conditions during which the formations of the Mauvaises Terres were deposited would appear to have been especially favorable for the preservation of the most delicate structures. The mammalian fossils, in the perfect preservation of their original sharpness of outline without the slightest trace of erosion and the character of their containing matrix, indicate quiet water with a soft muddy bottom. The chemical constitution, too, of the matrix and fossils indicate a petrifying quality in the mud and water favorable to the preservation of any animal skeleton.

The absence of remains of fishes and aquatic mollusks in association with the mammalian fossils, both in the Niobrara and Nebraska formations, may be accounted for by supposing that the lakes in which were formed the deposits containing the fossils may have been periodically subjected to admissions of salt water from the ocean, thus inducing a condition unfavorable to life in the lake waters.

He comments on the absence of crocodiles. He also introduces a few generalizations. It is noted that in the form of the skull the Oligocene forms present a greater uniformity of structure than the existing mammals. A valuable classification based on the system of Richard Owen is presented. A dissimilarity of the Oligocene and closer similarity of the Pliocene mammals to those of the Old World is noted. The presence of sloths is attributed to South American migration. Community of fauna with Europe is explained by a continental connection with Asia. The extinction of a very large part of the Oligocene fauna is commented upon.

The next great volume of Leidy was his "Contributions to the Extinct Vertebrate Fauna of the Western Territories," begun in 1870 and completed in 1873.^a As early as 1868, Dr. J. van A. Carter, of Fort Bridger, Wyoming, in correspondence with Leidy, had informed him of the frequent occurrence of the remains of turtles and other animals in the buttes of the neighboring country. During the same year Hayden commenced his geological observations in these great Middle Eocene deposits, now known as the Bridger formation, which opened a new chapter in the history of the American fossil vertebrates. Leidy's first notice of these fossils appeared in the Proceedings of the Academy of Natural Sciences, April, 1869, in the mention of a little supposed Insectivore, *Omomyx*

^a Contributions to the extinct vertebrate fauna of the Western Territories. Rept. U. S. Geol. Surv. Terr., vol. I, 1873, 40, pp. 358, pls. 37.

carteri, which he named after Dr. Carter. The animal has since been determined as belonging to the Primates. Descriptions of many other forms appear in the Proceedings of the Academy of Natural Sciences of 1870-1873, followed by the publication of the memoir. When the volume was ready for the press, in the summer of 1872, Leidy received an invitation to visit Dr. Carter at Fort Bridger, which he accepted with delight, and thus on the eve of the publication of his last great work on palæontology he beheld for the first time one of the grand fossil-bearing regions of the West. Referring to an excursion into the Badlands, he writes:

No scene ever impressed the writer more strongly than the view of one of these Badlands. . . . On ascending the butte to the east of our camp, I found before me another valley—a treeless barren plain, probably ten miles in width. From the far side of this valley, butte after butte arose and grouped themselves along the horizon, and looked together in the distance like the huge fortified city of a giant race. The utter desolation of the scene, the dried-up water-courses, the absence of any moving object, and the profound silence which prevailed, produced a feeling that was positively oppressive. When I then thought of the buttes beneath my feet, with their entombed remains of multitudes of animals forever extinct, and reflected upon the time when the country teemed with life, I truly felt that I was standing on the wreck of a former world (p. 18-19).

There follows a vivid description of the geology of the Basin which makes one regret that Leidy's first opportunity to visit the region had come so late in his life. The volume is mainly devoted (pp. 27-196) to the Eocene fauna, mammals, reptiles, and fishes, but there occurs also the first systematic account (pp. 210-226) of the mammals of the John Day River, Oregon, now known to be of Upper Oligocene age. The Miocene and Pliocene vertebrates determined by Leidy after the close of his memoir of 1869 are also treated (pp. 227-264). The volume concludes with Leidy's last contribution to the vertebrate fauna of the Cretaceous period (pp. 266-309) and a notice of Carboniferous fishes (pp. 311-313).

