Alice Evans, Pioneer Microbiologist

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In 1928, Alice Evans was elected President of the Society of American Bacteriologists, the first woman to hold the office. This was one of many firsts and one of her lesser contributions to the field of microbiology.

In 1963, many years after Dr. Evans had retired from the National Institutes of Health, Wyndham D. Miles, NIH historian at the time, prevailed upon her to write her memoirs, for she had lived through some of the early days of discovery in bacteriology and been in the midst of controversy.

Significantly and modestly, she starts her memoirs by noting, “Until my academic education was completed I seemed never to have an opportunity to make a choice in matters concerning my future. I always stepped into the only suitable opening I could see on my horizon. . . . I always thought that somehow I drifted into the work for which I was best adapted.” Her schooling started in the rural community of Neath, near Le Raysville, Pennsylvania, to which her Welsh grandparents had immigrated in 1831. After primary education in the district school, she studied in the Susquehanna Collegiate Institute in Towanda, Pa., where she was one in a class of seven, the last class to graduate from the Institute. At the time, it looked as if her formal education had come to an end. She had dreamed of going on to college, but she lacked the means, so she began her career in grade school teaching, one of the few professions then open to women. After 4 years of teaching, she took advantage of a 2-year tuition-free Nature Study course at Cornell University College of Agriculture, where the distinguished Liberty Hyde Bailey was dean. The course was designed especially for rural school teachers to foster a love of nature in country children. This course opened a new world to her.

During her life at Cornell, the first President of Cornell, Andrew D. White, still lived on campus and could occasionally be seen in flowing cloak strolling along the paths. Burt G. Wilder taught the course in vertebrate zoology which formed part of the Nature Study curriculum. He was the only member of the original faculty who was teaching during the early years of the class of 1909.

The entomologist, John Henry Comstock, was another of her teachers about whom Evans relates the following story. “In 1878 John Henry Comstock married Anna Botsford (Cornell ’78) and they worked together for more than 50 years. In 1898 she was named Assistant Professor of Nature Study, but trustee opposition to her title was so great that she was reappointed lecturer after the close of the summer school in 1899. Nevertheless, she remains on the record as the first woman to hold professorial rank at Cornell.”

Before completing the nature study course, Miss Evans realized that she wanted to continue the study of science. The Cornell College of Agriculture was then accepting out-of-state students tuition free, and, with the help of a Roberts scholarship during her junior and senior years, Miss Evans completed requirements for the B.S. Degree in
Agriculture. Seniors were required to major in some branch of applied science such as horticulture or dairying, or to specialize in bacteriology. It was Miss Evans's choice to major in bacteriology that established the direction she would follow.

During her senior year, Professor Stocking, her teacher of dairy bacteriology, told her that he had been asked by Professor E. G. Hastings of the College of Agriculture at the University of Wisconsin to recommend a graduating student for a scholarship in bacteriology. Alice Evans was asked if she would like to apply. The scholarship had never before been awarded to a woman, but the University of Wisconsin wanted to develop a bacteriology instructor for domestic science students, and Miss Evans was the successful applicant. Professor Hastings became her advisor at the University of Wisconsin and recommended that she spend much of her time on chemistry courses, although she held the scholarship in bacteriology.

Elmer V. McCollum, who taught chemistry of nutrition, was at the time conducting experiments which led to his discovery of vitamin A. Thus Alice Evans and the other three students in the class heard much about "fat-soluble A" and "water-soluble B." The word vitamin had not yet been coined.

At the end of the year 1910, Miss Evans received the M.S. Degree in Bacteriology from the University of Wisconsin. Dr. McCollum encouraged her to continue her studies for the Ph.D. on a university fellowship in chemistry, but she decided against it. The financial and physical strain of the past 7 years disinclined her to undertake further study at that time. Moreover, it was not then (1910) considered so important to have a Ph.D. Degree; some of the senior faculty at both Cornell University and the University of Wisconsin, and elsewhere, did not have Ph.D. Degrees.

In her mind she left the option open to complete the Ph.D. Degree some day, but now she was ready for a change, so she accepted Professor Hastings' offer of a research position with the Dairy Division of the Department of Agriculture. She began her work on 1 July 1910, there on the University campus. At the time, several state agricultural experiment stations were collaborating with the USDA in cooperative research while the east wing of the Department of Agriculture building (on Independence Ave. between 12th and 14th Streets, NW, in Washington, D.C.) was being completed. Both the Department of Bacteriology and the Department of Agricultural Chemistry in the College of Agriculture at the University of Wisconsin were involved in agricultural research. Alice Evans started out with the investigation into better methods of cheesemaking, then as now an important industry of Wisconsin. She spent 3 more years at the University and took one course each year to fill gaps in her education.

