WILLIAM STEBBINS BARNARD, PH. D.

Professor of Biology, Drake University, 1886-87.
Professor Natural History, Oskaloosa College, 1876-78; Assistant Professor of Entomology, Cornell University, 1879-81; Assistant Entomologist, Bureau of Entomology, Washington, D. C., 1881-86.

ANNALS OF IOWA

VOL. XX, NO. 5 DES MOINES, IOWA, JULY, 1936 THIRD SERIES

WILLIAM STEBBINS BARNARD

PROFESSOR OF BIOLOGY, DRAKE UNIVERSITY, 1886-1887

BY F. I. HERRIOTT

Professor in Drake University

Science is nothing but perception.—Plato.

The scholar must be a solitary, modest and charitable soul. He must embrace solitude . . . . that he may become acquainted with his thoughts. —Emerson.

In the list of his first faculty which Chancellor George T. Carpenter submitted to the Board of Trustees of Drake University on June 28, 1881, was the name of Dr. William S. Barnard for the chair of chemistry and biology.[1] He had held the chair of natural history in Oskaloosa College under Dr. Carpenter's presidency for the years 1876-78. To Chancellor Carpenter's great disappointment Dr. Barnard's engagement in some scientific work for the national government at Washington held him there until the fall of 1886 when he came to Des Moines and became a member of Drake's instructional staff. He was in his second year of service when death suddenly cut off a career of brilliant promise and rapidly spreading fame as a rising scientist.

Short as was his career in Drake, Dr. Barnard left a host of vivid memories in the minds of his colleagues and students that only an efficient teacher, an earnest scientist and a gentleman and a scholar could leave. He was a fine exemplar of what a scientist in the best and broadest sense of the term should be. He was alert and clear-headed; constantly searching for the basic controlling facts in his special fields of science; open-minded, free from fanaticism and traditional prejudice that prevented his candidly canvassing the pros and cons of matters in

[1]Minutes of Board of Trustees of Drake University, June 28, 1881.

dispute; cautious in assertion and considerate in discussion of moot points; and always willing to aid others, especially his students, with his stores of knowledge and ripe judgment, doing so generously, often to his own deprivation in time and energy.[2]

I

William Stebbins Barnard was born on February 28, 1849. His parents were then living on what was called the Cottonwood Grove Farm about three miles from Canton in Fulton County, Illinois, about forty miles straight east of Fort Madison, Iowa. He was the second of five children born to Theodore and Serena Barnard.

His parents were of New England ancestry with the educational traditions of that section. The father was born in Troy, New York, but was descended from forebears who had settled in Deerfield, Massachusetts, in prerevolutionary days. His mother, Lucy Stebbins Barnard, was the daughter of a Colonel Joseph Stebbins whose line traced back to one Rowland Stebbins who fled from France in 1594.

Young William's schooling started in a log schoolhouse located a mile or more from his father's farm, half a mile from a road to which he had to trudge anon through mud and snow, where he worked at desks made of "rough boards," seated on benches of "split roughly hewn logs with wooden pins for legs" on floors also of hewn logs. The pupils appreciated the rough realities of life and education. In time that school was incorporated in Canton Union High School District in which he continued his secondary education. Family tradition has it that he displayed the common characteristics of ordinary live boys, now and then joining with pranksters in "playing tricks on the teacher" after the manner of pioneer practice. His progress was seriously interfered with by an attack of typhoid fever which kept him out

[2]For the personalia and much of the scientific data in the following sections I am especially indebted to the following named persons: Professor Barnard's son, William N. Barnard, since 1906 professor of heat-power engineering, College of Engineering in Cornell University, Ithaca; Dr. Barnard's brother, Mr. Charles H. Barnard, of Palo Alto, California; Hon. Henry C. Wallace, Secretary of Agriculture, 1921-24; Dr. Leland O. Howard, chief of the Bureau of Entomology, 1897-1926; Dr. Herbert Putnam and his assistants of the Library of Congress, Washington, D. C.; Mr. Otto Kinkeldey, librarian of Cornell University, Ithaca, N. Y.; Mr. Charles H. Brown, librarian of Iowa State College, Ames, Iowa; Mr. Edgar R. Harlan, Curator of the Historical Department of Iowa; to Misses Helen Lightfoot and Ruth Lombard of the State Library, and Miss A. A. Haxmeier of the Historical Department I am especially indebted for the finding of documents, periodicals and aid in reading copy.

of school for the major portion of a year. Attendance at private schools in the summer vacation enabled him to catch up with his classmates. Among his accomplishments was proficiency in playing the flute and the guitar.

Near his father's farm was an old fort or stockade to which the early settlers fled when Indian forays threatened; and among his youthful diversions was picking up the arrowheads and flints and other remnants of primitive life, which may have had no little influence in his later interests in archaeology. The cultural level of his family circle may be inferred from the fact that his parents subscribed for and received the *Ledger* of Philadelphia, *Harpers' Weekly, Harpers' Monthly,* the *Atlantic Monthly,* and one of Chicago's daily papers.

After two years in the Canton High School he indicated his desire to go on with his schooling in the preparatory school of the University of Michigan. His parents promptly concurred and substantially furthered his plans. In the fall of 1867 young Barnard and a classmate journeyed to Ann Arbor and registered in the College of Liberal Arts of the University of Michigan. There are no memoranda of his experiences at Ann Arbor, save that in his home circle there is a tradition that he with others refused to join one of the "self-selected" aristocratic groups then as now called "fraternities," and stood out rather conspicuously as an "independent."[3]

II

At the end of his first year at the University of Michigan young Barnard decided to enter the newly established Cornell University at Ithaca, New York. What precisely caused him to leave Ann Arbor and attracted him to the newly established institution on Lake Cayuga cannot be stated with assurance; but we may presume that it was in part the distinction of its new president, Dr. Andrew D. White, who had achieved fame as professor of history at the University of Michigan (1857-64), and in part the emphasis upon the physical or "natural" sciences —biology and botany, geology and zoology—in the first pronouncements of Cornell. In view of his subsequent career we may be fairly certain that it was the presence of such men as

[3]Mr. Charles H. Barnard in various letters (MS) to F. I. Herriott, letters dated at Palo Alto, California.

Professors Louis Agassiz, Charles F. Hartt, James Law, and B. G. Wilder on the teaching staff that influenced him in his decision to enter Cornell University. But there were other stars that lured him towards Lake Cayuga. Mr. George William Curtis, the author of *The Lotus Eaters,* Professor James Russell Lowell of Harvard, Theodore W. Dwight of Columbia, and Bayard Taylor were announced as among the visiting lecturers; and further, President White had secured one of Oxford University's brilliant dons, Goldwin Smith, as professor of English history. Who would not be attracted by such a galaxy![4]

William S. Barnard entered Cornell University when the dreams and plans of Ezra Cornell and President White for what was then deemed by the learned bigwigs a dubious experiment in "higher" education were in process of realization.[5] They undertook to assure the general public not only liberal studies in the humanities, in the classics, literature and philosophy, but also discipline in the basic physical sciences and training in the "practical" arts—in agriculture, architecture and chemistry; in engineering, civil, electrical and mechanical; in horticulture as well as in law and medicine.[6] Young Barnard was there when the plans of Frederick Law Olmstead for the architectural arrangements were being achieved in the erection of dormitories; of Morrill, McGraw, Sibley and White halls, and when men of wealth were coming forward with generous gifts for the endowment of chairs, laboratories and libraries.[7] It was a time of glorious awakening and illumination for him and his fellow collegians.

We have no memorabilia of Barnard's personal experiences in his undergraduate days at Cornell. Whether by natural attraction he became interested in the "natural" sciences—botany, biology, geology and zoology—or whether class work and lectures under Professors Hartt and Wilder, both students under Agassiz, first fascinated him, we cannot say. But certain it is that he soon attracted the favorable attention of those two distinguished members of Cornell's faculty, with one notable result for the young man from Canton, Illinois.

---

[4]C. D. Von Engeln in *Concerning Cornell* gives a list of Cornell's first faculty with pictures of most of them, opposite p. 176.
[5]President Eliot of Harvard predicted failure. See his article in the *Atlantic Monthly,* Vol. XXIII, p. 215. Cited in Von Elgeln, *op. cit.,* p. 178.
[6]W. I. Hewett: *Cornell University—A History,* Vol. I, Ch. XX.
[7]*Ibid.,* Vol. I, pp. 305-6.

Professor Hartt had accompanied Agassiz to Brazil in the noted Thayer expedition of 1865-66. In 1870 Professor Hartt was asked to superintend the Morgan expedition to the same country, one purpose of which was to gather data to confirm or disprove Agassiz' theory of the effects of glacial drift in the Amazon basin. Among the technical assistants he asked to accompany him was young Barnard. Evidently his ability, alert intelligence and industry had attracted more than a casual flitting interest on the part of his instructors at Cornell or such an invitation would not have been tendered one so young.

III

What general or particular tasks were assigned young Barnard in the forepart of the expedition, whether to note and study the botanical or the geological, the zoological or the archaeological phenomena of the laterals of the Amazon River, is not quite certain. In October, however, Professor Hartt directed him to explore and to report upon the archaeological remains in and about Lake Arary on the island of Marago, the lower major island at the mouth of the Amazon River. His "Notes," kept in the fashion of a diary or journal, written in pencil on yellow sheets of ordinary note size, give us much miscellaneous data, and more or less descriptive and anecdotal data of his experiences and observations. They were jotted down at various hours of the day. He had evidently familiarized himself with Portuguese and Spanish, for local linguistic descriptives intermingle constantly with scientific terms for animals, fruits, plants and trees.[8]

The *Notes* open October 11, 1870, with the entry, "Derby and Wilmot[9] left this noon for Moronao. I start this evening for Lake Arary on the Island Marago. Professor Hartt and Eldredge return to Amazonas." The next morning at 8 o'clock his boat entered the river Arary. After passing an island, whence

---

[8]*Notes* (MS), by W. S. Barnard, made while in Brazil, 1870. The manuscript begins with page 130.