This important monograph therefore completes the foundations which Leidy laid down for the systematic determination of the extinct vertebrate life of America. Already, in 1872, Marsh and Cope had begun to collect in the Bridger Eocene

field, and Leidy prophetically observes in his preface: "The investigations and descriptions by these gentlemen of some of the fossils from the same localities have been so nearly contemporary with mine that from want of the opportunity of comparison of specimens we have no doubt in some cases described the same things under different names and thus produced some confusion, which can only be corrected in the future." It has required nearly forty years of painstaking work to correct the confusion which Leidy refers to in this kindly note.

Marsh's contributions to western palæontology were begun in 1868.^a Marsh had begun publishing in 1861. Cope began publishing in 1859, and it is noteworthy that his first paper on western vertebrates also appeared in 1868. While no doubt Leidy watched with keen satisfaction the promise of the development of the science in the hands of these younger men, an element of pathos entered into his own position. For the long period of twenty-one years (1847-1868) he had enjoyed a monopoly of vertebrate palæontology in America. Now the situation is suddenly changed; two younger men, full of energy and enthusiasm and with ample means, render it impossible for him to compete in the collection of fossils or to continue his best loved work. Sir Archibald Geikie, who visited Philadelphia in 1879, quotes Leidy's own words in explanation of his abandoning palæontology at this time: "Formerly," he said, "every fossil one found in the States came to me, for nobody else cared to study such things; but now Professors Marsh and Cope, with long purses, offer money for what used to come to me for nothing, and in that respect I cannot compete with them. So now, as I get nothing, I have gone back to my microscope and my Rhizopods and make myself busy and happy with them." Leidy's bibliography attests the truth of this statement. In 1874 there appear seventeen papers on Rhizopods and other microscopic forms and only four on fossil vertebrates. His active work between 1874 and 1879 culminated in his memoir, "Fresh-water Rhizopods of North Amer-

^a Notice of a new and diminutive species of fossil horse (*Equus parvulus*) from the Tertiary of Nebraska. American Journ. Sci., vol. 46, 1868, pp. 374-375.

ica," of 1879. In the meantime, however, he began to renew his notices of vertebrate remains of the Eastern States, especially from the phosphate beds of South Carolina, which he collected in his two memoirs of 1874 and 1879.^a In 1880 he describes the fauna of the bone cave in Pennsylvania and gives a second paper on *Bathygnathus*. Occasional contributions follow in succeeding years on the horses and peccaries, and in 1884 there begin his notices of the vertebrate fossils from Florida, which continued until 1889, when Leidy's last important contributions to vertebrate palæontology were published in the Transactions of the Wagner Free Institute of Science.^b By an interesting coincidence these animals, which were partly obtained by Leidy's intimate friend, Mr. Joseph Willcox, were closely related to those from the Loup Fork of Nebraska, which Leidy had begun to describe in 1856, forty years before.

EVOLUTION.

From the time of his first paper of 1847 on the fossil horse of America until his last paper of 1889, "On Hippotherium and Rhinoceros from Florida," Leidy was constantly accumulating facts for Darwin. It was a common saying that it is "a simple matter to construct the building after the materials are supplied." As a close observer of affinities of structure he anticipated by many years both Cope and Marsh in building up the materials for the phylogeny of the horses, camels, rhinoceroses, and other groups of ungulates. There does not seem to be a single case in which Leidy failed to recognize affinity. He showed extraordinary acuteness in distinguishing the various

^a Description of vertebrate remains chiefly from the phosphate beds of South Carolina. Journ. Acad. Nat. Sci. Philadelphia, vol. 8, 1877, pp. 209-261.

Notice of a new and diminutive species of fossil horse (*Equus parvulus*), from the Tertiary of Nebraska. American Journ. Sci., 2d ser., vol. 46, 1868, pp. 374-375.

