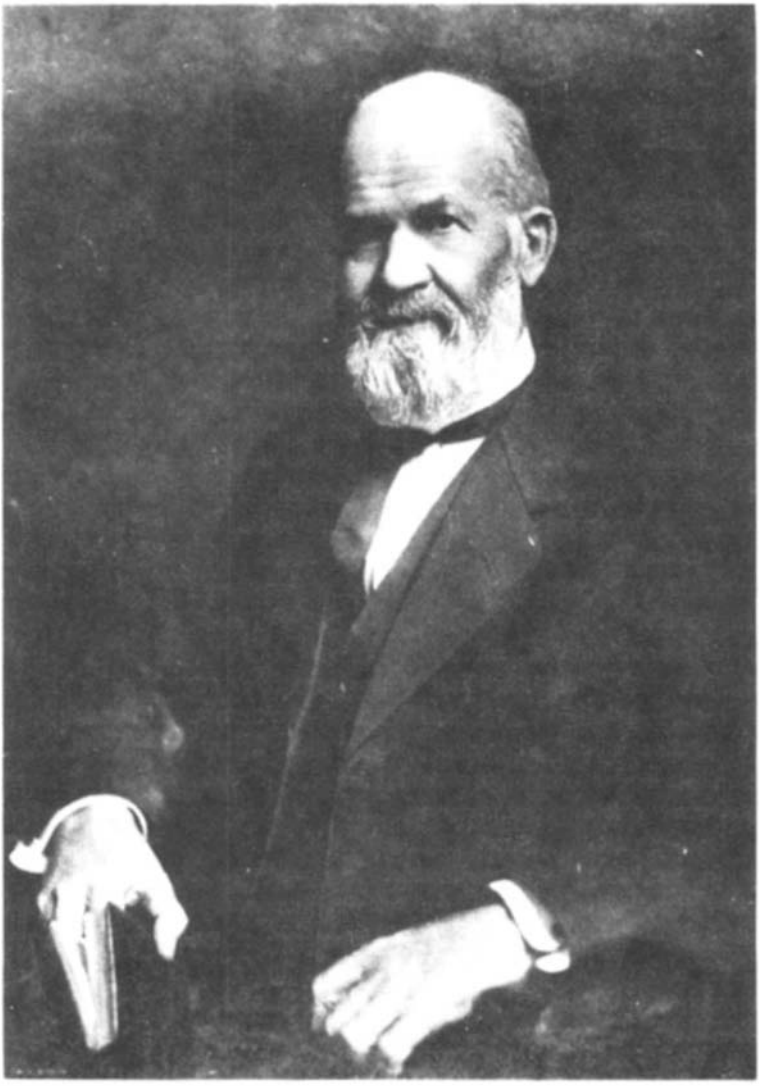

THOMAS J. BURRILL

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THOMAS J. BURRILL, PIONEER IN PLANT PATHOLOGY

Dean A. Glawe

Department of Plant Pathology, University of Illinois at Urbana-Champaign, Urbana, Illinois 61801

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INTRODUCTION

Perhaps no other American plant pathologist is so deserving of the title "Pioneer of Plant Pathology" as Thomas J. Burrill. A product of the American frontier and a researcher and teacher of plant pathology before the science even had a name, Burrill was a pioneer in every sense of the word. His original research on the cause of fire blight resulted in the first major conceptual advance in plant pathology made by an American. He also played an important role as an administrator and teacher at the University of Illinois. Many of the problems Burrill faced during his long and distinguished career will sound familiar to academic scientists of our own time. In particular, he and his contemporaries contended with student unrest, flagging public interest in higher education, heavy teaching loads, and insufficient support for research activities. By any measure, Burrill was unusually successful in coping with these problems and he fashioned a career remarkable in its contributions to his university, the public, and the scientific community.

EARLY LIFE AND EDUCATION

Thomas Jonathan Burrill was born in 1839 in Pittsfield, Massachusetts, to John and Mary Frances Burrill. His English father and Scotch-Irish mother came to this country early in their lives and married in Rhode Island. When

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Thomas was nine, they moved their family to Stephenson County in northern Illinois. The events leading to this dramatic change in the family's life are recorded in the manuscript "Boyhood biography a personal sketch" by Burrill that is housed in the Archives of the University of Illinois. In it, Burrill notes that "Although he [Burrill's father] knew nothing whatever of farming, he turned with longing to the establishment of a new home in the rapidly developing West." In 1848 he moved his family of seven children, including six boys, to a farmstead between Rockford and Freeport, Illinois. The family traveled by rail to Albany, New York, from there by the Erie Canal to Buffalo, then by steamer through the Great Lakes to Chicago, and by horse-drawn wagon over the last 120 miles.