[9]Messrs. Derby and Wilmot were classmates of Dr. Barnard of the class of 1873. Orville Derby became a geologist of note, being geologist of Brazil from 1907 to 1918 (*Who's Who in America*, Vol| XX); De Borden Wilmot became a prominent lawyer of New York City (Hewett, *op. cit.*, Vol. IV, p. 595). Mr. Rolfe Eldredge, who accompanied Professor Hartt in his explorations at Ererê in the Province of Para, states that one of the new trilobites—*Tentaculities Eldredgianus*—was dedicated to Mr. Eldredge (*Annals of the Lyceum of Natural History*, Vol. XI, p. 127).

they had obtained a good canoe, he makes the following entries which show that he had an eye for all species of life:

> After them two young Negro women came out in a canoe. They appeared as intelligent as any women I have ever seen. One had features as fine as most any white lady I have ever seen & eyes exceedingly bewitching. They had hair, however, which stood out nearly straight about 6 inches long. They appeared very neat and rowed the canoe very gracefully. . . . . Their hair showed that they were of a cross between the Indian and Negro. . . . ."[10]

Twice he escaped catastrophe by narrow margins. Once a huge alligator suddenly appeared in midstream and dashed ferociously towards his canoe. His Indian guide, who was supposed to have his rifle constantly within his (Barnard's) reach, was not within range; but a lucky shot from his revolver in the creature's eye stopped his onslaught.[11] Again he and his Indian guides found themselves in sore straits when a drove of wild hogs routed their dogs who retreated to their masters for protection, and the latter had to climb trees to escape a horrible fate. Barnard apparently had to hang at arm's length from a limb of his tree, and was very near the point of exhaustion when the hogs departed.[12]

On October 22 at 12:55 P. M. he entered the mouth of Lake Arary and came to the Island of Pacova on which was the ancient cemetery of the Indians—the exploration of which was the objective of his particular journey—located near the west shore slightly above the middle line of the lake. The burial grounds had been built up by the Indians between four and eight feet above the shore line to safeguard the burial mounds against the surge of spring or fall floods.[13] He found the shore littered with broken pottery which he says was "very nicely ornamented or figured with signs."[14]

His most interesting and puzzling find was the discovery of burial urns containing the bodies (or skeletons) of the dead in a sitting posture, the arms clasped about the knees and the head forward resting on the knees. The openings and the necks of the burial pots were too small to allow the body to be inserted or pushed in, yet he so found them. Among various explanations

[10] *Notes*, p. 134.
[11] Charles Barnard to F. I. Herriott, (MS) letter dated at Palo Alto, California, November 30, 1935, relates the incident.
[12] *Notes*, pp. 256-59.
[13] *Ibid.*, pp. 217-18.
[14] *Ibid.*, p. 195.

he suggests that the urns were made after death, built up or moulded about the body.[15] Among his comments on the pottery and earthenware I take the following:

> The execution, shown in the general form and in the detail of the ornamentation of their earthenware, indicates a considerably advanced artistic taste and appreciation; also that certain ones must have been specialists in the manufacture of the vases. This, with the large number of pots in each cemetery and the number of different kinds of fruit trees grown on the cemeteries which I visited, make me [conclude] that these people cultivated plants to some extent. I think that these cemeteries marked permanent camps or small villages.[16]

There were other things besides plants and trees, animals and pottery of which his journal makes note. We are given brief glimpses of the character of the government and of the inhabitants of the island.

> This island of *Marago* is a government *Parish.* All the inhabitants—Donons and all—are slaves of the government and go at its orders or the governor. Slavery here is possible only as a governmental institution. Soldiers are necessary chiefly to enforce slavery. Without slavery all the Fayendas would go down and Sugar &, the produce of labor could not be obtained. Cattle could not be raised on the campus, but would all go wild, and none would go to market, but like the deer would be taken occasionally and eaten by the inhabitants near their haunts. This is because the people are lazy, and do not care to work for money. The country is so rich they can live without money, or with very little.[17]

His *Notes* are crowded with interesting miscellaneous data relating to the flora and fauna of the regions he passed or visited, and with pencil sketches of birds and topography and particular sites that we might stop to consider. He had an eye which was at once microscopic and telescopic in discernment and comprehension; and his alert mind saw significance in the minutia of geological drifts or strata, in the myriad varieties of fauna and flora and in the archaeological remains. But suffice it to say that he returned to Professor Hartt with a considerable collection of valuable specimens that formed the substance of learned articles by Professor Hartt who publicly gave credit to his young assistant.[18]

---

[15] *Ibid.*, p. 216.
[16] *Ibid.*, a memorandum or note inserted between pages 216 and 217.
[17] *Ibid.*, pp. 221-22.
[18] *The American Naturalist*, Vol. V, p. 260. Specimens of idols, burial jars and ornamental pottery gathered by young Barnard are reproduced pictorially in Professor Hartt's article on "The Ancient Indian Pottery of Marajo, Brazil," published in the July, 1871, issue of *The American Naturalist, Ibid.*, pp. 259-71.

In his preliminary report on the Morgan expedition, Professor Hartt says:

> Mr. Barnard did some good work. On his return he gave himself up to natural history. If to discover a new carboniferous fauna will repay a journey to Brazil, of how much greater importance is the discovery of a new naturalist? Had the expedition produced no other results than to have added four new names to science, I should consider the time and money well spent.[19]

From the context it seems clear that W. S. Barnard was the one to whom the flattering reference is made.

IV

Mr. Barnard completed his undergraduate course at Cornell in 1871. His ambition and energy were displayed by his departure that fall for Germany, where for two years he pursued lectures and studies in natural history at the universities of Berlin, Bonn, Jena, Leipsig and Munich, with some studies in France and Italy. His important studies were under Karl Gegenbaur and Rudolph Leuckhart, both of Leipsiz, and Ernst Haeckel of Jena. His thesis was a study prepared under the supervision of and submitted to the celebrated Haeckel at Jena, whence he obtained his doctorate on February 15 in 1873. His thesis was entitled *Beitrage zur Myologie des Simia satyrus (Orangutan) besonders über die Morphologie der Beinmusculatur,* (Contributions to the myology of Simia satyrus *(Orangutan)* and especially the morphology of the limb musculatur).[20] Professor Haeckel spoke of his work in high terms, asserting that his studies exhibited "the highest degree of excellence."[21] Barnard was one of two out of forty-one of his class of '71 who obtained their doctorates abroad.

Dr. Barnard returned to Cornell. He was a lecturer on histology and Protozoa for the year 1873-74. In the summer of 1874 he was one of the lecturers in the Anderson School at Penikeese, on Buzzards Bay in Massachusetts, the famous first summer school conducted under the patronage of Agassiz. During 1874-75 he was professor of natural science in Mississippi

---

[19] *Preliminary Report of the Morgan Expedition to Brazil,* Vol. I, p. 3.

[20] Dr. Lockman, director of the University Library of Jena, Germany, to Professor Adelmann of Stimson Hall, Cornell University, (MS) letter (photostatic copy) dated at Jena December, 1935.

[21] Quoted in *The American Naturalist,* Vol. XXI, p. 1136, December, 1887.

Agricultural College. In the summer of 1875 he was lecturer on zoology at the Illinois State Summer Schools at Normal and Peoria, and the next year he was professor of natural science at the Wisconsin State Normal School.[22]

On July 7, 1874, Dr. Barnard married Mary Nichols, daughter of a dentist of Boston, Massachusetts, a sister of Mrs. B. G. Wilder of Ithaca.

In the summer of 1876 President George T. Carpenter of Oskaloosa College at Oskaloosa, Iowa, asked him to be professor of natural science at that institution, which position he held until the summer of 1878. That summer he went south to carry on studies of the cotton worm for the Bureau of Entomology at Washington. During the winter of 1879 he continued some of the investigations started in the previous summer. Meantime, on account of politics or other complications Dr. Riley, who had asked Dr. Barnard to make the investigations, resigned and Professor Comstock of Cornell was asked to take over the work; and Dr. Barnard came back to Cornell as assistant professor of entomology and lecturer on the zoology of invertibrates, which positions he held until 1881.

Ad interim, in 1878, according to *The Ten Year Book*, 1888, of Cornell University, Dr. Barnard was appointed the "zoologist" on the technical staff of the "Woodruff Scientific Expedition," sponsored and financed by Mr. James C. Woodruff, of which Professor B. G. Wilder of Cornell was to be the chief in charge. That undertaking was a rather ambitious project—a prototype of the modern "floating university" of recent years. A ship, the Ontario, capable of carrying four hundred students in addition to the technical staff and the ship's officers and crew, was chartered; and plans were made for sailing down the eastern coast of Mexico, Central and South America, thence up the west coast, thence to Hawaii, to Japan and China, thence through the islands of the Indian Archipelago and around Africa, stopping at notable points to get acquainted with the geology, animal and plant life, the archaeology, anthropology, ethnology and social life of the inhabitants of each country visited. Precisely what part Dr. Barnard had in the expedition and how long he was actually with it is not quite clear, for the financial

[22]*The Ten Year Book of 1888* of Cornell University, pp. 55-56.

sponsor died in June of 1879 and the general program could not be realized.[23]

The esteem in which Dr. Barnard was held by the authorities of Cornell University may be inferred from the following excerpts respecting him taken from Professor W. I. Hewett's *History of Cornell University,* published in 1904:

> Although the department [of comparative anatomy] possessed the only compound microscope in the university, no advanced work was done with it, or systematic instruction offered in its use, until 1873. In that year Dr. W. S. Barnard of the class of 1871 returned from Germany after a course under Gegenbaur, Leuckhart, Haeckel and others. During the two following years he did much original work as a graduate student in histology, and in the study of Protozoa.[24]
>
> During his [Professor Comstock's] absence, the work of this department [entomology] was carried on by Assistant Professor William Stebbins Barnard. . . . . During Dr. Barnard's administration of the department he made important contributions to our knowledge of the habits of certain insects. The most notable of these was his account of the habits of the pear psylla, which was published in the proceedings of the American Association for the Advancement of Science for 1879. In this paper he pointed out the serious nature of this pest, which ten years later destroyed many of the pear orchards of this state, and was the subject of an exhaustive investigation conducted by this department in 1891 and 1892.[25]

V

Dr. Barnard's studies of insect life, especially in relation to its connection with agriculture and horticulture, attracted the attention of Dr. C. V. Riley, then widely known for his work as state entomologist of Missouri, and as editor of *The American Entomologist.* Some of the results of his observations and studies appeared in various publications as follows:

"New Rhizopods," in the *American Quarterly Microscopical Journal* for January, 1879 (one plate).

