

PIONEER LEADERS IN PLANT PATHOLOGY: BENJAMIN MINGE DUGGAR

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If one were to drive into the village of Gallion in Northwestern Alabama, he would be attracted by a roadside sign which reads: "Benjamin Minge Duggar was born here." This birth was on September 1, 1872. Ben's father was a country doctor who served with the Confederate Army during the Civil War. Ben attended the University of Alabama from 1887 to 1889 and the Mississippi A & M College at nearby Starkville, Mississippi, where he graduated with first honors in 1891, a few months before his nineteenth birthday. During the next year this precocious youth worked under Professor G. F. Atkinson at Auburn Polytechnic Institute, where he received the M.S. degree in 1892, shortly before his twentieth birthday. During the next year he was Assistant Director of the Agricultural Experiment Station at Uniontown, Alabama. He entered Harvard University in the autumn of 1893, where he worked under two of the most prominent mycologists of the time, W. G. Farlow and Roland Thaxter. He received the A.M. degree in 1895.

After a year at the University of Illinois (1895-1896) he became Assistant Professor of Plant Physiology at Cornell University, working under G. F. Atkinson, who had recently moved from Auburn to Cornell. He completed his Ph.D degree in 1898. After a year of study in Europe and a year as plant physiologist with the United States Department of Agriculture he became Professor of Botany at the University of Missouri in 1902. The cotton root rot disease was becoming a major factor in the production of that crop in



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the Southwest. He discovered the conidial stage of the pathogen and on this basis transferred the species from *Ozonium* to *Phymatotrichum*. Mushroom growing was a new industry in this area. His experimental work resulted in the introduction of the pure-culture method. In 1903 he set up an exhibit on the culture of mushrooms at the World Exposition in St. Louis, Missouri, for which he 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 Strassburger at the Botanical Institute in Bonn, and with Professor Flahault at the Botanical Institute in Montpe-

lier. While at Missouri he began writing the first textbook in plant pathology published in this country. It came off the press in 1909 under the title, *Fungous Diseases of Plants*.

During his stay in Missouri his interests, as shown by his publications, began to shift toward plant physiology. In a paper at a symposium of the Botanical Society of America he pointed out that research in plant pathology and 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 the biochemist, or upon adequate consideration of the several viewpoints which these names represent" (*Phytopathology* 1:71-78).

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 textbook, *Plant Physiology*. In 1908 he was elected to the Council of the newly formed American Phytopathological Society. In 1912 he became Research Professor of Plant Physiology in charge of the graduate work in the Henry Shaw School of Botany at Washington University and the Missouri Botanical Garden in St. Louis. Here his research broadened into various aspects of plant physiology. It was concerned with 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. From 1917 to 1919 he served as Acting Professor of Biological Chemistry at the Washington University Medical School to relieve Professor P. A. Shaffer, who had been called into special war duties. I was a graduate student at Cornell in 1916, four years after Ben left for St. Louis. I remember Professor H. M. Fitzpatrick telling of the profound memory Professor Duggar had. He mentioned how at seminars Professor Duggar would often rise to make a comment involving a phase of botany far removed from his specialty. This quality impressed us at Wisconsin as well.

While at Washington University he began a study of the tobacco mosaic virus, which he continued at the University of Wisconsin to which he was called as Professor of Botany in 1927. In this field he was soon recognized as a leading investigator. His researches were directed primarily toward the nature of the infective entity. In 1926, nine years before Stanley's paper showing the tobacco mosaic factor to be a protein, Duggar estimated that the virus particle was in the size range of hemoglobin and was approximately 30 μm in diameter.

At Wisconsin, Ben served as major or minor professor to many graduate students in plant pathology and plant physiology. His research, aside from that with viruses, included collaboration with A. J. Riker and associates in studies of the fundamental nature of atypical growth in crown gall. He and his associates carried out research on photosynthesis with Farrington Daniels, Professor of Physical Chemistry. They found that the value of the best efficiency is considerably less than that reported by Warburg in Germany. This has been confirmed by most of the workers in this field in this country.