In 1913, when the Dairy Division Laboratories in Washington were ready for occupancy, she set out for the capital city with a "stoical demeanor." Contrary to her expectations, the environment at the Bureau of Animal Industry proved to be quite congenial. A number of women scientists were already employed in the Department of Agriculture, some in the Bureau of Chemistry, on work connected with enforcement of the Pure Food and Drug Act passed in 1906. Several were employed in the Bureau of Plant Industry where the distinguished plant pathologist, Erwin Smith, was a pioneer in giving opportunities to women. In the Dairy Division of the Bureau of Animal Industry, Alice Evans was the first woman scientist to hold a permanent appointment. She found that her immediate supervisors, B. H. Rawl, Chief of the Division, and Lore A. Rogers, in charge of research, had a favorable attitude toward women in science.

One of the problems under investigation when Miss Evans joined the Dairy Division in Washington was a search for sources from which bacteria entered dairy products—the thought being that freshly drawn milk was quite healthful if not contaminated. The study required a project director (Rogers), a chemist (William Mansfield Clark), and a
bacteriological technician. Evans was assigned to this project as the technician after two of the series of four papers on the subject had been published. The chemical aspects of these studies led to a field of investigation for which Clark became renowned. Accurate methods for measuring hydrogen-ion concentration replaced the titration methods then in use in biological laboratories throughout the world.

In addition to work on this investigation, Evans was given a project of her own: the study of bacteria that occur in milk freshly drawn from the cow's udder. She found the bacterial flora to be varied, with several species commonly present. Her attention focused on the causal organism of contagious abortion, *Bacillus abortus*, as then classified. Warnings of the possibility that this organism might be dangerous to human health had been reported. Her study of the relationship of *B. abortus* to other pathogenic bacteria included the organism causing Malta fever, *Micrococcus melitensis*, as then named. The similarity in habitat of the two organisms seemed to her a compelling reason for comparison, despite the suggested unrelatedness of the names. To her amazement, all strains of each type of organism behaved essentially the same in all culture tests then available for differentiating bacteria and in cross-agglutination. She then requested animal inoculations. Since the Division of Bacteriology had no facilities for animal experimentation, the tests were performed in the Division of Pathology of the Bureau of Animal Industry. Pregnant guinea pigs inoculated with *B. abortus* or *M. melitensis* aborted and produced specific antibodies and positive cultures for various organs. She then demonstrated that the two organisms could be differentiated by agglutinin-absorption tests.

Her results were presented at the 1917 Annual Meeting of the Society of American Bacteriology in Washington, D.C. At the time, she commented, "Considering the close relationship between the two organisms and the reported finding of *B. abortus* in cow's milk, it would seem remarkable that we do not have a disease resembling Malta fever in this country. . . . Are we sure that cases of glandular disease or cases of abortion, or possibly diseases of the respiratory tract may not sometimes occur among human subjects in this country as a result of drinking raw cow's milk?" According to Miss Evans, the published results (J. Infect. Dis., 1918, 22: 580-593) were greeted with skepticism on the part of bacteriologists and physicians who brushed it aside with such remarks as, "If the organisms were so closely related, surely some other bacteriologist would have noted it before." Those connected with the dairy industry had other problems at that time, for the Bureau of Animal Industry was carrying on its campaign of tuberculosis eradication in cattle which was trouble enough for the farmers.

Owing to World War I and the prevailing spirit of patriotism, Evans sought to utilize her efforts in service more closely related to the war effort and to the alleviation of human suffering. She found a position as bacteriologist at the Hygienic Laboratory (now NIH) then located at 25th and E St., N.W., in an old, red-brick building housing the entire institution, fewer than 100 people in all. She took up the new post in April 1918 and joined a group of doctors who were striving to improve antiserum used in treatment of epidemic meningitis, one of the dread diseases of World War I, with a fatality rate of more than 50%.