^b Description of mammalian remains from a rock crevice in Florida. Trans. Wagner Free Inst. Sci. Philadelphia, vol. 2, 1889, p. 15.

Description of vertebrate remains from Peace Creek, Florida. Idem, pp. 19-31.

Description of some mammalian remains from the salt mine of Petite Anse, Louisiana. Idem, pp. 33-40.

genera of Miocene and Pliocene horses; many of his determinations which were formerly questioned are now thoroughly established, yet with our understanding of Leidy's nature it is not surprising that he failed to place these animals in phyletic or successive stages and virtually left this phyletic reconstruction entirely to Cope and to Marsh. We may explain this partly by Leidy's indisposition to indulge in controversy, because he well knew that evolution was a keenly controverted question, partly by his unwillingness to indulge in theories which he did not consider thoroughly tested by facts; but chiefly it is attributable to his thoroughly Teutonic disposition to confine himself absolutely to direct observation and to amassing as large a number of well-attested facts as possible. He spent his life in amassing facts. He was often approached by this or that firm or representative of some book concern or journal to give expression to some new theory. His invariable reply was: "I am too busy to theorize or to make money. The time will come when such investigations as I may add from time to time may prove of value, and I believe I can do more good to science in adding some new facts than in preparing articles for popular treatises." The correspondence of Leidy with Hayden confirms this view. There is little doubt that during this entire formative period Leidy was practically an evolutionist, although the theory was not clearly formulated in his mind. He could hardly have been less, in view of his familiarity with the second volume of Lyell's "Principles of Geology." In this connection it is interesting to observe what Leidy, in prophetic vein, wrote in his memoir, "A Flora and Fauna within Living Animals," published in 1853, eight years before the publication of "The Origin of Species":

The study of the earth's crust teaches us that very many species of plants and animals became extinct at successive periods, while other races originated to occupy their places. This probably was the result in many cases of a change in exterior conditions incompatible with the life of certain species and favorable to the primitive production of others. Living beings did not live upon earth prior to their indispensable conditions of action, but wherever these have been brought into operation concomitantly, the former originated. Of the life present everywhere, with its indispensable conditions and coeval in its origin with them, what was the immediate cause? It could not have existed

upon earth prior to its essential conditions, and is it therefore the result of these? There appear to be but trifling steps from the oscillating particle of organic matter to a Bacterium; from this to a Vibrio; thence to a Monad, and so gradually up to the highest orders of life. The most ancient rocks containing remains of living beings indicate the contemporaneous existence of the more complex as well as the simplest of organic forms; but, nevertheless, life may have been ushered upon earth through oceans of the lowest types long previously to the deposit of the oldest Palæozoic rocks as known to us.

With Asa Gray, he was among the very first to accept Darwin's theory of the origin of species; for immediately after the appearance of the first edition of Darwin's work, in 1859, upon the recommendation of Leidy and of Dr. Isaac Lea, Darwin was elected a member of the Academy of Natural Sciences of Philadelphia, March 27, 1860. Thus the Academy was one of the first institutions to honor Darwin after the publication of his great work. Of this support Darwin wrote to Sir Charles Lyell:

MY DEAR LYELL: This morning I got a letter from the Academy of Natural Sciences Philadelphia announcing that I am elected a correspondent member. It shows that some naturalists do not think me such a scientific profligate as many think me here.

Yours gratefully,

CHAS. DARWIN.

In March, 1860, Darwin himself wrote a letter to Leidy referring to his early accounts of the horse and camel tribes.

HONORS.