In his seventy-first year he became Emeritus Professor, but he was not one to be shelved by retirement, especially in the midst of a devastating world war. At the Lederle Laboratories, a division of the American Cyanamide Company at Pearl River, near New York City, search was underway for a cure or corrective for malaria. It was known that the Chinese used an extract from the roots of a species of *Rhododendron*. Which species it was wasn't known, and if known its source was a problem. A young Ph.D. of Duggar's, who was working in Lederle's research laboratory at the time, suggested to the management that since Ben was now retired and since he had a wide knowledge of botany, he might be secured as a consultant. The end result was that in 1944 he accepted an offer from Lederle. I visited him about a year later. His apartment was full of books which might throw some light on the subject. He had not only found the name of the rare species, but also had learned that a specimen was imported some years earlier by the New York Botanical Gardens. From the Director (who was a former student of his) down to the head gardener he could get no knowledge as to whether it still existed. Not to be discouraged, he went through the records until he found when it came in and where it was planted. The gardener and his superiors had lost all track of it but Ben searched until he found and identified the bush. Next he told his president that he would need a greenhouse in which he could propagate cuttings in sufficient quantity that chemists could begin search analyses. After some thought, his president, who lived some ten miles or more from the plant, said he had a wealthy neighbor who had several greenhouses as a hobby and from whom he thought he could rent one for Ben's use. This materialized, and I remember his writing me that one of his immediate problems was to have attention given to the plants on weekends when his help was off duty. Later he wrote me that he was having a new experience, which consisted of having a millionaire as a greenhouse helper. It seems that he suggested to his president that his neighbor (the owner of the greenhouse) might know of someone nearby who could tend to the watering and ventilating on weekends. Well the neighbor said, when approached, "I can just as well do that for you." And then after a little thought he said: "But you will have to pay me for it." So the deal was made.

A few months later I visited Duggar again. At noon we went to the company coffee shop for lunch. He seated me at a table occupied by only one person, to whom he introduced me. This was at the time when streptomycin had come on the market. It had been developed and patented by Waksman at Rutgers University and pharmaceutical manufacturers were taking out licenses to produce it. I had just come from a meeting in Washington, D.C., in which Waksman had given a paper. Duggar had inquired of me in the morning as to whether Waksman had announced anything new, to which I had replied that I recalled nothing that he hadn't already published. After lunch, as we were walking back to his laboratory, he told me that the man we had lunched with was president of Lederle. He had mentioned to him during lunch that I had noted nothing "new" in Waksman's Washington paper. Ben went on to tell me that the president had been pressing for his opinion on whether or not they should take out a license to produce streptomycin. Ben's answer was that there were undoubtedly "better fish in the sea than had been caught." The president asked for him to explain, which he did out of his vast experience with soil fungi. He explained that the soil contained many (maybe thousands) of species which had not been described, to say nothing of being tested, for their production of antibiotics. The president said:

"Could you undertake this?"

"Yes."

"How many assistants do you need?"

"None, other than the two women I already have."

"How soon can you start?"

"Tomorrow."

Ben went on to tell me that he was collecting soils from every place he stopped in his travels and had already trained his assistants to screen them especially for *Streptomyces*. It was a few months later that he wrote me that they were having good results, so much so that his assistants and others were "stealing" portions of the crude extracts to cure their colds. It was not long until a fungus was found which emitted a strong antibiotic. It produced a yellow pigment in agar culture. A little later this antibiotic was on the market as "aureomycin" and the fungus was named *Streptomyces aureus* n. sp. I later learned on good authority that Lederle sold twenty million dollars worth the first year.

