

## PIONEER LEADERS IN PLANT PATHOLOGY: J. H. CRAIGIE

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John Hubert Craigie was a major force in the development of plant pathology in North America. We owe our present understanding of sexual and genetic processes in the cereal rusts largely to him. Until Craigie discovered the function of rust pycnia it was a mycological enigma and sexual processes in the rusts were not understood. His discoveries revealed one of the main mechanisms of genetic change in the rusts and opened the door to understanding the genetics of host: parasite relations. To understand the significance of his contributions one must understand the importance of wheat as well as the destructiveness and complexity of the rust fungi.

The story of Craigie's career begins in Nova Scotia, where he spent the first twenty-seven years of his life, and continues with his education at Harvard, Minnesota, and Manitoba, his research achievements at Winnipeg, his administrative accomplishments at Ottawa, and finally his return to research after retirement from his demanding administrative position. During the early years of Craigie's life wheat farming developed in the Great Plains of North America and wheat became the most important crop in the Mississippi Valley of the United States and in Manitoba and Sas-



*Figure 1* J. H. Craigie.

katchewan in Canada. The main hazards to wheat production were leaf rust and stem rust which periodically caused devastating losses. Craigie's discoveries had a direct bearing on efforts to control the rusts by resistant varieties and brought him prompt and widespread acclaim.

Dr. Craigie was born at Merigomish, Pictou County, Nova Scotia, on December 8, 1887. He attended school at French River, New Glasgow, and Pictou. After Normal School at Truro he taught for four years in Nova Scotia. Shortly after the beginning of World War I he enlisted in the Canadian Cyclist Battalion, but when he learned that the battalion was to be equipped with muscle powered bicycles rather than motorcycles, he transferred to the Canadian Mounted Rifles, mainly to avoid infantry service. However, in due course his unit arrived in France, not as mounted

troops, but as foot soldiers without even ordinary bicycles. In 1918, after more than two years on the western front, he received a commission in the British army, and later that year was assigned to service in India. His return to Canada after the armistice in November 1918 was delayed by an uprising in Afghanistan and he did not get back to Canada until early in 1920.

In the fall of 1920 Craigie, who was then nearly 33 years of age, entered Harvard College at Cambridge, Massachusetts, and in 1924 he graduated with an AB degree. While at Harvard, he assisted Professor W. H. Weston, Jr., in studies on *Sclerospora* and during this time he began to consider a career in plant pathology. After graduation he continued his studies in plant pathology at the University of Minnesota under Dr. E. C. Stakman, and was awarded the MS degree in 1925. Some of the ideas for his later investigations probably developed during his work at Minnesota. In later years he remarked to friends that while on barberry surveys he observed that closely associated rust infections on barberry usually had aecia, but scattered infections frequently did not. Such early observations undoubtedly increased his interest in the nature of pycnia and contributed in an important way to the manner in which he planned his investigations. Whether or not they indicated to him that there was a transfer of a fertilizing agent between self-sterile pycnia is unknown, but the comment itself suggests that he considered the development of aecia on closely associated pycnia as significant. He was awarded a PhD (botany) by the University of Manitoba in 1930 while Dr. A. H. R. Buller was professor of botany.

Serious rust losses had occurred in Canada and the potential seriousness of the wheat rust problem to the Prairie Provinces was recognized by the political and agricultural authorities. They also realized that developments in plant breeding and the discovery of physiologic races indicated that there was a good chance that resistant varieties could be developed. In September 1924, a meeting was held in Winnipeg, Manitoba, at which it was decided that the Canadian Department of Agriculture would establish the Dominion Rust Research Laboratory at Winnipeg. A group of young scientists trained in plant pathology and plant breeding was to be assembled to study the rust problem. Dr. D. L. Bailey, who had been appointed earlier to study cereal diseases at Winnipeg, was chosen to head the plant pathology section of the laboratory, and Dr. C. H. Goulden was appointed to head the plant breeding section. In the spring of 1925 Craigie was appointed to the staff, and he joined other staff members in temporary accommodation in the Botany building of Manitoba Agricultural College. Construction of the new laboratory on the college campus began in September of 1925 and was completed in the spring of 1926.

The life cycle of the rusts were known at that time in a general way, but had never been studied in detail. It was the lack of detailed knowledge,

especially concerning the function of the pycnium, that prompted a proposal from the Winnipeg group headed by Dr. D. L. Bailey that Craigie proceed from studies on infection of barberry initiated at the University of Minnesota to studies on the life cycle of the stem rust fungus. His methodical and inspiring research on this subject produced results that established his reputation as one of the world's leading plant pathologists.

Craigie discovered that haploid infections on barberry were hermaphroditic and self-sterile and that there were two mating types, which he designated plus and minus. Haploid pycnial infections do not develop further until pycniospores of opposite mating type are transferred to them. The pycniospores fuse with flexuous hyphae that protrude through the ostioles of the pycnia. These observations demonstrated that the pycnium and pycniospores are functional organs of the rust. Later, he showed that the pycniospore nucleus migrates via the flexuous hyphae to the protoaecidium dividing as it goes, dikaryotizing the infection, and stimulating the development of aecia and dikaryotic aeciospores. These results demonstrated that segregation of characters occurred when the diploid teliospore nucleus divided and recombination of characters occurred in the pycnium. Craigie's discoveries made genetic studies possible mainly by Newton and Johnson at the same laboratory. Newton and Johnson demonstrated that inheritance in the rust followed Mendelian laws and that aeciospores were recombinants that gave rise to new races with different pathogenicity than the parents.

