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BENJAMIN MINGE DUGGAR

1872—1956

A Biographical Memoir by

J. C. WALKER

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WHEN BENJAMIN MINGE DUGGAR passed away on September 10, 1956, at New Haven, Connecticut, he was well along in the seventh decade of his scientific activity. Few scientists have contributed over so long a period in so many areas of biological science.

His mother, Margaret Louisa (Minge) Duggar, was the daughter of a plantation owner in eastern Virginia. His father, Reuben Henry Duggar, was a native of central Alabama where he practiced medicine, primarily in the rural areas. He served a term of duty in the Confederate Army during the Civil War.

Benjamin Minge Duggar, the fourth of six sons, was born on September 1, 1872, at Gallion, Alabama. His secondary education was gained in the local school and under private tutors. That he was a precocious youth is shown by the fact that he entered the University of Alabama within a few days of his fifteenth birthday. After two years at that institution he transferred to the Mississippi Agricultural and Mechanical College (now Mississippi State College), near Starkville, Mississippi. This transfer would lead one to surmise that he had developed an early interest in agricultural science. As an undergraduate he assisted in the introduction of forage grasses new to the region and, by the time he was graduated in 1891, a few months before his nineteenth birthday, he had settled on the major course of his life career. He received the Bachelor of Science degree and first honors in his class. He spent the next year at Alabama Polytechnic Institute at Auburn as Assistant in Mycology and Plant Pa-

thology to Professor George F. Atkinson, who was several years older and was soon to move to Cornell University to embark on an outstanding career in cryptogamic botany. It is significant that Duggar was to follow Atkinson to Cornell several years later to complete his Ph. D. thesis under his direction.

Duggar received the degree of Master of Science at Auburn in 1892. The subject of his Master's thesis was the germination of the teliospores of *Ravenelia.* It shows remarkably thorough, painstaking, and mature workmanship, unusual in a man only twenty years of age. During the next year Duggar was Assistant Director of the Agricultural Experiment Station at Uniontown, Alabama, where he was in direct contact with the agricultural problems of the region. In the autumn of 1893 he went to Harvard University to work under two other outstanding cryptogamic botanists, Professors W. G. Farlow and Roland Thaxter. Although he already held a B. S. and M. S. degree, he aspired to a Master of Arts from Harvard. This necessitated his matriculation in Harvard College for certain basic courses required of candidates for the M. A. degree. Having completed these, he was eligible for a Bachelor of Arts degree which was granted him in 1894. While at Harvard, he served as an assistant in botany at Radcliffe College. He completed his M. A. degree in 1895.

About this time the chinch bug was rampant on wheat in Illinois and contiguous areas. Dr. S. A. Forbes, an outstanding figure in entomology, was director of the Illinois State Laboratory of Natural History on the University of Illinois campus at Urbana. The question of fungus and bacterial parasites as means of control of the bug was beginning to receive attention. It was thus natural that Forbes should hire a promising young mycologist from Farlow's laboratory to work on this subject. Duggar was the man, but he spent only about one year as Assistant Botanist in Forbes's laboratory. Presumably he felt the need of completing his doctorate, since he was now twenty-three years of age. For this he went to Cornell and back to Atkinson. There he also became an associate and close friend of Liberty Hyde Bailey. Duggar, beginning in 1896, spent the next four years at Cor-

nell, serving as Assistant Cryptogamic Botanist and Instructor in Botany. He completed his Ph. D. with Atkinson in 1898. His doctor's thesis was in the field of cytology. It was on the development of the pollen grain and embryo sac in *Bignonia, Symplocarpus,* and *Peltandra.* He also spent a considerable portion of his time in the chemistry department with Professors Bancroft and Orndorff. His first research in the field of physiology was concerned with germination of fungus spores. After starting this investigation at Cornell he took the problem with him to Europe (1899–1900) and completed this study in the laboratory of Wilhelm Pfeffer, the outstanding plant physiologist at Leipzig. He also worked in the laboratory of Georg Klebs at Halle and conferred with Julius Kühn, the outstanding plant pathologist at the same institution, where they exchanged their experiences with the genus *Rhizoctonia,* which Duggar had begun to study at Cornell. Returning to Cornell in the fall of 1900, he became Assistant Professor of Plant Physiology.