In the year 1869 the honorary degree of LL. D. was conferred on Leidy by the Franklin and Marshall College of Lancaster. Not long after this he received his appointment as professor of natural history in Swarthmore College, and for fourteen years he lectured once or twice weekly to the students. His reputation kept steadily growing on both sides of the Atlantic and each fresh volume brought him new fame. In palæontology he was held as the Cuvier of America, while as an anatomist and zoölogist he was held in high esteem. In 1863 Leidy became one of the fifty leading men of science of America who joined in the incorporation of the National Academy of Sciences (March 3, 1863). When he went abroad in

1875 for the third time his acquaintance was sought by scientists everywhere. In 1879 he was elected an honorary member of the Royal Microscopical Society of London; of the Zoölogical Society of London in 1883. In the year 1880 the Boston Society of Natural History awarded to him the Walker Grand Prize for 1879 for prolonged investigations and discoveries in zoölogy and palæontology, and in consideration of the extraordinary merit of Leidy's works the sum awarded was \$1,000. In 1884 the Geological Society of London awarded to Leidy its Lyell Medal in recognition of his researches in geology and palæontology. In announcing the award of the medal, Sir Archibald Geikie said: "Among the scientific laborers in the palæontological harvest field, Dr. J. Leidy has held a foremost place. Careful in observing, accurate in recording, cautious in inferring, his work has the high merits which trustworthiness always imparts." This award was followed not many years afterward by that of the Cuvier Prize Medal, sent to Leidy by the Institute of France. In 1886 Harvard University conferred on Leidy the honorary degree of LL.D.

BIOGRAPHIES AND BIBLIOGRAPHIES OF JOSEPH LEIDY.

The present writer is chiefly indebted to Dr. Joseph Leidy, Jr., a nephew of Leidy, for many of the personal references in the above review, as well as for calling attention to the dates of some of Leidy's most important discoveries. The bibliography prepared by Dr. Leidy for his important review of the elder Leidy's work, entitled "Researches in Helminthology and Parasitology, by Joseph Leidy, M. D., LL. D.," is the most complete which has been published, and is reprinted herewith, with corrections and the addition of a few omitted titles.

The writer is indebted also to Dr. Joseph Willcox, of Philadelphia, an intimate friend of Leidy's, for an opportunity to examine the journal taken on Leidy's last journey abroad and for some interesting personal experiences.

On the whole, the memoir of Joseph Leidy prepared by the late Dr. Henry C. Chapman for the Academy of Natural Sciences is the most authentic of the ten which have been prepared and published by various writers. It appears that W.

Ruschenberger's sketch for the American Philosophical Society contains some matter which is less authentic. The most appreciative reviews of Leidy's contributions to geology and palæontology are those of Persifor Frazer (1892), of Angelo Heilprin (unpublished address), and of Archibald Geikie (1892). Relating especially to Leidy's contributions to helminthology is the brief memoir by Henry B. Ward, prepared for the French Archives de Parasitologie (1900). The memoir by Dr. William Hunt was published for private distribution. There is also a biographical note in Spitzka's "Study on Brains," published by the American Philosophical Society. The fullest information regarding the life of Leidy will, however, be found in the biography now in course of preparation by Dr. Joseph Leidy, Jr.

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[On *Tapirus haysii*.] Idem, p. 106 (3 lines).

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- [On *Rhynchodemus sylvaticus*.] Idem, pp. 171-172.
- [A species of *Cristatella*, *Fredericella*, and *Lophopus*.] Idem, pp. 188-190.
- [On *Hadrosaurus foulkii*, a huge extinct herbivorous saurian.] Idem, pp. 215-218. American Journ. Sci., 2d ser., vol. 26, pp. 266-270.
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- [Remarks on an Acephalous fœtus.] Idem, pp. 8-9.
- [Remarks on blood crystals.] Idem, p. 9 (5 lines).
- [Remarks on honey dew.] Idem, p. 10 (10 lines).
- [Remarks on death from chloroform.] Idem, p. 11 (5 lines).
- [Remarks on sections of the human cranium.] Idem, p. 10 (8 lines).
- [Remarks on *Echinococcus hominis*.] Idem, p. 12 (9 lines).
- [Remarks on disease of the scales of minnows.] Idem, pp. 12-13.
- [Remarks on growth of hairs on the cornea of an ox.] Idem, p. 15 (4 lines).
- [Remarks on mucous corpuscles.] Idem, p. 16 (6 lines).
- [Remarks on the stomach of a mink (*Mustela vison*) containing a large number of worms.] Idem, p. 25 (18 lines).
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- [Remains of fishes found in Triassic shales at Phoenixville, new species, *Eurydorus serridens*.] Idem, p. 110.
- [On fossil bones contained in so-called guano from Sombrero, W. I., and on *Ursus americanus* and Mastodon from Mississippi.] Idem, p. 111.
- [On *Palæotrochus*.] Idem, p. 150 (5 lines).
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[Observations upon a small collection of fossils from Bangor, Maine.] Idem, p. 237.