The family immediately occupied itself with farming. This work involved clearing the land that was forested with oak, hickory, aspen, and willows, a landscape that Burrill likens to "an immense park." Crops included potatoes and wheat, but the remoteness of the area made it difficult to reach markets. Fortunately for the family, Burrill's father had been a skilled weaver before he took up farming. Using locally produced wool, the Burrill family worked together on "stormy days and the long winter evenings" to produce a cloth that was in some demand in their area, thus supplementing their other income.

At first there was no public education in the area, but the family sent several of the children to a private school run by a neighboring farmer in his log house. Burrill's description of the teacher suggests that his qualifications were limited, but "At least he could make a good quill pen, then an essential qualification for a teacher, and could write a good hand well ornamented with flourishes." Later, the area organized a district school. Farm work kept most boys away from school for all but the winter months.

When he was nineteen, Burrill's parents sent him to the Freeport high school as a boarding student. Burrill found himself an uncomfortable outsider, ill at ease with his new classmates. He notes that "Homesickness overtook me and after three weeks of the struggle, I started one afternoon afoot and alone for a tramp of 13 miles, back to my own people." After working for a year as a manual laborer, Burrill made another attempt at further education, enrolling in high school at Rockford. He went on to complete his high school education there, and he closes his essay with the statement "the country boy did not again lose out."

In 1862, at the age of 23, Burrill began study at the Illinois Normal University at Normal, Illinois (21). He studied natural history, associating with the botanists J. A. Sewall and G. W. Vasey, and the entomologist B. D. Walsh. He also came into contact with Jonathan Baldwin Turner, famous for leading the movement for public higher education that culminated in the land grant universities. Burrill graduated from the University in 1865. His bachelor's degree marked the end of his formal education. His advanced degrees were honorary, and included an M.A. from Northwestern University in 1876,

a Ph.D. from the University of Chicago in 1881, an LL.D. from Northwestern University in 1893, and an LL.D. from the University of Illinois in 1912 (3).

Shortly after graduation he became a principal in the public schools at Urbana, Illinois. During the summer of 1867 he accompanied Major John Powell's first expedition to Colorado as a botanist. Those plant collections that survived the journey (most perished along with a burro that drowned in a mountain stream) later became the basis of the botanical herbarium of the University of Illinois (22).

SERVICE TO THE UNIVERSITY OF ILLINOIS

The Urbana schools were perennially short of money. In the spring of 1868 they closed entirely due to a lack of funds. Fortunately, the Illinois Industrial University (later to be called the University of Illinois) had just begun classes in Urbana and was in need of an algebra teacher. Burrill accepted the position, and his appointment began on April 20, 1868. He was made professor of botany and horticulture in 1870. Barrett (3) quotes a friend of Burrill's in describing his activities: "He taught most of the days, was horticulturist to the experiment station, planted with his own hands or saw to the planting of most of the trees on the campus, after he had laid it out for treatment, wrote reports, lectured here and there, served on innumerable committees, collected specimens up and down the state, and, lest some remnant of his time should be unoccupied, was charged by the Board [of Trustees of the University] with the sale of mules, whose labors on the south farm showed that they were not so able to stand the strenuous life as he was. His professorship began at sun-up and lasted indefinitely, and included everything that needed doing."

His philosophy of education was both enlightened and practical. Davenport (19) quotes Burrill as stating

> Education... must be a real preparation for a real life, in order that this life shall be both the richest possible and the fittest possible for the individual, whatever his vocation and surroundings.... The true meaning of a liberal education, a phrase often used in a different sense, is fitted for life, for its affairs, for its duties, its hopes, its pleasures, its future, its fruitions. These are not incompatibles. They ought to be the outcome of the work of all our schools, but this cannot be unless both the facts and the methods of science have due consideration in the curriculum and proper appreciation on the part of educators.

He taught subjects that included general horticulture, pomology, forestry, floriculture, vegetable physiology, cryptogamic botany, microscopy, and bacteriology. Almost from the beginning he taught about plant diseases. He continued to develop and introduce new courses until 1911, the year before his retirement. Among his assistants who became well known mycologists and plant pathologists were G. P. Clinton, A. B. Seymour, W. M. Waite, B. M. Duggar, and J. T. Barrett (H. H. Thornberry, unpublished manuscript).

Burrill also occupied various administrative positions. These included Dean of the College of Science, Dean of the General Faculty, Dean of the Graduate school, Vice-president of the University, and Acting Regent or President (after the title was changed) on four occasions (18). He regarded the faculty as central to the operation and well-being of the University, and took dramatic steps to increase the role of faculty in governing it. He also instituted sabbatical leaves, and began the present tenure system for faculty (23).