In 1901 he joined the staff of the Bureau of Plant Industry, United States Department of Agriculture, as Plant Physiologist. In this capacity be began studies upon cotton diseases in the South and Southwest and upon methods of mushroom culture. These investigations were continued at the University of Missouri, where he became Professor of Botany and Head of the Department in 1902, and retained a connection with the Bureau of Plant Industry as Collaborator. The cotton root rot disease was looming up as an important factor in the cotton crop which was moving steadily westward in Texas and beyond. He discovered the sporulating stage of the pathogen, on the basis of which he transferred the species from *Ozonium* to *Phymatotrichum.* He began experimental work with mushrooms, which ultimately resulted in the introduction of pure culture methods in the mushroom growing industry in this country. In 1903 he set up an exhibit on the culture of mushrooms and other fungi at the World Exposition in St. Louis, Missouri, which was awarded a grand prize. In 1905–1906 he spent fifteen months in Europe working with Professor Goebel at the Botanical Institute

in Munich, with Professor Strasburger at the Botanical Institute in Bonn, and with Professor Flahault at the Botanical Institute in Monpelier. During his stay at the last institute, he participated in a botanical expedition in Algeria.

While at Cornell, he had given some attention to practical aspects of plant pathology and had begun an intensive study of *Rhizoctonia.* His interest in plant pathology continued at the University of Missouri, where he began and practically completed the manuscript of the first American textbook in plant pathology, *Fungous Diseases of Plants,* published in 1909. It remained the standard American text in the subject for many years.

In 1907 Duggar was called to the Chair in Plant Physiology at Cornell University. He remained there for five years, during which period he completed his well-known text, *Plant Physiology.* In 1912 he became Research Professor of Plant Physiology in charge of graduate work in the Henry Shaw School of Botany at Washington University and the Missouri Botanical Garden in St. Louis. It is evident from a perusal of his writings that beginning with his second stay at Cornell he became more and more interested in plant physiology. This was dictated no doubt to some extent by the nature of his position, but probably more so by the fact that he was one of those rare individuals who could not and would not narrow his interests and outlook. His interest in grasses had begun at Starkville and Uniontown; he had later been exposed to leading minds in mycology at Harvard and Cornell; but he had also been exposed to Pfeffer and others in Europe. At the turn of the century he saw in plant pathology and in mycology the opportunity and need of injecting physiology into both sciences. His ideas are expressed in a paper which he gave at a symposium on plant pathology at the annual meeting of the Botanical Society of America held at Minneapolis in December, 1910. In this address he pointed out that researches in plant pathology and in mycology had up to that time been concerned more with morphology than with physiology. He stressed the fact that "every disease produced by an organism presents the definite problem of

certain complex relations between the cells of the host and those of the parasite. . . . The advancement of physiological pathology is dependent upon the work of the physiologist, of the pathologist, and of the biochemist, or upon adequate consideration of the several viewpoints which these names represent."

At St. Louis his researches broadened into various aspects of plant physiology. His research papers were concerned with such widely different topics as the development of red pigment in tomato fruits, enzymes of the red alga *Fucus vesiculosus,* nitrogen fixation, the effects of surface films on transpiration, and the application of colorimetric methods to the determination of hydrogen ion concentration in biological fluids. During the First World War, he gave particular attention to the studies of the salt requirements of higher plants. From 1917 to 1919 he served as Acting Professor of Biological Chemistry in the Washington University Medical School, in order to relieve P. A. Shaffer, who had been called into special war duties.

About 1920, when there was a rapidly growing interest among plant pathologists in virus diseases of plants, he began a study of the tobacco mosaic virus which continued for more than fifteen years. In this field he was soon recognized as a leading investigator. His researches were directed primarily toward the nature of the infective entity. He was one of the first to bring forth evidence as to the approximate size of the infective particle of the virus. He also demonstrated for the first time that the juices of certain plants, such as *Phytolacca,* inhibited the infectivity of the virus.

In 1927 Duggar was called to the University of Wisconsin as Professor of Plant Physiology and Economic Botany. In 1929 his duties were broadened to include a part-time professorship in Plant Pathology. While he gave no formal courses in plant pathology, he served as major or minor professor to many graduate students in this discipline. His broad knowledge of botany, his encyclopedic memory, his original and brilliant mind, combined with a gentlemanly, sympathetic, and helpful attitude, made for him an unrivaled position as

an adviser to students and staff members in various branches of plant science.

In the late twenties there was a growing interest nationally in the biological effects of radiation. A Committee on Effects of Radiation on Organisms was formed in the Division of Biology and Agriculture of the National Research Council to bring together known information and to aid in allocation of certain research funds. Duggar served as a member of this committee. He initiated an extensive program in his own laboratory on the effects of irradiation on plant viruses and microorganisms. He also assumed the task of editing a two-volume work, *Biological Effects of Radiation,* published in 1936 under the sponsorship of the Committee. About the same time he launched with Farrington Daniels, Professor of Chemistry, a research project on quantum relations in photosynthesis in the alga *Chlorella.* He and his co-workers concluded from their experiments that the maximum efficiency with which the alga photosynthesizes in optimum environment corresponds to about 8 photons of light per molecule of oxygen evolved. This was equivalent to stored energy of about 30 per cent of the absorbed light. While this value was considerably less than that previously reported by Warburg in Germany, it has since been confirmed repeatedly in Duggar's laboratory and by most workers in this field in this country.