"Some Interesting Insect Habits and Their Development," in the *Proceedings of the American Association for the Advancement of Science,* 1879, Vol. XXVIII, pp. 472-78 (one plate).

---

[23]*Scientific American* for September 8 and 22, 1877, and June 29, 1879. In a letter to Professor William N. Barnard, dated at Ithaca, New York, April 25, 1936, Professor S. H. Gage says of the failure of the Woodruff Expedition, ". . . the inquiry fell through. It was not wholly because Mr. Woodruff died. He died partly because of the failure of securing enough paying students. You see it was to be a sort of traveling college, not a mere collecting and scientific expedition. Only a few students could be induced to invest enough time and money, and hence the whole thing fell through, and Mr. Woodruff's keen disappointment was at least a contributing factor in his death."

[24]Hewett, *op. cit.,* Vol. II, pp. 205-6.

[25]*Ibid.,* pp. 196-97.

"The Bud Blight Insect," *ibid.*, pp. 478-86 (one plate); Vol. XIV, pp. 233-42.

"Protoplasmic Dynamics," in the *American Naturalist*, April, 1880.

"The Army Worm," in the *N. Y. Journal* published at Ithaca, July 9, 1880.

"Buccalatrix Cocoons," in *The American Entomologist*, Vol. III, N. S. Vol. I, p. 76 (March, 1880).

"European Tussock Moth," *ibid.*, p. 77.

"Campodea Fragilis Meinert," *ibid.*, p. 199 (August, 1881).

"Parasitic Rove Beetle; *Aleochara anthomyise* Sprague," *ibid.*, pp. 199-200.

"Entomological Legislation," *ibid.*, p. 222 (September, 1880).

"Parthenogenesis in Orgyia Antiqua," *ibid.*, p. 227.

"Dominican Case Bearer," *ibid.* (illustrated).

Several of the titles listed above were in the form of letters to the editor of the *Entomologist*. If space limits permitted it would be instructive to summarize Dr. Barnard's observations and suggestions on some of the subjects dealt with. Parthenogenesis, or asexual reproduction in insect life was a matter of lively interest to biologists in the seventies and eighties. He found the eggs of the tussock moth within the cocoons on the willow trees and asks, "Must we conclude from this that there are no males to this generation, and that wingless females are parthenogenetic? To me it seems so."[26] The subject attracted him especially in 1880. He had fifty specimens under close observation between January and August.[27] He watched the nature and proceedings of the parasitic rove bettle and concluded that it was "the best enemy against the fly which has ruined so many crops here [Ithaca]."[28]

In view of the extraordinary public interest today in the promotion of agriculture by legislative acts and governmental supervision thereof, especially in the prevention or destruction of insect pests that menace crops and orchards, his pointed and urgent suggestions in his article on "Entomological Legislation" are interesting. He urges:

> . . . . a set of law for all states. They would be as beneficial and as easily enforced as the game laws. . . . . Only by some such arrangement can farmers be compelled to co-operate for their own interests and successfully combat the thieves which are robbing them of their produce.

---

[26] *The American Entomologist*, Vol. III (n. s. Vol. I), p. 77, col. 2.
[27] *Ibid.*, p. 227.
[28] *Ibid.*, p. 200.

. . . . Who will be the first to move in this project and see its execution?[29]

We shall have occasion to note other pithy suggestions of Dr. Barnard urging public action to protect the cotton industry of the South against the insect pests which menaced its basic sources.

During the seventies the biologists were rapidly awakening to the enormous influence of micro-organisms in the weal or woe of mankind, Louis Pasteur's researches and discoveries opening up vast and various vistas in what we may call invisible nature known chiefly through the microscope. Dr. Barnard clearly indicated his appreciation of this important field in an article in *The Popular Science Monthly* for October of 1879 under the caption, "Micro-organisms and Their Effects in Nature."

What is too small to be seen, people are generally apt to regard with contempt or indifference, as of no practical consequence. This is one of the grossest of popular errors. There is not only a profound scientific interest in the realm of microscopic life, which is every day becoming deeper as its organisms are viewed from the standpoint of evolution, but they have a significance in the economy of nature, a usefulness to man, and a value in the industrial arts, of which but a few glimpses have as yet been popularly obtained. To the inquiry: Of what services are those swarms of infinitesimal objects which are revealed only through the microscope? Do they subserve any other purpose than to amuse infatuated microscopists? The reply is that their operations in nature are on a grand and imposing scale, and that their influence on man and other organisms, as well as on the air, the water, and the solid earth, is nothing less than enormous. Although we do not see these infinitesimal creatures at work, their proceedings are none the less real; and though their operations are infinitesimal, the aggregate results are vast and in the highest degrees important. It may be shown: (1) That, as *food,* they feed a greater number of beings than any other kind of organisms; (2) That, as *scavengers,* they eat more refuse than any other group of organisms. (3) That despite their minuteness, their *fossil remains* are much greater in *bulk* and of far more consequence than those of large quadrupeds and serpent-like monsters, such as the *mastodon, megatherium, plesiosaurus, ichthyosaurus,* etc. (4) That, as *builders,* they have produced immense structures, which far surpass in size all the colossal works of man. The evidence of these statements will be presently given, but meantime it may be remarked that such grand results redeem the study of microscopical objects from that pettiness which is often imputed to it.[30]

[29] *Ibid.,* p. 222.
[30] *Popular Science Monthly,* Vol. XV, pp. 764-65.

Dr. Barnard found himself in a distinguished company in that issue of *Popular Science Monthly*—three notable British writers and one American. He was preceded by Professor G. J. Allman, president of the British Association for the Advancement of Science, on "Protoplasm and Life," and Professor Alexander Bain of the University of Aberdeen on "John Stuart Mill." He was followed by George J. Romanes on "The Science and Philosophy of Recreation," and Major J. W. Powell, head of the Bureau of Ethnology at Washington, on "Mythological Philosophy."

VI

In 1881 Dr. Riley was reappointed chief of the Bureau of Entomology at Washington, and Professor Comstock returned to Cornell University. Dr. Barnard was called to Washington and made assistant entomologist of the bureau and for the next five years served in that capacity. It was this engagement which interfered with his coming to Drake University in 1881.

Dr. Barnard was immediately assigned again to an investigation of the cottom worm that was then menacing the cotton industry of the South, the damage being estimated at $15,000,000 annually. He continued his studies in this field begun in the summer of 1878. He was sent to Selma, the county seat of Dallas County, Alabama, in the heart of the cotton belt. In due course he conducted his researches in Georgia, Louisiana, Mississippi and Arkansas. His work covered three general divisions: (1) Experiments with insecticides and various corrective and preventive measures. (2) The construction of mechanisms or devices for effective use on a large scale of the insecticides. (3) Observation of the nature, species and activities of the insects affecting the cotton plants. In each division of his work he achieved results that were more than ordinary.

Addressing the delegates to the Cotton Convention in session at Atlanta on November 4, 1881, Dr. Riley made specific mention of Dr. Barnard's work in connection with the serious dangers to life and health which he encountered in the prosecution of his intimate studies of the cotton worm. Referring to the most important and interesting sections of the cotton belt for study he said that they were:

. . . . most malarious and unhealthy [because of the menace of yellow fever]. . . . . Few of my agents have escaped sickness after a summer's work in the field. Professor W. S. Barnard, who is here with me now in charge of the machinery on exhibition beneath this hall, and to whose perseverance and ingenuity we owe various important mechanical contrivances, was so seriously ill at Selma last fall that I at once almost despaired of getting him back safe to his home in the North. I mention these facts because the synopsis of results which I shall now endeavor to present to you will convey no adequate idea of the time and labor involved in getting at the truths which once obtained appear simple enough. "What is missed is mystery; what is hit is history."[31]

If the cotton industry was to be saved from the serious losses, if not its destruction, threatened by the cotton worm, two objectives had to be achieved: (1) An insecticide had to be discovered or hit upon which would be effective, cheap and easily applied; one, too, which would not kill or injure the soil or the cotton plant, its roots, leaves, blossom or boll, or the fibre or lint. (2) An invention of a device or mechanism, cheap and practicable wherewith the insecticide could be either injected into the soil about the roots or sprayed upon the cotton plant, its stock, leaves, flower and boll. If the device was to be effective, the primary and exacting problem in the latter case was that the insecticide must be ejected upward from either the ground or underneath the plant so as to hit the underside of the leaves and boll whereon the worms clustered. Otherwise, much, if not most of the spraying would be futile.

The history of the efforts or experiments to secure a feasible insecticide is a long history much mixed with controversy into which it is not necessary to enter, even if space permitted. Dr. Barnard, however, holds more than "honorable mention" in its pages. In a paper read before the Society for the Promotion of Agricultural Science in Washington, D. C., August 17, 1891, Dr. Riley, summarizing the history of the experiments up to that date of "The Kerosene Emulsion," states, "The late Dr. W. S. Barnard first suggested the use of milk."[32] Dr. Leland O. Howard was an associate of Dr. Barnard in the bureau from 1878 until 1886, continuing as assistant entomologist until 1894 when he was made chief, which position he held until 1927. He

[31] *Report of Commissioner of Agriculture for 1881-1882*, p. 154.
[32] C. V. Riley: "The Kerosene Emulsion—Its Origin, Nature and Increasing Usefulness," in the *Proceedings of the Society for the Promotion of Agricultural Science*, p. 83.

writes that Dr. Barnard was "the first inventor of the kerosene-milk emulsion to enable the dilution of kerosene with water as an insecticide."[33]

Dr. Barnard's name is intimately connected with the invention of what is called the "cyclone nozzle" for spraying the underside of cotton plants. In the *Fourth Report* of the Entomological Commission for 1885 he contributed 321 pages with 61 plates, most of which he either drew or sketched himself or had done under his supervision. Dr. Riley, chief of the commission, refers to his work as follows:

> Experience had shown that a professional engineer was not best fitted for the work, and we were finally fortunate in securing, in the summer of 1880, the services of Dr. Barnard, who, in addition to his knowledge of natural history, possesses mechanical ingenuity of a high order. After giving some time to general observations in Mississippi and Alabama in the summer of 1880, he was called to Selma the latter part of August, and charged with mechanical work. It was there and early in September that the cyclone nozzle originated in our endeavors to contrive something that would throw a spray from the ground up. The question was discussed between us as to whether water forced tangentially into a flattened disc would rotate and issue from an outlet in a straight or in a spreading jet. Dr. Barnard took the latter view, and a disc, improvised by means of two watch crystals, so as to permit the motion of the liquid to be seen, proved that he was correct. The size and form finally adopted is the result of numberless subsequent experiments covering a period of nearly two years.
>
> While we have always had a number of original ideas to carry out and our direction of this work has been active, yet Dr. Barnard's assistance was fertile from the first, and there is so much that has resulted therefrom that the preparation of these chapters was finally assigned to him, and he deserves much of the credit that attaches to them.[34]

In the *Catalogue of the Exhibits of Economic Entomology* at the World's Industrial and Cotton Centennial Exposition at New Orleans, 1884-85, published by the Bureau of Entomology, Dr. Barnard is the only one mentioned in the letter of transmittal in connection with the section of "Insecticide Machinery and Contrivances for Destroying Insects," as follows:

> . . . . and it will be noted that a large proportion of the more useful contrivances are such as have been designed and perfected in the work of the Bureau or of the U. S. Entomological Commission during the past

[33]Dr. Leland O. Howard to F. I. Herriott, (MS) letter dated at Washington, D. C., March 26, 1935.

[34]C. V. Riley in the introduction to W. S. Barnard's *Report of Machinery and Devices for the Destruction of the Cotton Worm*, (author's edition) p. iv.

four years, and chiefly by the aid of Dr. W. S. Barnard, who has had charge of this part of my work.[35]

Dr. Barnard applied for patent rights for his emulsion and for his cyclone nozzle spray in May, 1882. Sundry antecedent and collateral claims, however, delayed the issuance of the patents which were finally granted in April, 1897, almost ten years after his death. The most bothersome counterclaims were those of Dr. Riley who insisted that he be accorded one half interest in them, or the bureau of which he was chief.[36] The commissioner of patents declared, however, that the evidence showed that "Barnard originated the basic idea of the improvement in question."[37] Mr. Lodeman in his volume, *Spraying Plants* (1896), not only credits Barnard with originating the nozzle spray, but states that he was "unfortunate" in that others had their names attached to the invention "which is without doubt the most important of the many bearing on the subject of spraying."[38] Dr. Howard informs me that it was taken up by "certain manufacturers and came into use very extensively in France in the early work against Phylloxera and was made very extensively by Victor Mermorel and became known over there as the "Mermorel nozzle."[39]

VII

Recalling his associate in the bureau nearly half a century after, Dr. Howard says of Dr. Barnard that he "was a good, broadly educated biologist . . . . and a good investigator."[40] All accounts concur that he was an alert observer, keen in his discernment, indefatigable in his researches, widely read in the literature of his subject, and quick to sense the basic significance and interrelations in the mazes of minutia which his investigations comprehended. Various instructive exhibits of his work in the cotton fields might be offered. One will suffice and because it affords a good illustration of his close observations and of his concise, lucid style of exposition and habits of induction from his data, I venture to quote at considerable length

[35] *Catalog of the Exhibit of Economic Entomology at the World's Industrial and Cotton Centennial Exposition, New Orleans*, 1884-85, p. 4.
[36] W. N. Barnard to F. I. Herriott, (MS) letter dated at Ithaca, New York, February 27, 1936.
[37] Quoted in E. D. Lodeman, *The Spraying of Plants* (1896), p. 202.
[38] Lodeman, *op. cit.*, p. 203.
[39] Howard, *op. cit.*
[40] Howard, *ibid.*

from an article on "The Cotton Worm" which he contributed to a publication in Philadelphia in March, 1882:

> The cotton worm is now assuming a very conspicuous part in connection with the great staple industry of the South, and a much wider interest will be aroused by the researches and experiments . . . . to discover the life history and methods of opposing the ravages of this little creature, which appears in myriads to devour the foliage from the growing crop. . . . . Indeed the cotton worm should now occupy a foremost rank with our leading insect rogues, its mischief being not exceeded by the maraudings of the Colorado potato beetles, the Western locusts and the wheat flies of the North.
>
> . . . . .
>
> The presentation of some of the facts suggested by my work in this undertaking may prove of interest to many readers.
>
> But let us first get acquainted with its different appearances and habits in the successive forms or stages of development which it assumes. These are partly illustrated in our sketch. The foliage of the plant has already become ragged with the notches and holes eaten by the worms, which are generally not noticed until the sad condition of the plants exhibits their work. . . . . On examining carefully we find that the larger worms, which are one and one-half inches long or more, and somewhat like cutworms, have the three pairs of front legs and the four hindmost pairs of legs like those of other caterpillars, but the two foremost hind legs are so much shorter that they cannot be used and are worthless, rudimentary appendages. Looking about we shall find that to some extent the larger worms venture to expose themselves on the upper surfaces, but they are very shy and always on the alert for danger. The slightest disturbance causes the worm to swing the fore half of its body from side to side in a vibratory manner, and if more severely alarmed it hurls itself headlong from the plant in such a sudden wriggling and spasmodic way as almost to startle a person and make it not an easy matter to observe the direction in which the creature disappeared; but upon looking beneath he will be found somewhere on the ground hastily creeping toward the plant. These wild actions seem as though a kind of craziness and frenzy had seized upon it; but all have meaning and purpose for its well-being and are founded in its organization and instinct. The jar which causes it to hurl itself away in a confusing manner must be as heavy as that from a bird alighting on the plant in search for worms. In a state of nature that instinctive behavior has been probably acquired as the only possible method of escape from its enemies among the birds, many of which are exceedingly fond of such delicate morsels as these delicious, juicy caterpillars. The blackbirds especially sometimes appear in large numbers and make great havoc among them. The indictation that a fatal catastrophe is at hand is instantly acted upon by the worm, which has such imperfect eyes that it cannot distinguish forms, but only the difference between light and darkness, and hence does not know a man from a bird.

But why the rapid vibratory swinging of the front half of its body which appears upon the slightest disturbance? An explanation was forced upon me one hot day in August as I sat among the cotton plants in southern Arkansas, watching these and other insects there at work in great abundance. Among the other insects it has many enemies, seeking its destruction. For example, the large red wasp, eagle-like, would seize the worm and fly off bearing it away to devour it bodily; the ants would pounce upon it tearing like a pack of bloodthirsty wolves; and the soldier bug would pierce it with his sabre-like mouth to suck out its vital juices; while the tachina flies were most numerous and active of all, watching the worms and darting suddenly at their fore parts, which were vibrated at every attack, as also when a fly lit upon the same leaf. This vibratory motion upon the slightest disturbance was to ward off and confuse its tiny insect enemies, but is apparently best adapted against the tachina flies which are probably the worst of its destroyers. These little black imps seem only to be sporting with the worms and might be regarded as very innocent playmates, for one cannot notice that they do any immediate harm to the worms. But their later history has been well observed. When the worms have matured and are transforming, great numbers die and are found to contain maggots which have killed them. These maggots when kept and watched are seen to metamorphose into those active winged insects, the tachina flies, and we have been viewing the sportive procedure by which they in turn produce the maggots in the caterpillars. The fly darting successfully enough to touch the worm plants on its skin a very small, adhesive white egg which can only be seen by very close inspection. This egg yields a little sharp-headed maggot which bores from the under side of the egg shell downwards through the skin of the worm into the interior of its body, where, as an internal parasite, it lives upon the less vital parts until nearly grown, when it destroys some of the more essential tissues, and the worm is thus killed while the maggot has a grand final feast and then transforms itself into the angelic condition of a tachina fly, which to the worm is an angel of death. When the flies were abundant their eggs could be seen on the majority of the larger worms. One fly which I captured alive and placed in a bottle with a worm, put several eggs upon it and sometimes two, three or four eggs could be found on a single one of the worms seen on the plants.

Now, why did the worm vibrate only the fore half of its body? Because this is the part which the fly darted at and put its eggs upon. Why did the fly aim only at the front region of the worm? Because the insect, or its egg, or the irritating young maggot, if on the hind half of the body would receive a blow from the worm, which can thus strike back upon itself with its hard head, but it has no means of removing the egg or the maggot from over the fore part of its body; and this is the vulnerable point which the fly instinctively aims at, although it is more active and harder to hit than the hinder parts.

. . . . .

The question, "Whence come these myriads of worms?" has long been asked by the planters. By very close search they are found of different sizes and ages from time to time, but while young and small they remain concealed under the foliage gnawing small spots from its under sufface. These light patches always indicate that the young worms have appeared.

It is a much more difficult task to find the very minute, flattened somewhat, apple-shaped eggs, smaller than the head of a pin, whence the youngest worms are seen to hatch out; but a trained observer can discover them quickly whenever they exist, and can also tell a good egg from a bad one by its color and degree of transparency, or see if it contains a young caterpillar or a young parasite, for strange to say even these tiny eggs are often infested. An insect of almost microscopic dimensions inserts its own egg inside these other eggs, and the former yields a maggot which eats the embryo caterpillar in its shell.

As the normal end of the egg is the beginning of the worm, so the latter changes into a different shape, known as the pupa form, which it takes on after rolling itself up in a leaf and stripping off the entire skin from its body, which gets a hard outer surface. In this condition it lies dormant to transform into a moth or miller, resembling some of our common so-called candle flies. Like them it often enters houses in the night, being attracted by the light. Indeed, at times when they were swarming near the Alabama River, I have seen over a hundred enter an open window in a single evening; and the great electric lights at the Exposition Hotel in Atlanta, Georgia, became surrounded and covered by swarms, often a quart of the dead moths accumulating in the globe of each burner in a single evening, while the ground beneath would be littered with the killed and wounded.