[Exhibition of teeth of *Mastodon ohioiticus* from Big Bone Lick, Ky.] Idem, p. 290 (5 lines).

[On *Drepanodon* or *Machairodus occidentalis*.] Idem, p. 345 (6 lines).

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[On *Bison latifrons* and the skull of *Bison antiquus*.] Idem, p. 85.

[On the seventeen-year Locust.] Idem, p. 93 (2 lines).

[On a fossil skull of *Geomys bursarius*.] Idem, p. 97 (6 lines).

- [On a fossil skull of *Castoroides ohioensis*.] Idem, pp. 97-98.
 [Remarks on antique copper implements.] Idem, p. 97 (9 lines).
 [Reference to specimens of black hornstone.] Idem, p. 125 (4 lines).

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- [On *Sombrero guano*.] Proc. Acad. Nat. Sci. Philadelphia, vol. 20, p. 156 (5 lines).
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 Indications of an *Elotherium* in California. Idem, p. 177.
 Notice of some reptilian remains from Nevada. Idem, pp. 177-178.
 Notice of some Vertebrate remains from the West Indian Islands. Idem, pp. 178-180.
 Notice of some remains of Horses. Idem, p. 195.
 Notice of some extinct Cetaceans. Idem, pp. 196-197.
 Remarks on jaw of *Megalosaurus*. Idem, pp. 197-200.
 Remarks on *Conosaurus* of Gibbes. Idem, pp. 200-202.
 Notice of American species of *Ptychodus*. Idem, pp. 205-208.
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 On Coprolites from the Huronian slates. Idem, p. 302.
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- [Description of *Megacerops coloradensis*.] *Proc. Acad. Nat. Sci. Philadelphia*, vol. 22, pp. 1-2.
- [On *Poecilopleuron* and other fossils, *Clidastes*, *Leiodon*, *Emys*, etc.] *Idem*, pp. 3-5.
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- [On fossil bones of extinct giant sloths resembling *Mylodon robustus*.] *Proc. Acad. Nat. Sci. Philadelphia*, vol. 22, pp. 8-9.
- [On *Dromatherium sylvestre*.] *Idem*, p. 9 (12 lines).
- [On the reptile from the Cretaceous formation near Fort Wallace, Kansas, described by Professor Cope under the name of *Elasmosaurus platyurus*.] *Idem*, pp. 9-10.
- [On a fossil mandible, *Patriofelis ulta*, from Fort Bridger, Wyoming.] *Idem*, pp. 10-11.
- [Observations on *Ichthyodorulites*.] *Idem*, p. 12.
- [On *Megalonyx jeffersoni* and *Bison antiquus*.] *Idem*, p. 13.
- [On *Discosaurus* and its allies.] *Idem*, p. 18. *American Journ. Sci.*, 2d ser., vol. 50, pp. 139-140.
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- [On fossil bones from the Pliocene formation in Dakota and Nebraska.] *Idem*, pp. 65-66.
- [On fossil Mammalia from Idaho, Utah, and Oregon.] *Idem*, pp. 66-67.
- [On *Hadrosaurus* and its allies.] *Idem*, pp. 67-68.
- [On the family Anguillulidæ, a new species of vinegar eel.] *Idem*, pp. 68-69.
- [On fossils from the vicinity of Burlington, Kansas, and from the Rocky Mountains.] *Idem*, pp. 69-71.
- [On the difference between animals of the same species inhabiting Europe and America.] *Idem*, p. 72.
- [On a fossil lower jaw of a large ruminant, *Ovibos cavifrons*.] *Idem*, p. 73.
- [On *Nothosaurops occiduus*.] *Idem*, p. 74.
- [Description of *Nepheleis punctata*, a new leech.] *Idem*, pp. 89-90.