The great pandemic of influenza reached Massachusetts in September 1918 and spread to Washington in early October, where, on account of war-time overcrowding, it was very severe. In October 1918, Congress passed a resolution "to enable the Public Health Service to combat 'Spanish Influenza' . . . by aiding state and local Boards of Health." As a result, all medical officers of the Hygienic Laboratory were sent into the field or served in Washington. To Evans fell the task of investigating the cause of the epidemic. One of the organisms under suspicion was *Haemophilus influenzae* found frequently in epidemic cases. But she barely commenced when she herself became
ill. When she finally recovered, the war was over. The peak of the epidemic had passed Washington, and the work on meningococci was resumed.

During these early years at the Hygienic Laboratory, the controversy on the significance of *Brucella abortus* in milk continued. After her discovery of the similarity between *B. abortus* and *M. melitensis*, Evans reviewed British and French literature on Malta fever. She learned that, besides the cases readily diagnosed by a significant titer of agglutinins in the blood serum, there were mild cases in which the titer was too low to be considered significant. Because the Maltese objected to the opprobrious use of their homeland in the name Malta fever, the disease had been officially named “undulant fever” at the International Congress of Medicine and Hygiene held in London in 1913. The new name derived from the wavelike character of the fever curve in typical acute cases, but the old name persisted for some time. Miss Evans states, “It is easy to deduce from the name the converse idea that Malta or undulant fever could be ruled out in a case without an undulating fever curve.” This was one of the fixed ideas that obstructed the recognition of chronic cases. Another erroneous idea that impeded progress in understanding of undulant fever was the incorrect generic name *Micrococcus* given by Bruce to the organism he reported to be the cause of the disease. It was an understandable error for the early state of bacteriology in 1887, when David Bruce and his wife Mary succeeded in culturing the organism from the spleen of a fatal case of Malta fever. Bruce was knighted for his scientific discoveries and, after his death, Lady Bruce received recognition when she was made an Honorary Female Fellow of the Royal Microscopical Society, the first woman to be so honored (J. Eyre. 1936. London J. State Med 44: 64).

Another aspect of the undulant fever problem was the attitude prevalent in the first decade of this century toward milk as a carrier of disease. It had been incriminated in several typhoid outbreaks. Health authorities recognized that cows with tubercular infection might harbor tubercle bacilli in the udder, but Robert Koch had allayed their fears by stating authoritatively (1901) that bovine tuberculosis was not transmissible to man, and it was therefore unnecessary to take precautions to protect humans from bovine tuberculosis. Although human cases of tuberculosis caused by the bovine organism had already been described by Ravenel (1900) and by others, Koch’s views were widely accepted, and it was many years before overwhelming evidence proved them to be wrong. Evans noted that “The most vocal scientist opposing the idea that brucellae in cow’s milk might cause human disease was none other than Theobald Smith who had been one of the first to warn of this possibility.” Smith had been working on brucellosis of cattle for several years before Evans’s first publication on the subject in 1918. However, in 1919 and again in 1925, he published reports disagreeing with the premise that brucellae in milk might be hazardous to the health of those drinking the milk. Although he recognized brucellae in milk as an indicator of bovine infection, he rejected the human hazard from consumption of such milk.

In 1925, William Welch of Johns Hopkins Medical School entered the controversy. He was then a member of the advisory board of the Hygienic Laboratory. During his visit to the Laboratory in the spring of 1925, he checked with the director, Dr. McCoy, as to Evans’ competence and accuracy. Being reassured by McCoy, he then suggested to her that she and Smith resolve their differences. Shortly after, at a meeting of the American Society of Tropical Medicine, Welch complimented her on a paper she had just presented on the geographical distribution of various serological groups of brucellae. He stated, however, that he could not believe that infected cow’s milk might be the source of human brucellosis. He then repeated his wish that she would compose her differences with Smith. In her memoirs Evans indicates that, when pressed by the
authoritative Welch to "compose her differences" with the authoritative Smith, she made no comment.