The moths fly to fresh fields to lay their eggs, whence new worms develop, and thus several generations of moths and worms successively appear during the year, although the broods generally do not become notably large or destructive until the latter part of the season. Then they often strip all the foliage from the cotton over a large part of the South, preventing a portion of the crop from maturing, and their filth somewhat impairs much that is already perfected. Often they take that proportion of the crop which the planter should clear above his expenses or much more, and this has become a great discouragement over extensive regions which are regularly afflicted. During the past autumn the cotton of the entire South was stripped completely of its leaves from the Gulf to Kentucky.

Although this pest is a very old one, its depredations in recent years have become worse and worse until a war against it became necessary and the leading planters now systematically apply poison on their plants to kill the insects which attack them. But not a few are too indolent or religious to adopt this practice, which pays well when properly done. As one individual of a certain class representing "the salt of the earth" expressed it: "The worms are sent upon us and we must

submit; if we fight them we are flying in the face of the Almighty and he will make it worse for us. We can't beat Him." Such people may never learn that only those are helped who help themselves, and that poisoning might be an improvement on idle prayer.[41]

The foregoing narrative displays a number of interesting facts worthy of note in passing. First, Dr. Barnard was as effective in popular exposition as he was in technical scientific analysis and description. He expresses himself in clear-cut, concise, comprehensive language which conveys accurate and vivid impressions, which the lay reader easily follows. Second, he does not belabor or befuddle his lay reader with ponderous, sesquipedalian scientific terms—although, as we have seen in the various extracts previously taken from his scientific studies, he was easy master of them and had them at his pen's point, or his tongue's end. Third, his narrative suggests the close, constant attention he gave to minutia, wherein the basic or important facts surrounding or underlying his problem were to be found. Success in his work called for ceaseless patience and the utmost alertness and watchfulness in discernment and comprehension of the infinite variety of nature roundabout him—and all, too, far from the madding crowd, with no one to aid or to applaud him in his work.

VIII

During the seventies and eighties academic and lay circles were torn with acrimonious discussion over the truth or error in the theories of Charles Darwin, precipitated first by his epoch-making volume published in 1859 entitled *The Origin of Species,* and immensely aggravated in 1871 by his volume, *The Descent of Man.* The evidence, which for thirty years he had quietly but laboriously assembled, sifted and studied, seemed to indicate conclusively that mankind was not only a species of general animal kind but was a resultant of centuries of evolution from lower antecedent forms, mayhap ultimately from

> A fire mist and a planet,
> A crystal and a cell,
> A jelly fish and a saurian,

up to his present estate. The heavens were split with the rancorous contention of theologians and scientists as to the truth

[41] *Our Continent,* March 22, 1882, p. 93.

of the story of man's advent upon the earth given us in Genesis. Was that account controlling upon the judgments of men seeking the truth as to Nature's laws or principles and procedure?

What were young Barnard's first views on the hotly debated questions we cannot say precisely, but we may presume that he entertained the traditional views common in his home and neighborhood circles. Further, these views may have been confirmed when he heard the great Agassiz hurl his bolts against the Darwinian hypothesis. It must have been a stirring and trying time for him amidst the whirling discussion. But his mind was controlled by St. Paul's famous injunction to "Prove all things; hold fast that which is good." His thoughts and conclusions were coerced by Nature's phenomena and by the preponderance of the clearly sifted evidence. Slowly his studies, especially those he pursued in Germany under Haeckel, compelled him to see the basic similarities in the structures and functions of all animal species. Evidence was omnipresent that all forms of species were evolved from antecedent simpler forms, and Dr. Barnard did not ignore its import.

So far as I can discover Dr. Barnard did not venture into any of the rancorous controversial discussion which raged all about him in academic and lay circles. But there is clear evidence that he did not hesitate to go the whole length of the new theories of the origin of life and of mankind. At the meeting of the American Association for the Advancement of Science at Detroit in August, 1875, he appeared twice on the program. The Proceedings contain some thirty pages giving some of his "Observations on the Membral Musculation of the Simia Satyrus (orang) and the Comparative Myology of Man and Apes,"[42] which was a minute study of the similarities in the muscular arrangements of the orang in particular and extensive comparisons with those of man and apes.

That paper was in substance, if not entirely, his thesis which he had submitted to Ernst Haeckel in fulfillment of the requirements for the doctorial degree at the University of Jena in February, 1873. Needless to say, any one familiar with the ruthless contentions as to man's nature and origin entertained

[42] *Proceedings of the American Association for the Advancement of Science*, Vol. XXIV, pp. 112-44.

by Professor Haeckel need not be told that any old-time notions of the traditional or theological character as to man's ancestral origin would not be tolerated by Jena's belligerent critic of Bishop Usher's *ipse dixit*. The drift and nature of Dr. Barnard's observations may be easily discerned in the following paragraph:

> Finding these *communis* muscles in their typical condition among the lemuroids, and tracing them upwards step by step through all their degrees of differentiation until we reach their most specialized (proprius) forms in the higher apes and man, we follow out with proximate exactness the lines of descent of these specialized muscles from their ancestral typical forms, and this, as well as the inheritance of many rudimentary and other small muscles, may indicate the descent of man, the higher apes and the lemuroids from a common ancestry. Considering its myology we would not reckon the orang as man's nearest relative among the apes. In respect the gorilla and chimpanzee probably show closer affinities to the human race. Recognizing the wonderfully superior powers of man's brain and the surpassing functional capacity of his other organs, we cannot avoid concluding that as regards man's physiological or spiritual powers he differs in a greater degree from the higher apes than these do from the lower apes; yet when we observe the close structural resemblance of man to the gorilla, chimpanzee and orang and feel bound to conclude with Huxley (6) that these are more closely related to man than to the lower apes. This, then, leads us to an important distinction always to be made in expressing this relationship of man to the apes; namely, that *physiologically* and *teleologically* man stands farther from the higher apes than these do from the lower ones of their kind; whereas *morphologically* the higher apes rank nearer to man than to the lower apes.[43]

The drift of his exposition is not uncertain and it coincides with the course of the predominant scientific thought in the half century following, respecting man's relationship to the higher mammals.

About the time the foregoing was published Dr. Barnard published a portion of another interesting and instructive study in the *Popular Science Monthly* (December, 1875) under the title of "Opossums and Their Young." He was in distinguished company in that issue. Professor John Tyndall discussed "Martineau and Materialism" and Herbert Spencer dealt with "Idol Worship and Fetich Worship." If by chance any of the excessively orthodox had come upon that article and glanced through its contents they would have been astonished at the reach and sweep

[43] *Ibid.*, p. 116. The "(6)" refers to Huxley's "On the Position of Man in Nature."

of some of his quiet observations and deductions suggested by the structures of an animal that few would consider within the ancestral lines of the *genus homo*. Two paragraphs are given in part:

> But in all probability Professor Haeckel is right in believing that this group affords a series of forms connecting the lower apes or lemuroids above them with the monotremes below. This would bring some of the marsupials within the lineage of human ancestry, and before all others, the opossums seem most closely allied to the lemuroid apes.[44]
>
> The embryo opossums show resemblances to lower animals in the general shape of the body, in the early form of the brain, the peculiarities of the lips, the thymus gland, the glandular apparatus of the stomach, the early conditions of the reproductive and urinary organs, and the primitive condition of the mammary glands. Peculiar embryonic resemblances are found in the young of every animal of which the embryology is known, and these facts have no meaning at all to us, unless they mean inheritance and descent.[45]

The critical and the curious may find confirmation of Dr. Barnard's observations as to embryological and morphological similarities in the charts and pages of Romanes' *Darwin and After Darwin* published in 1892.

Four years later amidst his investigations of the insect pests in the cotton fields of the South, and his efforts to perfect mechanical devices for destroying or dispersing the cotton worm he sent the following letter to *Science* that shows his alert and constant interest in man's close connections with other types of animal kind, under the caption, "Movement of the Arms in Walking":

> In *Science*, February 9, Mr. F. W. True recognizes the "movement of the arms in walking" as a functional relic of quadrupedal locomotion; urging thereby a modification of the expression of Professor Dana, sanctioned by Dr. Gill, that "man stands alone among mammals in having the forelimbs not only prehensile, but out of the inferior series, the posterior pair being the *sole* locomotive organs." And the questions are asked, "Have we not at least a ghost of a pre-existing function? Does man walk by means of his feet and legs alone?" Viewing the question from the developmental standpoint, it seems to me that the strongest evidence appears in the first locomotor acts of the child. Before bipedal progression is learned, *the child goes on all fours, and is an actual mammalian quadruped.* At the beginning of this the prehensile power of the fingers is very imperfect. Men have been known to educate their toes to do more than the fingers can at that stage of

[44] *Popular Science Monthly*, Vol. VIII, p. 152, October, 1875.
[45] *Ibid.*, p. 158.

functional development. At that time the palms are of more value as soles than for holding things. In the beginning, also, the arms in some children are better legs than are the hind limbs, being more easily used. For example, it is more common for children to creep on the knees than on the elbows; but some learn remarkably early to elevate both knees and elbows, to creep on the soles and the palms. My own boy walked on his soles and palms from the start, and never upon his knees. The speed with which he finally learned to run in this way was remarkable. After learning to move somewhat on his hind legs, when he got in such haste as to make bipedal balancement difficult or uncertain, he would take to all fours, thereby making better speed with less danger of a fall.[46]

Again we may note Dr. Barnard's invariable habit of seeing things in their universal relationships, and not, as the average person does, in isolation and unconnected with anything else. The ambitious lad referred to in the last lines quoted above has been for many years professor of heat-power engineering in Cornell University, his father's alma mater.

Dr. Barnard's views as to man's origin, evolution and relations to the animal kingdom were especially significant in view of his two years' teaching at Oskaloosa College, and Chancellor Carpenter's efforts in 1881 to secure him for Drake University. Academic precincts, no less than religious circles, were then wracked, and anon wrecked, by violent controversies over the Darwinian theories and the Spencerian doctrine of evolution. Was Chancellor Carpenter aware that Dr. Barnard's views were in concurrence with the then advanced scientific theories in biology? We may presume so, for after 1875 Dr. Barnard had been publishing his views in scientific and popular periodicals. We may therefore conclude that Drake's executive was liberal and tolerant on moot questions.