The practical significance of these results was immediately evident to Craigie and the plant pathologists of that time. The rust had an effective method of producing new races that might attack resistant varieties. This threat was the main consideration in all subsequent work on physiologic specialization and resistance breeding.

Craigie's world-wide scientific reputation was established mainly by his elucidation of the nature of the rust haplophase, its dikaryotization, and its significance; however, he was a man of broad interests. He placed great emphasis on the need for practical control of plant diseases, and he contributed to disease control by addressing farm meetings and writing farm bulletins. He wrote a classical account of the epidemiology of the rusts in western Canada. Craigie's personal qualities were recognized early in his career and he was appointed officer-in-charge of the Rust Research Laboratory in 1928, when D. L. Bailey resigned to join the staff of the Department of Botany, University of Toronto.

Craigie was a very persistent and resourceful worker. During his endeavors to prove the sexual function of basidiospores he devised a micromanipulator to enable him to pick up the four spores of a single basidium one by one and place them on a barberry leaf to cause infection. He was

unsuccessful, not because the apparatus did not function, but because of difficulty in inducing basidiospores to infect. Finally, realizing that this was a fruitless approach, he devised a method of briefly suspending germinating teliospores over barberry leaves on which a few scattered, presumably monosporous, infections would develop. His persistence was complemented by his ability to become completely absorbed in his work. One of his colleagues (T. Johnson) recalls that while rooming with Craigie, he had difficulty getting to sleep at night because of Craigie's long-continued speculations on just how sexuality functioned in the rust organism.

Craigie's leadership qualities and understanding of people gained for him the respect and affection of all those who associated with him. Kindly, quiet, humorous, and scrupulously fair-minded, he was the type of man who creates friends and no enemies. His sincerity and geniality won him friends wherever he went. He was also a man with a scholarly inclination, a good critical sense, and excellent research abilities. Although he objected to many of the changes in life style going on in the world, he was not dedicated to the old way of doing things. In a conversation with a colleague he remarked, "The only good thing about the good old days is that they are gone forever." He set high standards for whatever work he undertook. While working in his office in later years a student entered and observed, "I see you are writing a paper," to which Craigie responded, "I don't write papers—I rewrite them."

Craigie's attitude toward scientists and scientific work seems characteristic of his approach to life. One associate commented that in his view Dr. Craigie believed that scientists worked best in a goal-oriented environment and that scientists owe it to themselves and their country to exercise a great deal of self-discipline to get the job done. He seemed to believe that all workers had something to contribute but that more could be expected of some scientists than others. He was never heard to downgrade scientists or support staff, and he regarded personal bias in the assessment of individuals as unjust and regrettable.

His abilities and accomplishments gained him many distinctions and honors. He was in charge of the plant pathology section of the Dominion Rust Research Laboratory at Winnipeg from 1928 to 1945. He was then transferred to Ottawa, with much reluctance on his part, where, as Dominion Botanist, he directed plant pathological research in Canada until 1952. He was elected a Fellow of the Royal Society of Canada, the Royal Society of London, England, the Agricultural Institute of Canada, and the Canadian Microbiological Society. He was awarded the Eriksson prize (1930), the gold medal of the Professional Institute (Canada) (1937), the Flavelle medal of the Royal Society of Canada (1942), and the E. C. Stakman award of the University of Minnesota (1964). He served as president of the Cana-

dian Phytopathological Society (1934–35), and president of the American Phytopathological Society (1946–47) and was awarded honorary degrees by the University of British Columbia (1946), University of Saskatchewan (1948), Dalhousie University (1951), and the University of Manitoba (1959).

Dr. Craigie served as Canada's chief plant pathologist with the same dedication and self-discipline that had characterized his scientific endeavors. Despite his heavy load of administrative duties he felt it his duty to read critically all papers written by his staff before they were submitted for publication. He directed the development of plant pathology in Canada during a critical period (1945–1952). During World War II there were severe budgetary restrictions and recruitment of new staff was impossible. In the years immediately after the war many scientists and support staff reached retirement age and had to be replaced. In addition, the tremendous technical and scientific advances arising from the war effort impressed the nation and the world with the benefits possible from research. There was a sharp increase in support for scientific endeavors, and many new scientists were required to fill the positions resulting both from retirements and the expansion of research into new areas. The wisdom of Dr. Craigie in directing these new developments and in selecting staff contributed to the success of plant pathological research in Canada for many years.

After retirement as Dominion Botanist in 1952 Craigie returned to research to attempt to describe more fully the nuclear events in the aecium. He published the results of his cytological work in two papers dealing with nuclear behavior in pycnia and aecia and in one paper on trinucleate uredial cells in oat stem rust. In recent years his health has deteriorated but at the time of writing (May 1978), despite a physical handicap, he continues to read and to study and maintains a keen interest in a variety of subjects. He continues in the spirit of a remark made to a colleague who visited him recently while he was intensively studying recent scientific developments, "I am trying to determine how we got the way we are."

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