Students clashed frequently with the University administration over such issues as whether fraternities would be allowed, and whether student publications should be free to print opinions regarding the institution. Fortunately for the young University, Burrill was held in high regard by the students, faculty, and administrators and was frequently called upon to act as a mediator between these often fractious elements. Among the changes he made in student life were the abolition of the much-hated loyalty oath and the demerit system, the elimination of compulsory chapel, and the legalization of fraternities (23).

One of his contemporaries, Eugene Davenport, Dean of Agriculture at the time of Burrill's death, wrote that "Dr. Burrill always occupied a place very close to the heart of the institution. He was indeed a kind of godfather to the University and the father confessor of the faculty" (19). Burrill's connection with the University was long-lived and deep. Davenport (19) noted that "He was never connected with any other institution of college grade; indeed, he told me once that a proposition to go elsewhere would be regarded as an affront, so completely had his life become bound up with the 'Uni-ver-si-ty.'"

CONTRIBUTIONS TO PLANT PATHOLOGY

Burrill's appointment as Professor of Horticulture at the new University meant that all aspects of plants and their cultivation came under his purview. Much of his first work involved starting the University forestry plantation (remnants of which still persist as a park known as "Illini Grove") to test the ability of various trees to grow under Illinois conditions. This was no small effort. By 1871 the plantation comprised some 20 acres of trees, including 1400 varieties of apples alone (4).

Burrill soon developed a special interest in plant diseases. He was well-informed about scientific developments in Europe, and frequently quoted the work of Pasteur, Berkeley and other luminaries in his own papers. Despite his rather rudimentary education (Forbes notes that Burrill had received no instruction whatsoever in cryptogamic botany or bacteriology; 21), Burrill had access to a surprisingly good library and a laboratory with excellent microscopes. Most important, he was a careful observer and an independent thinker. Over the next four decades he published numerous articles and bulletins describing the causes, effects, and control of plant diseases.

Burrill was particularly interested in the microscopic fungi associated with diseased plants. Much of his early work dealt with fungal taxonomy, and he published a series of papers on rusts (12), smuts (14), and powdery mildews (13). The celebrated American mycologist J. B. Ellis had Burrill write the powdery mildew section of the classic book *The North American Pyrenomycetes* (20). Burrill also published early reports dealing with apple scab (10), bitter rot (15), and other diseases. In all, he wrote or coauthored some 190 publications (H. H. Thornberry, unpublished manuscript). His final scientific paper, published posthumously, dealt with investigations on nitrogen-fixing bacteria (16).

Of all his research, it is the work he did on fire blight that most firmly established his position in the history of plant pathology. This disease was a scourge of American orchardists. In many areas it was simply impossible to grow pear trees commercially because of this disease. Early theories on the cause of the disease included the effects of "frozen sap," insect damage, effects of lightning, weather, and fungi (1).

Burrill's research on the disease began in the early 1870's. In 1871 he reported results of studying peach and pear diseases near Cobden, Illinois, where he found little fire blight (5). In a paper on "aggressive parasitism of fungi" (6) he wrote, "The fire blight of pear needs more study." In 1877 Burrill (7) stated:

> It has been quite generally conceded, by those who have kept posted upon the literature of the subject, that this malady is due to the injurious effect of a parasitic fungus. Other theories and speculations are still common, as the effect of frost, or of the excess of heat or moisture, or of a deficiency in the elementary substances of the soil, etc; but the want of proof in any of these, and the contradictory facts so often presented, prevent the acceptance of any such explanation. On the other hand, those who have carefully investigated, with the microscope, the conditions and progress of the disease, agree in finding evidence of the connection of fungi with the blight of the tree; but no one has yet positively traced what this connection is.

He goes on to report observations of his own that appeared to implicate a fungus in the disease. His microscopic observations indicated that

> The cambium of the blighted branch, when the trouble first shows itself, and for some days thereafter, is filled with very minute moving particles, very similar to those known as Spermatia in fungi and other low plants, and which are now known through the researches of M. Cornu, of France, to be reproductive, or capable of germinating, and thus giving origin to the plant.... Not unfrequently, a thick brownish, sticky matter exudes from affected limbs, sometimes so abundant as to run down the surface or drop from the tree. This proves to be identical with that noticed in the cambium, and unquestionably has the same origin. The sticky, half-fluid substance thus exuding is entirely made up of these minute oscillating particles. The origin of these has not yet been certainly traced; but, if Spermatia, as their appearance indicates, they doubtless are produced in little inclused conceptacles somewhere in the tissues of the plant.

He summarizes his findings with the statement, "There is evidence that the theory of the fungus origin of the fire-blight of the pear, and the common twig-blight of the apple, is well founded; but, though particular species, or what have been regarded as species, are known to accompany the disease, proof has not yet been obtained as to their causing the death of the limbs, nor as to the real action of any fungi upon these limbs."