One fact is conspicuous. Neither at Oskaloosa nor at Drake was Dr. Barnard the center of controversy anent his scientific views, and for a very simple and sufficient reason. He was not forward in arrogant assertion, nor ostentatious in belligerency in promoting his biological opinions. He quietly assembled and presented his facts, pointed out their connections and significance. No one would suspect from his narrative that the heavens were split with angry debates over the matters in issue dealt with by him in his articles. He hurled no bolts, no epithets, and

[46] *Science* for March 9, 1883, p. 140.

indulged in no harsh or contemptuous comments upon those who might dissent from his views.

IX

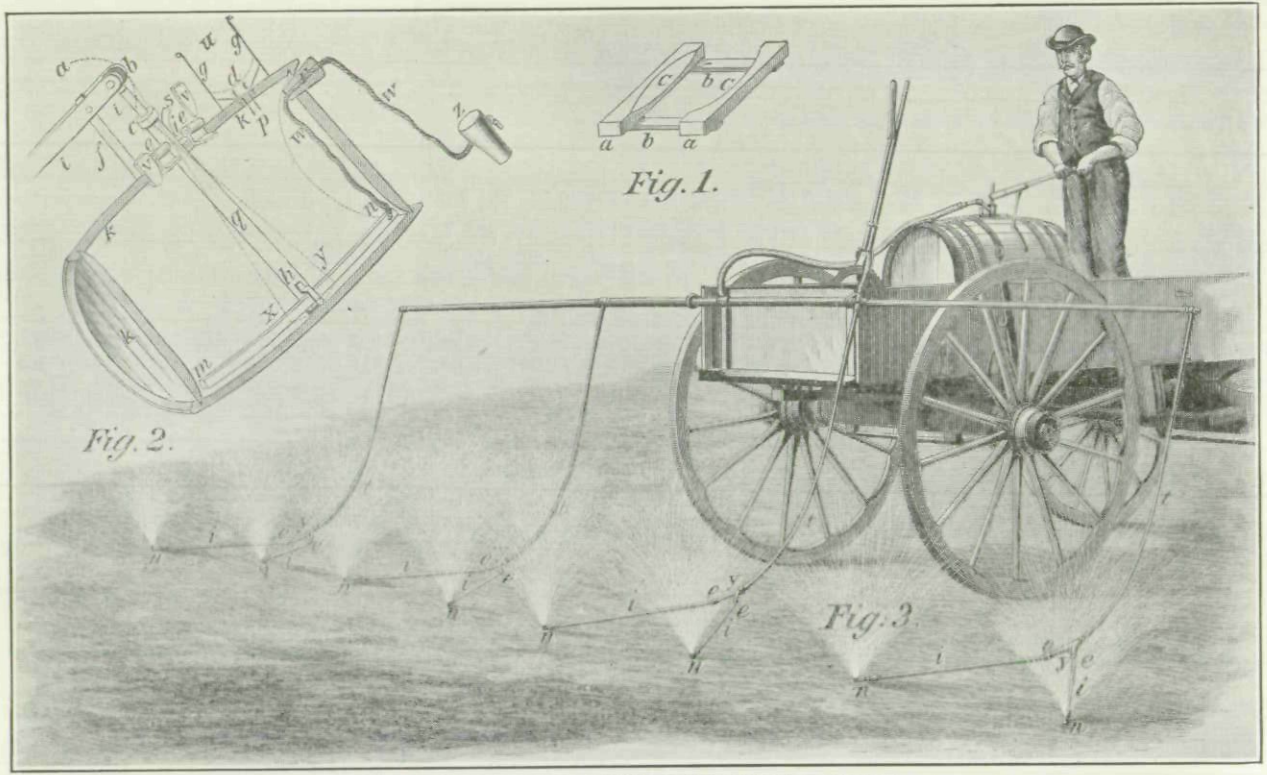
Mention has already been made of Dr. Barnard's invention of a notable labor-saving device, the cyclone nozzle, for spraying his insecticide of kerosene emulsion on the underside of cotton plants. This appreciation of his multiform and multicolored abilities in various lines would be seriously deficient if I did not emphasize his constant alertness in looking for modes of economy not only in physical effort but in the reduction of hindrances to mental effort, or rather of its enhancement. It made no difference where he was, or the things with which he was working. His mind's eye was incessantly alert in discerning ways of saving time and effort, be it when on vacation on his father's farm near Canton, Illinois, or in the cotton fields of the South, or in his laboratory, lecture room or library.

Thus when on his father's farm in 1871 he devised a "method of supporting a portable fence," and in 1878 and 1879 he contrived machines for cutting, for harvesting and for shocking corn, each working on a revolving platform. He applied for patents, but in the case of the first was denied because he had been anticipated; and probably the same reason controlled in the latter mechanisms. He also constructed a "potato bug catcher."[47]

In the course of a discussion of the use of naphthalin as an insecticide before the Biological Society of Washington (December 14, 1883), a contemporary report published at Cambridge, Massachusetts, gives us an interesting account of Dr. Barnard's practical bent:

> Dr. W. S. Barnard said that naphthalin might prove valuable as an insecticide, if made cheap enough and so applied as not to injure the plants. He had devised a method and apparatus by which those insecticides which are dangerous to plants, such as kerosene, cyanide of potassium and bisulphide of carbon might be used so as to be safe for the plants and destructive to insects in the ground. These substances have usually been applied on the surface of the ground or buried shallowly, either among the roots or above them, but when brought in contact with the roots, in strength, they kill them. When applied in the volatile form they are not so injurious. Naphthalin and kerosene especially

[47]Professor W. N. Barnard and Mr. Charles H. Barnard to F. I. Herriott, (MS) letters.



STIRRER-PUMP AND NETHER-SPRAYING MACHINE

Fig. 1. Barrel rest or skid; cleats, bb; side rests, aa; chamfer, cc.

Fig. 2. Stirrer-pump with barrel and mixer funnel in section; funnel, u; its cylindrical sides, gg; funnel base, tt; spout, p (in bung hole, k); gauze septum, d; barrel, kk; trunnions, i; trunnion-eyes, e; wedges, vv; lever fulcrum, f; pump-lever, ii; swing of the lever-head and piston top, abc; packing-cap, c; cylinder, g; its swing, x; spout, s; strainer loop or eye, h; stirrer bar, mn; rope, ww; bungs, rz.

Fig. 3. Wagon or cart machine for spraying from below with stirrer-pump all in operation; suspension pipes, t; Y-forks, y; nozzle-arms, i, flexile, at e; nozzles and sprays, n.

should be placed deep below the roots. The apparatus, which Dr. Barnard names a "nether-insector," consists of a tube which is made to fit closely around a central solid shaft somewhat longer than the tube and pointed at its lower end. The tube may have an internal diameter of 15 mm. and the shaft a diameter of 12 mm. The upper end of the tube expands like a bowl. The upper portion of the shaft is weighted with a heavy ball so disposed that the shaft can be grasped above the ball. By withdrawing this shaft partially from the tube and then returning it with force, as the lower end of the tube rests on the ground, both tube and shaft can be driven into the ground to any required depth. The shaft is then wholly withdrawn and the insecticide poured into the tube, by which means it is placed beneath the roots without coming in contact with them. The tube is then withdrawn, and the hole made by it is filled with earth. The insecticide, being volatile, rises through the ground and becomes diffused. With this method of application kerosene is probably superior to naphthalin.[48]

It would be interesting, if space permitted, to point out the interesting phases of the fifty-six plates which Dr. Howard informs me,[49] Dr. Barnard prepared himself or personally supervised the drafting, showing the various species of nozzles and sprays, atomizers, blowers, deflectors, hydronettes, hand pump and fountain sprayers, and various machines for nether spraying. And if one were to examine with discrimination the 230 pages of technical description and acute discussion of the various types of machines and devices for the destruction of the cotton worm in his final report to the United States Entomological Commission in 1884, he would have no doubts about his intimate knowledge of, or fondness for, mechanical contrivances.[50] His interest therein, however, please note, was all incidental to the destruction of insect pests in one of the great industries of the country.

We shall see that he hit upon a scheme for "note-taking" in class work and lectures for his students at Drake that anticipated the common practice of these days. In 1877 he applied for a patent for book supports or book ends. He is credited with devising "the Harvard Book Rack,"[51] and just before his death he had perfected a letter file, or box file for holding and making serviceable collections of letters, his widow making the application for patent rights after his death. The sketches ac-

[48] *Psyche*, for January-February, 1884, pp. 133-34.
[49] Dr. Howard, *op. cit.*
[50] See *Fourth Report of U. S. Entomological Commission*, Chapters XI-XII, pp. 191-321, and the 61 plates accompanying Dr. Barnard's report, reprinted in the author's edition.
[51] Appleton's *Cyclopaedia of American Biography*, Vol. I, p. 170.

companying the application display the type of filing case very commonly used in the past forty years.[52]

Among the miscellaneous papers left by Dr. Barnard are two rough sketches of serviceable devices for use in a chemical laboratory. One was a holder for a test tube or a pipette. It was simple in the extreme, consisting of a single wire, one portion of which bent at a right angle, was run down a wall catch serving as a hinge, then run out, twisted, the size of the tube to be held, thence to the hinge and back again with another twist. The other was a gasoline heater. This consisted of a one or two-inch iron tube two or more feet long filled with sand. The gasoline or kerosene would be fed into one end and lighted at the other.

Part and parcel of Dr. Barnard's genius in the way of inventiveness was his marked ability in drawing. In his *Notes* of his experiences in the Morgan Expedition to Brazil in 1870, scattered here and there are many pen or pencil sketches of plants and animals. Most of them are rough, merely in outline, but they display keenness of observation and an accurate sense of perspective and proportion. Many of his pictures or sketches of plants or shrubs show exceptional effectiveness in delineation of delicate shadings, lines or filaments. It was his ability in rapid sketching that made his lectures, especially in the use of blackboard demonstrations, so effective.

X

Dr. Barnard's ideas on the true principles and correct practice of effective education attracted attention at Cornell and elsewhere early in his career, for he was asked to give the address before the University Convocation at Albany on July 13, 1880. There was so much pith and point in it that it was printed in *Popular Science Monthly* for September under the title, "Zoological Education." His opening sentences indicate his philosophy and procedure:

> It is the office of education to direct the mental growth of the individual; and this should be by developing and not by a cramming process. In our present system there is too much burdening of the verbal memory, and too little of what may be called the objective memory, resulting from the exercise of the mind upon actual objects. What we want is more of observation, more inductive reasoning, judgment and under-

[52]Letters Patent. No. 384,601, dated June 19, 1888.

standing—in short, intelligent thinking; but how little do we find of this in the prevalent method of education in institutions of all grades.