The company saw to it that Duggar was exhibited around the world. He told of one occasion when they were in Rome (he was always accompanied by one or more company executives). After business matters were attended to, they were taken to call upon the Pope. There was the usual long line of people going by to shake hands with the dignitary. Ben said he noticed that he was not hurried along and actually was the last one to pay his

respects. It was then obvious that this had been prearranged, for the Pope entered into a lengthy conversation and finally presented him with a special medal.

Lederle took out licenses for aureomycin in various countries including Japan. Here they joined up with a well-established Japanese pharmaceutical company. It was not long before another Japanese company, ignoring the patent, came on the market with aureomycin, probably under another name. This required legal action and Duggar was taken to Tokyo as an expert witness. When the trial was completed, in their favor, his colleagues told him that they had arranged for an audience with the Mikado. Since it was customary to leave a token in the outer chambers as one went in, they had secured by air mail a copy for this purpose of a two-volume work, which had been edited by Duggar in 1936. The visit soon changed into a friendly informal discussion an hour or more in duration, since Ben found the Mikado to be a well-informed biologist. After the visit they returned to the hotel to find that there was little time left to pack for the flight home, early the next morning. However, the imperial limousine drove up promptly and the imperial messenger asked for Duggar. This was followed by a presentation from the Mikado of a volume which was one of his treatises on the algae of Japanese waters.

I became most acquainted with Ben during our annual fishing trips in northern Wisconsin, which began in the 1930s and lasted up to his retirement in 1943. He enjoyed these immensely as he did other outdoor activities. He was a member of the University of Wisconsin Faculty Bowling League and at Pearl River he organized a bowling league of women employees. Our last fishing trip together was in 1956, after he had received the honorary D.Sc. degree at the University of Wisconsin, Madison. Soon after that, on his return to Pearl River, he was asked by his company to guide a fishing tour in the Atlantic after a convention of employees from throughout the country. This occurred not long before his final illness. He wrote me about it on his death bed. He said: "These men were rather lazy the first day we were out but on the second day, Charles, I wish you could have been there. It was the greatest haul I have ever experienced." Thus came to a close the long, useful life of one of our greatest botanists and plant pathologists.

During his long career, Duggar occupied many extracurricular positions. His part in the organization of the American Phytopathological Society has already been mentioned. In 1907 at the Chicago meeting of AAAS, he participated in the organization of the American Society of Agronomy and became one of its two first vice presidents. He belonged to numerous other scientific societies including the National Academy of Sciences and the American Philosophical Society. He served as president of the Botanical

Society of America in 1923 and of the American Society of Plant Physiologists in 1947. He was a vice president of Section G, AAAS, in 1925, and of the American Society of Naturalists in 1928. He was Chairman of the Division of Biology and Agriculture, National Research Council in 1925–1926. He was trustee of the Marine Biological Laboratory at Woods Hole, of the Oceanographic Institute at Woods Hole, and of the Bermuda Biological Station. He was editor of plant physiology for *Botanical Abstracts* during its entire period of publication (1917–1926), and he continued in the same capacity for *Biological Abstracts* from the time of its inception (1926) until 1933. He was editor of the *Proceedings of the International Congress of Plant Science* (2 volumes) when that Congress met at Cornell University in 1926 and of a 2-volume work on *Biological Effects of Radiation* issued in 1936. A list of over 100 of his publications is available in the *National Academy of Sciences Biographical Memoirs* (32:113–31, 1958).

In addition to the D.Sc. degree conferred by the University of Wisconsin in 1956, he received the L.L.D. degree from University of Missouri in 1944 and the Sc.D. from Washington University (St. Louis) in 1953. He was elected a fellow of the International College of Surgeons in 1952 and received the Medal of Honor of Public Education in Venezuela in 1951. Special tributes were extended to him at the annual banquet of the American Phytopathological Society at Memphis in December, 1950.

Dr. Duggar was married to Marie L. Robertson of Ithaca, New York, in 1901; she died in 1922. In 1927 he married Elsie Rist of St. Louis, Missouri. He had two sons and four daughters.