- [On Mastodon remains in the Warren Museum, the museum at Cambridge, and at Amherst College, and on a new species of Mastodon.] Idem, pp. 96-99.
- [On *Crocodylus elliotti*, a new species of crocodile.] Idem, p. 100.
- [Observations on *Manayunkia* and *Urnatella*.] Idem, pp. 100-102.
- [On fossils from Sweetwater River, Wyoming.] Idem, pp. 109-110.
- [On fossils from Bridge Creek, Oregon.] Idem, pp. 111-113.
- [On *Cordylophora*.] Idem, p. 113 (13 lines).
- [Description of *Palaeosyops paludosus*, *Microsus cuspidatus*, and *Notharctus tenebrosus*, etc., and observations in reference to fossils from Fort Bridger.] Idem, pp. 113-114.
- [On *Graphiodon vinearis* and *Crocodylus elliotti*.] Idem, p. 122.
- [On *Emys jeansi*, *Emys haydeni*, *Baëna arenosa*, *Saniwa ensidens*, with a description of the new fossil species.] Idem, pp. 123-125.
- [Observations on fossils from Table Mountain, Cal., submitted for examination by Prof. J. D. Whitney.] Idem, p. 125.
- [On *Lophiotherium sylvaticum*, a fossil pachyderm from Wyoming.] Idem, p. 126.
- [On *Protohippus* and *Hippidion*.] Idem, p. 126.
- Observations on a human inferior *Maxilla*, having imbedded in its substance a perfect third molar tooth. Idem, p. 133 (12 lines).
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- [On *Tania mediocanellata*.] Idem, pp. 53-55.
- [On extinct fossil turtles from Wyoming. *Anosteira ornata* and *Hybemys arenarius*.] Idem, pp. 102-103.
- [On Polydactylism in a horse.] Idem, p. 112.
- Remains of mastodon and horse in North Carolina. Idem, p. 113.
- Remains of extinct mammals from Wyoming [*Trogosus* and *Sinopa*]. Idem, pp. 113-116.
- Remarks on a fossil *Testudo* of Wyoming. Idem, p. 154.
- Remarks on supposed fossil turtle eggs. Idem, pp. 154-155.
- Remarks on the Garnets of Green's Creek, Delaware Co. Idem, p. 155.
- Remarks on donation of fossils from Wyoming. Idem, p. 197.
- Remarks on mastodon, etc., of California. Idem, pp. 198-199.
- Note on *Anchitherium*. Idem, p. 199 (8 lines).
- Remarks on fossil vertebrates from Wyoming. Idem, pp. 228-229.
- Notice of some extinct rodents. Idem, pp. 230-232.
- Remarks on the minerals of Mount Mica. Idem, pp. 245-247.
- Remarks on fossils from Oregon. Idem, pp. 247-248.
- Flies as a means of communicating contagious diseases. Idem, p. 297.