Ordinary courses of study do not include subjects upon which these mental faculties can be sufficiently employed. They consist too much in learning rules pertaining to language and mathematics and then deductive applications, and too little in the objective investigation of things, the making of generalization and the investigation of laws. School facts and deductive sciences are means instrumental to business success; but they are not in themselves sufficient to carry on the work of mental development. But even where natural science is taught in public schools, it is generally for a short time, late in the course, and by the old method of memorizing or parroting from books instead of making it a constant study of concrete objects, to which some time should be devoted on two or more days of each week throughout the student's whole career. This learning of nature from books alone is an impossibility, a deception, and a fraud, like the teacher's "can't for want of time and specimens" when the crops are suffering from insects which swarm everywhere, and the chief amusements of the boys are to go hunting and fishing.

. . . . .

Teachers should utilize what they can obtain by the help of students. This is dangerous for the unfitted teacher.[53]

Dr. Barnard's ideas anent the methods of effective instruction in the natural or physical sciences are mere commonplaces today. But when he penned those lines they were very heterodox, not to say radical in the extreme. Herbert Spencer, Thomas Henry Huxley and John Tyndall had assailed the traditional cast-iron collegiate curriculum, which for the most part ignored the physical sciences, and insisted on confining attention chiefly to Latin, Greek and mathematics with some consideration for the "humanities," somewhat narrowly interpreted to comprehend only ancient and mediaeval philosophy, logic and a few forays in literature and political economy. But the critics both in England and the United States were not numerous and Dr. Barnard was thus in the vanguard of those who have since made the notable revolution in the instruction in the concrete sciences—the most conspicuous fact in educational circles in the last half century.

One may have correct ideas and high ideals and true theories of what constitutes mental cultivation and real education and fail sadly when he undertakes to put them into practice. He may suffer from a plentiful lack of that incomprehensible but

[53] *Popular Science Monthly*, Vol. XVII, p. 666, October, 1880.

much needed power or quality called "personality" which constitutes the *sine qua non* in successful instruction.

Answering my inquiry about his work in the Bureau of Entomology, the secretary of agriculture, Hon. Henry C. Wallace, after summarizing his work, wrote of Dr. Barnard: "He was much liked by his colleagues, but was not very communicative."[54] One of his colleagues and admirers in the bureau who deemed him an excellent investigator doubted if he was a "very successful teacher,"[55] because he was so quiet and undemonstrative outside of his laboratory and away from his special studies. In the jargon of these latter days Dr. Barnard was neither a "mixer," nor a "socialite," nor a devotee of the goddess, "Publicity."

Dr. Simon H. Gage, professor emeritus of histology and embryology, was an associate of Dr. Barnard in the instructional staff of Cornell University, and retains some vivid memories of the young scientist from Canton, Illinois. He writes:

> While it was after my own graduation (1877) I . . . . attended Dr. Barnard's lectures on Protozoa, and as he worked in the laboratory common to us all, students, assistants and professors, I saw much of him and was certainly an admirer of his tireless industry, and the extent of his knowledge.
>
> He was very ingenious in devising apparatus to meet various needs. During his professorship here [Cornell] he was greatly interested in methods of spraying . . . . which we of the younger generation enjoyed seeing work. . . . . Dr. Barnard was very tall and slender and had a keen sense of the ridiculous. . . . . Dr. Barnard was . . . . a right human kind of individual.[56]

Dr. Barnard had a complex of essentials for a successful teacher. First, he had a clear and comprehensive knowledge of his subject in its vast reaches and in its minutia. Second, he had a command of lucid speech in exposition, and his many and varied studies in Europe, South America, and in the United States enabled him to speak with a certainty, a variety of illustration and a vividness that compelled attention, allured interest and aroused youthful enthusiasm and energetic desire to know more of his fascinating subjects. Third, he displayed an inventive genius in the way of practical suggestions and devices for labor-saving in study and ordinary work that greatly enhanced

[54]Hon. Henry C. Wallace to F. I. Herriott, (MS) letter dated at Washington, D. C., May 23, 1923.
[55]Howard, *op. cit.*
[56]Professor Simon H. Gage to F. I. Herriott, (MS) letter dated at Ithaca, New York, April 2, 1935.

his students' love for his particular course of study or research. The memories of his students are still vivid, and from them we must conclude that his lectures and class procedure were never dull or wearisome. He made the formula of chemistry and the phenomena of life, its animalcule and all microorganisms scintillate with a radiance which made them alive with significance in daily life.

It was true that outside of his classes and laboratory he was reserved if not reticent and undemonstrative—not an uncommon trait of serious students of nature—but when approached by colleagues or students, and those with earnest inquiries, he was congenial, and acquaintance easily attracted and held good will and developed admiration. It is clear that on coming to Drake he demonstrated at once that he was not only a scientist in the strictest sense of the term but a teacher *par excellence*, as well.

Prior to the eighties in western colleges and universities instruction in natural history, as the manuals of chemistry, physics, and zoology were generally labeled, was largely by mastery of "the book," the students having little experience or discipline in a laboratory or field. Dr. Barnard was a realist first and last. He put his theories of education into daily practice. At the outset he asked his students to bring into class specimens of animals or grains, plants or shrubs, and to describe and differentiate them, and to study them in their functions and structures, in their environment and heredity and relations with competing species; and in sundry ways to get in touch with nature at first hand and on the ground. Memories of the novelty of such procedure still remain green in the minds of his students.

One of the innovations which he inaugurated in his class work and laboratory lectures was a method of note-taking which all of his students recall foremost among their recollections. One who attended one of his extra class on Saturday, Mr. Edgar R. Harlan, Curator since 1909 of the State Historical Department of Iowa, gives the following description of his practice:

> . . . . But Professor Barnard proceeded at once to let us into the arts of taxidermy and note-taking. I think it was the very first meeting in which he showed us that in achieving anything worth while it was not to be merely by memory, but by recording on a standard card, of which he gave us specimens from his own stock. They were about three inches wide and five inches long. He had us each write at the top of

the card "Taxidermy Card, No. 1" with name and date. Having done that he cautioned us not to write anything on the cards that would occur at that first class meeting, saying that he would enter on his own card and at the next meeting would have each of us know what he had written, discuss what was worth while and what valueless, then enter upon our own cards, under the new date, the subject and statement appropriate, which was agreed upon through his placing on a blackboard the language that should become an identical line on each of our cards. I remember that he altered a word or more of the line, due to the queries submitted by the bolder members of the class. The alteration, however, took place only after his eliciting the reasons for change in every case and from everyone who had suggested change until, without realizing it, his mind and our own minds reached the exact word or phrase to be made the permanent record for the day.

There were but two or three meetings previous to his asking whether any of us could bring to the class a specimen of small mammal or destructive bird, to be used as the first in the course on the next Saturday. . . . . I remember also Professor Barnard's serious and gentle inquiry of the class, whether there was any variation from other quadrupeds which a rat possessed which would make it an impractical or an impossible subject for experiment. In the same or a continued discussion the class, without the specimen, developed a fair description, and the discussion led into the identity and characteristic names of every rodent any of us knew, the reason for the name rodent and the differences in the tracks they made, the character and color of the hair, or fur, and the like. There was delegated to each who manifested particular interest, the task of bringing to the class, sooner or later, a specimen.

. . . . so the next meeting resulted in ample specimens, upon which Professor Barnard complimented us and continued the instruction by way of notations on our respective cards of other entries indicated by our several experiences.[57]

XI

A colleague, Professor Bruce E. Shepperd, who was foremost in beneficial influence in Drake's faculty for thirty years, appraised Dr. Barnard and his influence:

Dr. Barnard, in my estimation, is the first thoroughgoing scholar to come to Drake. He was always easy to meet and friendly, but one felt that a true scholarship was there. His attitude toward the new when it came up was characteristic of the painstaking investigation. He was

[57]Edgar R. Harlan to F. I. Herriott, (MS) letter dated at the Historical Department of Iowa, Des Moines, May 3, 1935.

Mr. M. A. Olmsted of Des Moines was a member of Dr. Barnard's classes and he has loaned me his chemistry notes taken under Dr. Barnard's directions. They are recorded on light-buff colored cards of the size described by Mr. Harlan. Professor Barnard anticipated the modern card system now so generally used by students and research workers who wish to keep their findings in readily accessible form to enable rapid finding.

not greatly given to the taking on of any matters outside his own particular line. Association with him meant much for my own upbuilding.[58]

Mr. Maurice Ricker of the Drake class of 1892 and for many years now intimately associated with technical work of the motion picture industry, and one of the founders and engineers of the laboratory of United Research Corporation of Long Island City, a subsidiary of the Warner Bros. Company, thus summarizes his recollections of Dr. Barnard:

Professor Barnard was the first real man of science I ever knew. Afterwards there were notable men, all of whom made a deep impression on me—Bruner, Davis, Call[59] in natural and physical sciences as we then called them. In the exact sciences of mathematics and astronomy Professor Shepperd stands out above all others as the man who did more for me than any teacher I ever had.

I was not assigned to any class under Professor Barnard as he died before I progressed that far. However, we enjoyed a privilege in those days long since extinct at Drake, namely, those of us who lived at a distance were allowed to study in the building between classes. Since no supervised study rooms were available, we "sat in" wherever we could and, country school like, we profited by the recitations of our elders.

It was thus as a not unwelcome interloper that I gathered my earliest impressions of the natural sciences. There for the first time I saw strange animals dredged from the sea and preserved in bottles. Naturally I searched the books for descriptions of these strange forms and haunted the classroom after the pupils had gone.