In his seventy-first year (1943) Duggar became Emeritus Professor at the University of Wisconsin. Still very active physically and mentally, he was not one to be easily shelved by mandatory retirement rules, especially in the midst of a devastating world war. In 1944 he accepted an appointment with the Lederle Laboratories Division of the American Cyanamid Company at Pearl River, New York, as Consultant in Mycological Research and Production. In the beginning his work here was concerned with plant sources of antimalarial drugs. The new wonder drug, penicillin, was coming into use rapidly, and streptomycin had only recently been released. Duggar was quick to see that the surface had only been scratched in the field of antibiotics. He shortly began a project which entailed a

systematic search for other antibiotic-producing fungi. Thousands of soil samples were assembled and assays were conducted methodically. This project had no novice at the helm. Fifty years of experience with fungi and their physiology were focused toward a clearly defined goal. Many antibiotic-producing organisms were collected, assayed, and catalogued. But more than finding and assaying is necessary. Many biochemical and physiological tests are essential before a wonder drug is known to be effective, safe, and industrially economical. Under Duggar's leadership dozens of workers were kept busy in various laboratories and pilot plants until, within a period of about three years, *Streptomyces aureofaciens* was defined, its metabolic product, aureomycin, was isolated, and the new antibiotic with its wide applicability to human pathogens was on the production lines.

During his long career, Duggar occupied many important extracurricular positions. He was one of the organizers of the American Society of Agronomy in 1907 and served as one of the two first vice-presidents. In 1908 he served on a committee which organized the American Phytopathological Society, and served as councilor during its first year. He was vice-president of the Botanical Section of the American Association for the Advancement of Science in 1925, and of the American Society of Naturalists in 1928. He was president of the Botanical Society of America in 1923 and of the American Society of Plant Physiologists in 1947. He was granted the Charles Reid Barnes Life Membership Award by the latter society in 1941. He was president of the Society for Industrial Microbiology in 1952. When the International Congress of Plant Sciences was held at Ithaca, New York, in 1926, Duggar served as chairman of the organizing committee and as editor of the two-volume *Proceedings*. He served as editor for plant physiology of *Botanical Abstracts* during the entire period of its existence (1917–1926) and continued in the same capacity for *Biological Abstracts* from the time of its inception (1926) until 1933. He was elected to the American Philosophical Society in 1921, and to the National Academy of Sciences in 1927.

Other scientific societies of which he was a member included the Mycological Society of America; American Chemical Society; Society for Experimental Biology and Medicine; Wisconsin Academy of Sciences, Arts and Letters; New York Academy of Sciences; Torrey Botanical Club; Academy of Natural Sciences of Philadelphia; American Public Health Association; Society of American Bacteriologists; and Société Botanique de France. He was Chairman of the Division of Biology and Agriculture, National Research Council (1925–26). He was a Trustee of the Marine Biological Laboratory at Woods Hole, Massachusetts; of the Oceanographic Institute at Woods Hole; of the Bermuda Biological Station; and of the International Basic Economy Corporation Research Institute. He was a member of Sigma Xi, Phi Beta Kappa, and Phi Sigma.

Three institutions at which he had served conferred honorary degrees upon him (University of Missouri, L.L.D., 1944; Washington University, Sc. D., 1953; University of Wisconsin, D. Sc., 1956). He was given special recognition at the annual banquet of the American Phytopathological Society in 1950. As the discoverer of aureomycin his fame extended far beyond the field of plant science. He accepted speaking engagements before medical science groups in many parts of the world. He received the Medal of Honor of Public Education of Venezuela (1951); Pasteur Institute Medal (1951); Distinguished Service Medal of the Brooklyn Botanical Garden (1953); a plaque for "inquiry and improved pharmaceutical service" from the Brooklyn College of Pharmacy and Alumni Association (1954); and a Certificate of Merit from the Botanical Society of America (1956). He was elected a Fellow of the International College of Surgeons (1952). Honorary membership was conferred upon him by La Societa Italiana de Ematologia. He was made a corresponding member of La Societa Lancisiana di Roma. He was received in private audience by Pope Pius XII and given a special medal. On one of his two visits to Japan, he was invited to a private audience by the Emperor. This formal affair soon changed to a friendly informal discussion an hour or more in duration between

two biologists. The next day Duggar was surprised to receive a call from the imperial messenger, who presented him with a copy of one of the Emperor's treatises on the algae.