- Notice of some worms (*Dibothrium cordiceps*, *Hirudo*, *Gordius*).
 Idem, pp. 305-307.
- Tænia caused by the use of new beef. American Journ. Med. Sci., 2d
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- Remarks on some curious sponges. American Nat., vol. 4, pp. 17-22,
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- Notice of corundum. Idem, p. 19.
- Remarks on fossils from Wyoming. Idem, pp. 19-21.
- Remarks on some extinct mammals [from the Tertiary of Wyoming].
 Idem, p. 37.
- Remarks on some extinct vertebrates [from Niobrara River, *Felis
 augustus*, *Oligosimus grandævus*, and *Tylosteus ornatus*]. Idem,
 pp. 38-40.
- Remarks on mastodon from New Mexico. Idem, p. 142.
- On a new genus of extinct turtle (*Chisternon*). Idem, p. 162.
- On some remains of Cretaceous fishes. Idem, pp. 162-164.
- On *Artemia* from Salt Lake, Utah [and on fossil shark's teeth]. Idem,
 pp. 164-166.
- Remarks on fossil shark teeth. Idem, p. 166.
- Letter dated Fort Bridger, Uinta County, Wyoming, July 24, 1872,
 from Dr. Leidy to Mr. G. W. Tryon, Jr., in reference to fossil
 mammals found there. A copy of this letter Dr. Leidy sent to
 the American Journal of Science and Arts, because in it he referred
 to *Elasmosaurus platyurus*, Cope. Idem, pp. 167-169.
- Remarks on the habits of an ant [at Fort Bridger]. Idem, p. 218.
- Remarks on mineral springs, etc., of Wyoming and Utah. Idem, pp.
 218-220.
- Notice of a corundum mine [in Chester County, Pennsylvania]. Idem,
 pp. 238-239.
- Remarks on fossil mammals from Wyoming [*Uintatherium* and other
 fossil remains]. Idem, pp. 240-241.
- Remarks on chipped stones from Wyoming. Idem, pp. 242-243.
- Notice of donation of fossils from Wyoming. Idem, pp. 267-268.
- Remarks on fossils from Wyoming. *Palæosyops junior*, *Uintacyon
 edax*, *U. vorax*, etc. Idem, pp. 277-278.
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- Notice of some parasitic worms collected during Professor Hayden's
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 pp. 381-382.

1873.

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- Notice of remains of fishes in the Bridger Tertiary formation of Wyoming. Idem, pp. 97-99.
- Remarks on the occurrence of an extinct hog in [the Pliocene sands of Niobrara River, Nebraska]. Idem, p. 207.
- [On bituminous coal from Westmoreland.] [Of a black rat (*Mus rattus*), and note on Dufreynite.] Idem, p. 257.
- Remarks on extinct mammals from California. Idem, pp. 259-260.
- Fungus parasite on a mouse. Idem, p. 260.
- On *Distoma hepaticum*. Idem, pp. 364-365.
- On *Lingula* in a fish of the Susquehanna. Idem, pp. 415-416.
- Remarks on fossil elephant teeth. Idem, pp. 416-417.
- On circulatory movement in *Vaucheria*. Idem, p. 420.
- Contributions to the extinct vertebrate fauna of the Western Territories. Report of the U. S. Geological Survey of the Territories, vol. 1, pp. 358, 37 plates.

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- Remarks on *Hydra*. Proc. Acad. Nat. Sci. Philadelphia, vol. 26, p. 10.
- Remarks on Protozoa. Idem, pp. 13-15 (13 lines).
- On the mode of growth of Desmids. Idem, p. 15.
- On *Actinophrysol*. Idem, pp. 23-24.
- [Criticism of Professor Cope's observations on *Thespesius* and *Ischyrotherium*.] Idem, pp. 74-75.
- On the enemies of *Diffugia*, and on a supposed compound derived from leather. Idem, p. 75.
- Notice of some new fresh-water rhizopods. Idem, pp. 77-79.
- Notice of some fresh-water and terrestrial rhizopods. Idem, pp. 86-89.
- Remarks on the revivification of *Rotifer vulgaris*. Idem, pp. 88-89.
- On *Pectinatella magnifica*. On a parasitic worm of the house fly, *Filaria musca*. Idem, pp. 139-140.
- [On fresh-water Infusoria. On a remarkable *Amaba*, its process or mode of swallowing.] Idem, pp. 142-143.
- On the motive power of Diatoms. Idem, pp. 143-144.
- Remarks on sponges. Idem, pp. 144-145.
- Notice of some rhizopods. Idem, pp. 155-157.
- Notes on *Dryocampa*. Idem, p. 160 (7 lines).
- Notice of remains of *Titanotherium*. Idem, pp. 165-166.
- On supposed spermaries in *Amaba*. Idem, p. 168.
- Notices of rhizopods. Idem, pp. 166-168.
- Remarks on fossils presented. Idem, pp. 223-224.
- Notices of rhizopods. Idem, pp. 225-227.