Professor Barnard was a good teacher. . . . . My most vivid recollection of his classwork was when he was teaching a class in drawing. The subject was perspective. On the blackboard he developed with what seemed marvelous speed and dexterity a scene of a railway track, crossties, and even the fence and telegraph poles. He taught it so well that to this day I never look into a picture that I do not try to fix the "vanishing point." He had a certain touch and lively enthusiasm for his classwork that must have been genuine. It was rumored that he was a government scientist and had been associated with the Smithsonian Institution. This was probably the first time I had ever heard of such a place.[60]

The impressions which an instructor makes upon a class of

[58]Professor Bruce E. Shepperd to F. I. Herriott, (MS) letter dated at Donna, Texas, March 14, 1926.

[59]The Messrs. Bruner, Davis and Call referred to by Mr. Ricker were Professor H. L. Bruner now of Butler University, Indianapolis, Indiana; Professor Floyd Davis, Dr. Barnard's successor at Drake; and R. Ellsworth Call, from 1898 to his death, was curator of the Museum of the Brooklyn Institute of Arts and Sciences (*Who's Who in America* for 1905-7).

[60]Maurice Ricker to F. I. Herriott, (MS) letter dated at Long Island City, New York, March 22, 1935. One encounters in the contemporary letters and press the assertion that Dr. Barnard was connected with the staff of the Smithsonian Institution. It is without basis.

students are multicolored and unpredictable. One will note his eccentricities and mannerisms. Another will be impressed by his learning or "lack" of it. Another will be struck by his balance and fairness of judgment, or by his extreme views and radicalism. Others will be struck by his temperament, his humanness and affability. The following from the pen of Mr. D. W. Witmer, a busy lawyer in Kansas City, records some interesting and abiding memories:

> My vivid recollections of Professor W. S. Barnard are his quick, accurate manner and method of preparing and outlining his lectures on the blackboard. . . . . From these outlines you were expected to record and report the next day on your findings.
>
> Professor Barnard never seemed to sleep, thus he burned out a bright light at an early age.
>
> He instilled confidence into his pupils so that they could meet the banker, the corporation manager, the president, the speaker of the house . . . . with the same ease as you would meet the merchant, the tiller of the soil, or his hired laborer.
>
> This courage came in good for me once when, single-handed and alone, I faced a battery of six able lawyers. . . . . For this *courage* I give great credit to Professor Barnard, for *he* never quit.[61]

Significant evidence of Professor Barnard's widespread fair fame among scientific men in the country at large was given the public in the forepart of 1887. Then the first volume of Appleton's *Cyclopaedia of National Biography* was published, the first notable undertaking of the kind on this side of the Atlantic. It contained an effective sketch or summary of his career and scientific work.

XII

In the forepart of October, 1887, it was noticed that Professor Barnard was not in the best of health. Indeed it was obvious that he was far from well. Two accounts have been current regarding the developments that soon proved fatal.

One is that personal memoranda among his effects disclose that he was suffering from diabetes. That dread disease insidiously but steadily grew worse. His zeal for his work, or his heedlessness or indifference permitted it to become irremediable.

The other tradition is that he was afflicted with a slight "cold," sometime in November. He paid no special attention to it; said nothing about it, and attended his classes, pushing his work as

[61] D. W. Witmer to F. I. Herriott, (MS) letter dated at Kansas City, Missouri, November 11, 1935.

vigorously as usual. His condition became slowly but steadily worse. He did not apparently deem it serious or menacing, and did not or would not, summon a physician. Suddenly it was realized that he was in the grip of advanced pneumonia. Medical aid was invoked but, alas, too late.

Dr. Barnard died a few minutes past midnight on the morning of Sunday, November 13, 1887, in his home at 1139 Twenty-second Street, Des Moines, at the age of thirty-nine years.

Besides his widow there survived Dr. Barnard one son, William Nichols Barnard, who has been since 1906, professor of heat-power engineering in the College of Engineering in Cornell University. Mrs. Barnard died at her son's home in Ithaca, May 8, 1915.

The announcement of Dr. Barnard's death was a shock to colleagues and students, and the expressions of their sense of loss were instant and generous. Professor Norman Dunshee voiced the feelings of the faculty in resolutions adopted, one paragraph reading:

> . . . . we found in him a faithful and efficient teacher; one of the most eminent scientists of our nation; a faultless coworker in all that was pure and good; one who loved truth for its own sake; a patient and ardent student; a true gentleman of pure heart and upright life; one whose noble character is a legacy bequeathed not only to his family but to us.[62]

A committee of students, consisting of Messrs. F. A. Morgan, John E. Northrup and Edward S. Ames, each among the leaders of the classmen, formulated the sentiments of the undergraduates. The first mentioned probably penned the following editorial in the *Delphic*, the student publication, in the issue for November:

> Dr. Barnard came to Drake University in September, 1886. He found the department to which he had been elected poorly equipped in everything save a large number of eager students bent upon the acquisition of knowledge in biology and physical science. This the professor was able and willing to impart, and did so with such clearness and precision that he at once enlisted the zeal and interest of every student in his department. His ability was not only in giving instruction, but also in creating a desire for private investigation and original research. This is the true genius of the teacher. Not in how much he can do for the student, but in what he gets the student to do for himself. All were learning to follow his zeal, thoroughness and untiring energy. Systematic in all things and careless in none, he early taught the student the

[62] *The Delphic* for November, 1887, p. 19.

best plan of work, which gave the desire for its thorough and careful accomplishment. A man of great modesty, he was most admired and appreciated by those who knew him best.[63]

Those sentiments were not in the usual terms of funereal, eulogistic laudation, uttered *pro forma*. They expressed the feelings of a genuine admirer who spoke the common opinion of those who had enjoyed intimate acquaintance and daily contact with their instructor. A month later another entry in the *Delphic* reads: "We feel more deeply each day the loss of our 'model teacher and friend.' "[64]

The feelings of the community at large were clearly indicated in the headlines of the announcement, in *The Iowa State Register*, of Dr. Barnard's death, in its issue of Tuesday morning, November 15, 1887:

DEATH OF AN ABLE TEACHER

Career of Brilliant Young Scientist—A Man of Broad Learning and an Original Thinker

A Good Man Gone

PUBLICATIONS OF WILLIAM STEBBINS BARNARD

"Beitrage zur Myologie des Simia saturys (Oranguten) besonders über die Morphologie der Beinmusculatur." (MS) Doctorial dissertation submitted to faculty of the University of Jena on February 15, 1873, and deposited in the library of the University.

"Observations on the Membral Musculation of *Simia satyrus* (Orang) and the Comparative Myology of Man and the Apes."—*Proceedings of the American Association for the Advancement of Science* for August, 1875, pp. 112-44. (2 plates.)

"Observations on the Development of Didelphys Virginiana (the opossum)." *Ibid.*, pp. 145-47, an abstract. (4 plates.)

"Protozoan Studies," an abstract. *Ibid.*, pp. 240-42.

"Opossums and Their Young."—*Popular Science Monthly*, December, 1875, Vol. VIII, pp. 149-58.

Catalogue of the Invertibrates (excepting insects) in Ward's Natural Science Establishment, octova, p. 96, Rochester, New York, 1876. (8 plates.)

"New Rhizopods."—*American Quarterly Microscopic Journal*, January, 1879, Vol. I, No. 2, pp. 83-85. (1 plate.)

[63] *Ibid.*, p. 23. The character of the committee may be inferred from the careers of Messrs. Ames and Northrup. Dr. Ames has been head of the Department of Philosophy in the University of Chicago and Mr. Northrup has been a prominent lawyer of Chicago. See *Who's Who in America*.

[64] *Ibid.* for December, p. 50.

"Some Interesting Insect Habits."—*Proceedings of the American Association for the Advancement of Science,* Vol. XXVIII, pp. 472-78, 1879.

"The Bud-blight Insect."—*Ibid.,* pp. 478-86.

"Microorganisms and Their Effects in Nature."—*Popular Science Monthly,* October, 1879, Vol. XV, pp. 764-72.

"Zoological Education." Read before the University Convocation, Albany, New York, July 13, 1879. Printed in the *Report of the Regents of the University of the State of New York,* 1879, pp. 529-32; also *Popular Science Monthly* for September, 1880, Vol. XVII, pp. 666-69.

"Buccalatrix Cocoons."—*The American Entomologist,* March, 1880, Vol. III, New Series Vol. I, p. 76.

European Tussock Moth."—*Ibid.,* p. 77.

"Protoplasmic Dynamics."—*The American Naturalist,* April, 1880, Vol. XIV, pp. 233-42. (5 plates.)

"The Army Worm."—*New York Journal,* Ithaca, July 8, 1880.

"Memert."—*The American Entomologist,* August, 1880, Vol. III, New Series, Vol. I, p. 199.

"Parisitic Rove Beetle. *Aleochara anthomyiae.*"—*Ibid.,* pp. 199-200.

"Entomological Legislation."—*Amer. Ent., op. cit.,* September, 1880, p. 222.

"Dominican Case Bearer."—*Amer. Ent. Ibid.,* p. 227. Illus.

"*Parthenogenesis in Orgyia antiqua.*"—*Ibid.,* p. 227.

"The Cotton Worm."—*Our Continent,* March 22, 1882.

"Insecticides."—*Indiana Farmer,* December 9, 1882.

"Some Results by Massage et Contre-Coup." Abstract of communication to the Biological Society of Washington, D. C., December 28, 1883.—*Proceedings of the Biological Society of Washington, D. C.,* Vol. II, 1882-1884, pp. 116-17.

"Use of Naphthalin and of Nether-insertor." Summary of observations made before the Biological Society of Washington, D. C., in *Psyche,* January-February, 1884, p. 134.

"Test of Machinery for Destroying the Cotton Worm."—*Bulletin No. 3,* Division of Entomology, U. S. Department of Agriculture, December 8, 1883, pp. 39-48.

"Machinery and Devices for the Destruction of the Cotton Worm."—*Fourth Report of the U. S. Entomological Commission,* 1885 (February 3, 1886), pp. 191-321.

MEMORANDUM

"Hundreds of accurate and beautiful drawings and diagrams, with notes and manuscripts equivalent to several large volumes, bear witness to his scientific spirit and industry, and indicate what he might have put in shape for publication but for imperfect health and an almost too faithful devotion to his duties as a teacher."

The Memorandum just given was prepared under date of January 30, 1888, by Professor B. G. Wilder of the Department of Biology of Cornell University, Ithaca, and printed in the December issue of *Scientific News,* p. 1137.