To those who were so fortunate as to be associated with Duggar personally, he was known as a modest, friendly gentleman, slight in stature, keen in intellect, and broad in scientific and nonscientific interests. He was alert, critical, and keenly discriminating in everything he did, whether performing an experiment in his laboratory, preparing a complete southern dinner in his kitchen, or enticing a walleye or muskie to the lure on his fishing line. He had many interests. He was an expert and persistent gardener; he played tennis and golf; he loved to cook; and among his acquaintances he was recognized as an enthusiastic and expert fisherman on fresh and on salt water. He was an ardent bowler and a devoted follower of the St. Louis Cardinals when he lived in St. Louis and Madison, and of the New York Giants when he lived in New York. All of these pastimes he integrated with a busy laboratory program right up to the day of his final illness. Few persons are privileged to impress so many people in all walks of life with their sterling character and their kindly interest in humans and human affairs. Few men have left their indelible print on so many phases of biology over a period of nearly seventy years.

Dr. Duggar was united in marriage on October 16, 1901 with Marie L. Robertson of East Aurora, New York, who died in 1922. To them were born two sons and three daughters: Benjamin M. Duggar, Jr., George S. Duggar, Mrs. Charles Plunkett, Mrs. John F. Adams, and Mrs. David Saunders. On June 6, 1927, he married Elsie Rist of St. Louis, Missouri, who survived him. To them was born one daughter, Gene Lorraine Duggar. All of his children and thirteen grandchildren survived him.

KEY TO ABBREVIATIONS

Ala. Canebrake Exp. Sta. Bull.=Alabama Canebrake Experiment Station Bulletin
Am. J. Botany=American Journal of Botany
Ann. Mo. Bot. Garden=Annals of the Missouri Botanical Garden
Ann. N. Y. Acad. Sci.=Annals of the New York Academy of Sciences
Ann. Rev. Biochem.=Annual Review of Biochemistry
Biol. Bull.=Biological Bulletin
Botan. Gaz.=Botanical Gazette
Bull. Ill. State Lab. Nat. Hist.=Bulletin of the Illinois State Laboratory of Natural History
Bull. Torrey Botan. Club=Bulletin of the Torrey Botanical Club
Carnegie Inst. Wash. Yearbook=Yearbook of the Carnegie Institution of Washington
Cornell Univ. Agr. Exp. Sta. Bull.=Cornell University Agricultural Experiment Station Bulletin
J. Agr. Res.=Journal of Agricultural Research
J. Am. Chem. Soc.=Journal of the American Chemical Society
J. Bacteriol.=Journal of Bacteriology
J. Cancer Research=Journal of Cancer Research
J. Cellular and Comp. Physiol.=Journal of Cellular and Comparative Physiology
J. Phys. Chem.=Journal of Physical Chemistry
N. Y. State Agr. Exp. Sta. Tech. Bull.=New York State Agricultural Experiment Station Technical Bulletin
Proc. Amer. Acad. Arts Sci.=Proceedings of the American Academy of Arts and Sciences
Proc. Amer. Phil. Soc.=Proceedings of the American Philosophical Society
Proc. Amer. Soc. Hort. Sci.=Proceedings of the American Society of Horticultural Science
Proc. Intern. Cong. Plant Sci.=Proceedings of the International Congress of Plant Sciences
Proc. Nat. Acad. Sci.=Proceedings of the National Academy of Sciences of the United States of America
Proc. Soc. Amer. Florists=Proceedings of the Society of American Florists
Proc. Soc. Exp. Biol. Med.=Proceedings of the Society for Experimental Biology and Medicine
Proc. Soc. Hort. Sci.=Proceedings of the Society of Horticultural Science
Proc. Soc. Promotion Agr. Sci.=Proceedings of the Annual Meeting of the Society for the Promotion of Agricultural Science
Trans. Acad. Sci. St. Louis=Transactions of the Academy of Science of St. Louis

Trans. Mass. Hort. Soc.=Transactions of the Massachusetts Horticultural Society

U. S. Dept. Agr. Bur. Plant Indus. Bull.=United States Department of Agriculture Bureau of Plant Industry Bulletin

U. S. Dept. Agr. Farmers' Bull.=United States Department of Agricultural Farmers' Bulletin

Wash. Univ. Studies=Washington University Studies

Zentr. Bakteriol., Parasitenk.=Zentralblatt für Bakteriologie, Parasitenkunde, Infektionskrankheiten und Hygiene

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