Later that year, Ludwig Hektoen, Director of Medical Sciences of the National Research Council, held part-time research space in Evans's laboratory. One day he mentioned to her that Theobald Smith had declined to become Chairman of the Committee on Infectious Abortion of the National Research Council when he learned that Evans was to become a member of the Committee. In his letter to the National Research Council, Smith explained that he was at that time studying cultures of "so-called Malta fever in man," one of which was ascribed by Evans to the cow, and his results so far indicated that Evans' strain and several strains of known bovine origin were not identical. The strain in question, Evans' Baltimore strain, proved to be *Brucella suis*. It had been isolated from a patient in 1922 at Johns Hopkins Hospital and sent to Evans for identification. It was the first strain of *Brucella* of human origin to be identified in this country. Simultaneously, cases of human brucellosis caused by drinking infected cow's milk were being found in Southern Rhodesia. When Evans learned from Hektoen that the validity of her work had been questioned in the National Research Council, she wrote to Welch asking him to intercede with Smith noting, "It seems to me that Dr. Smith could not take the point of view that the so-called *B. abortus* is non-pathogenic for man if he knew the evidence that has accumulated in the last few months in South Africa as well as this country." Two days later Evans received a handwritten reply from Dr. Welch saying, "I am very much interested in your letter. I am taking the liberty of sending it to Theobald Smith. I think so highly of the work of both of you that if I can be the means of bringing about a rapport between you and him in this important study I shall be gratified. . . . If it is not too much trouble can you give me the reference for the South African cases?" She answered the letter by return mail listing references from recent British and South African medical journals to more than 30 cases of brucellosis in man contracted from infected cows. Welch sent the list to Smith. About a week later, Evans received a letter from Smith mentioning Welch's letter and adding, "On the whole, I think the accuracy of your work does not come in question as far as it has gone. Nor do I think it would suffer if you suspended judgment until the unknown factors responsible for or contributing to the incidence of the human cases have been brought to light." (The original letters from Welch and Smith and carbon copies of Evans's letters were given to the Department of Bacteriology library at the University of Wisconsin.)

About 6 months later, Evans received an invitation to serve as a member of the Committee on Infectious Abortion of the National Research Council which had been organized under the leadership of Theobald Smith. She accepted and remained a member of the committee for 6 years "without memorable incident."

In 1926 Smith, admitting "probably more than 100 cases in USA," wrote, "I shall view the subject solely from the standpoint of one who is endeavoring to find out from existing data whether or not the bovine type of *B. abortus* produces undulant fever in man. . . . How can we explain the scarcity of infection?" During the late 1920s and early 1930s there were hundreds of cases of human brucellosis reported throughout the world, many of them proven by culture to be of bovine or porcine origin. Yet the question was still raised by Smith and many others as to why there were so few cases reported in some communities where cattle were known to be infected. Keeping in mind that brucellosis is not transferable from person to person, acute cases were being found wherever brucellosis in cattle existed. However, on account of the extreme difficulty of diagnosis and the fickle nature of brucellosis, they were believed to be influenza, tuberculosis, typhoid fever, osteomyelitis, etc. Although Theobald Smith explained, on scientific and economic bases, his resis-
tance to the idea that raw milk may carry brucellae pathogenic to man, Evans notes that "... the nineteenth amendment was not a part of the constitution of USA when the controversy began, and he was not accustomed to considering a scientific idea proposed by a woman."

Alice Evans was infected in October 1922 with a strain of *B. melitensis* isolated from a case in a tubercular colony of Arizona where goats were the milk animal. After about a year of miserable health, her discovery of her own infection resulted from her own blood serving as a control for a serological test for her laboratory assistant. The assistant's blood serum was negative and hers was positive in 1:40 dilution not then considered significant, but "nature is no respecter of empirical rules," as she states. Her symptoms became acute about a year later, and she spent 10 weeks in a Baltimore hospital while the titer remained at 1:40. This was the first of many long experiences in five different hospitals during the next 21 years; the last attack occurred in 1943. In 1928, surgery in Johns Hopkins Hospital for other causes revealed lesions from which *B. melitensis* was cultured. This took care of the "imaginary illness." For years before the Johns Hopkins Hospital episode and for years afterward, Evans suffered attacks of mild disease considered by officers of NIH work-connected but by the general public as malingering. This caused agony for the patient. It is the kind of misunderstanding that has been the fate of many chronic brucellosis patients wherever brucellosis exists.

Around 1939 Evans began investigation of immunity to streptococcal infection when there were about 30 known types of streptococci. By 1945, when she retired, there were 46 types. Sulfa drugs and penicillin had been added to the armament against infection, but she continued the study and found that, when the antigen is unbroken bacterial cells, the immune sera fall into groups.

Some of the honors which Alice Evans received included an honorary M.D. from the Women's Medical College in 1934 (now Medical College of Pennsylvania), D.Sc. from Wilson College in 1936, and D.Sc. from University of Wisconsin in 1948. Her interest in education and in youth was recently (1969) manifested by her gift through the AAUW of a scholarship fund for Federal City College.

In January of this year, Alice Evans celebrated her 92nd birthday in tolerable health and good spirits.