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 Remarks on some marine rhizopods. Idem, pp. 73-76. (Illustrated.)
 Remarks on a coal fossil. Idem, p. 120. (Illustrated.)
 Remarks on elephant remains. Idem, p. 121.
 On a curious rhizopod [on a mouthless fish]. Idem, pp. 124-125.
 On psorosperms in a mallard duck (on our amoeba). Idem, p. 125.
 On *Mermis acuminata*. Idem, p. 400 (14 lines).
 Remarks on rhizopods. [On *Quercus heterophylla*.] Idem, pp. 413-415.
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Mastodon audium. Idem, p. 38 (11 lines).
 Remarks on Arcella, etc. Idem, pp. 54-58.
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 Remarks on vertebrate fossils from the phosphate beds of South Carolina. Idem, pp. 114-115.
 Remarks on the rhizopod genus *Nebela*. Idem, pp. 115-119. (Illustrated.)
 Bituminous sediment of the Schuylkill River. Idem, p. 193.
 Remarks on the structure of precious opal. Idem, pp. 195-197.
 Observations on rhizopods. Idem, pp. 197-199.
 On ozocerite hyraceum and itacolumite. Idem, p. 325.

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- [On the contamination of the drinking water.] Proc. Acad. Nat. Sci. Philadelphia, vol. 29, p. 20.
 On *Eozoon canadense*. Idem, p. 20 (10 lines).
 On the human diaphragm. Idem, p. 20 (6 lines).
 Remarks on the Yellow Ant. Idem, p. 145.
 On intestinal parasites of *Termes flavipes*. Idem, pp. 146-149.
 Remarks on gregarines. Idem, pp. 196-198.
 On *Chilomonas*. Idem, p. 198.
 On flukes infesting mollusks. (*Monostoma lucanica*, *Distoma ascoidea*, *Distoma appendiculata*.) Idem, pp. 200-202.
 Remarks on some parasitic infusoria. Idem, pp. 259-260.
 Remarks on the seventeen-year locust, the Hessian fly, and a Chelifer. Idem, pp. 260-261.
 The birth of a rhizopod. Idem, pp. 261-265.

- On the bed-bug and its allies. *Idem*, p. 284.
 On the feeding of *dinamoeba*. *Idem*, pp. 288-290.
 Concretions resembling bones. *Idem*, p. 290.
 Apparent discriminative power in the selection of food by a heliozoön.
Idem, pp. 291-292.
 Remarks on rhizopods, and notice of a new form. *Idem*, pp. 293-294.
 Remarks on ants. *Idem*, pp. 304-305.
 Remarks on the American species of *Diffugia*. *Idem*, pp. 306-308.
 Circumspection of ants. *Idem*, p. 320.
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 Species of *Euglypha*, *Trinema*, *Pamphagus*, and *Cyphoderia*, with Sy-
 nonyma and descriptions of new forms. *Idem*, pp. 171-173.
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 On crustaceans at Cape May, N. J. *Idem*, p. 336.
 Notice of a Tetrarhynchus (*T. tenuicaudatus*). *Idem*, p. 340.
 On *Donax fossor*. *Idem*, pp. 382-383.
 Notice of gordius in the cockroach and leech. *Idem*, p. 383 (11 lines).
 On *Tænia mediocanellata*. *Idem*, p. 405.

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