Burrill had, of course, taken the bacteria in infected plants for fungal spores. However, he soon realized his error. His work implicating the bacteria as the cause of fire blight was published in 1880 (8, 9). He reported:

> After establishing, by thorough researches, the presence of *bacteria* in the tissues of dying limbs and the scarred blotches upon the trunks of apple and pear trees, I began, July 1st, 1880, a series of experiments with the view of determining whether these organisms were really active agents in the observed changes, or simply accompanying other causes of destruction. Other interests at the same time so engaged my attention and time [that year he had also assumed the post of Acting Regent following the turbulent ouster of the University's first Regent (23)] that this was not so fully done as I heartily wished it had been, after gradually becoming convinced of the possible complete demonstration of the perplexing problem. However, the results are sufficiently clear to warrant their announcement and to establish the aggressive activity of the organisms.

The experiments reported "were made by cutting pieces of diseased bark freshly taken from the tree, and inserting them after the manner of budding as practiced by nurserymen." He also made "inoculations with a sharp-pointed knife or needle dipped in virus collected as it exuded from diseased trees, and usually thinned with distilled water... this exudation is composed almost purely of bacteria. By careful collection and frequent microscopical examinations, it was possible to be quite sure that the inoculating material contained nothing but water and the living bacteria" (8).

His results were striking. While less than two percent of the uninoculated trees in the control treatment became diseased,

> of the pear trees inoculated sixty-three percent *became diseased,* exhibiting all the characteristics, externally and internally, of the so-called fire-blight.... Of the pear trees inoculated with virus obtained from diseased pear, fifty-four percent received the disease, while of those inoculated from blighting apple seventy-two percent became as thoroughly infected as those with pear virus, and as speedily died in the vicinity of the parts treated.... The four inoculations of the quince from pear virus were all successful (7).

In these and subsequent publications he discussed other aspects of this disease, and possible means for its control. Other duties prevented him from describing the bacterium as a new species (*Micrococcus amylovorus,* now known as *Erwinia amylovora)* until 1883 (11).

Despite the handicap of being unable to culture the bacterium, Burrill's

work forever changed the course of research on fire blight and other plant diseases caused by bacteria. The eminent phytobacteriologist E. F. Smith (17) evaluated Burrill's work by writing

> Prof. Burrill, an expert microscopist and mycologist, although working before the era of exact methods in bacteriology, proved four things conclusively; 1) The absence of any fungus in the blighting pear twigs; 2) The constant presence of a motile bacillus in enormous numbers in the freshly blighted twigs, which bacillus, moreover, could always be found pushing into the sound tissues some centimeters in advance of the visible browning and death; 3) The infectious nature of the freshly blighted material; 4) The identity of the blight on pear, apple and quince.

In 1885, J. C. Arthur (2) published his classic paper on the completion of Koch's postulates with the bacterium, thus proving beyond doubt that fire blight was indeed caused by this organism. Important aspects of epidemiology remained to be clarified. One of the most significant findings, that honey bees transmit the pathogen during pollination, was described in 1891 by Burrill's former student Waite (24). Despite this early work, controversy raged for some years as to whether bacteria could, in fact, cause disease in plants. German scientists in particular denounced this heretical strain of American phytopathology. The dispute finally culminated in the famous debate waged in publications written by Smith and Fischer (17). Eventually the Americans were vindicated and the new science of phytobacteriology was firmly established.

CONCLUSIONS

Burrill received wide acclaim for his work. Besides his honorary degrees, he served as president of the American Microscopical Society in 1904; the American Society for Microscopy in 1885; the Illinois State Horticultural Society for two terms, 1878–1879 and 1886–1887; the Society of American Bacteriologists in 1916; and was Vice President of the Biological Section of the American Association for the Advancement of Science in 1886–1887 (H. H. Thornberry, unpublished manuscript). In 1916, the year of his death, the Society of American Bacteriologists passed a special resolution honoring Burrill for founding "the science of bacterial plant pathology" (19).

Burrill was a complex man. Over the course of his long career he played many roles: researcher, teacher, administrator, mentor, and peacemaker. All of his professional activities were the direct outgrowth of his deeply held belief that his duty was to help improve the lot of people, whether farmers or city folk, students or professors. His personal motto, "Necessity knows no law," (H. H. Thornberry, unpublished manuscript) seems a clear outgrowth of his pioneer childhood, and most appropriate for someone who spent his professional life on the edge of so many frontiers. As a man who worked

tirelessly toward scientific and scholarly excellence, and in service to others, he remains a model worthy of emulation.

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