ARS National Academy of Sciences Members

1. **Edward F. Knipling**
   Insect control

2. **Howard L. Bachrach**
   Animal health

3. **Myron K. Brakke**
   Plant virology

4. **Glenn W. Burton Forage and turf science**

5. **Earnest R. Sears**
   Wheat genetics

6. **Cecil H. Wadleigh**
   Salinity and water stress on crops

7. **Hamish N. Munro**
   Nutrition for the aging

8. **Theodor O. Diener**
   Viroid detection and control

9. **Robert W. Holley**
   Transfer ribonucleic acid (tRNA)

10. **George F. Sprague**
    Hybrid corn breeding and genetics

11. **Arnel R. Hallauer**
    Plant genetics and breeding

12. **Sterling B. Hendricks**
    Plant physiology, mineralogy, and chemistry

13. **Harry Alfred Borthwick**
    Plant physiology and biology

14. **R. James Cook**
    Plant disease control

15. **William L. Ogren**
    Photosynthesis and plant physiology

16. **James H. Tumlinson III**
    Insect control

17. **Richard L. Witter Avian disease control**
    Animal Nutrition, and applied microbial sciences

18. **Harley W. Moon**
    Livestock disease control

19. **Janice M. Miller Ruminant disease control**

20. **Robert E. Davis**
    Plant pathology

21. **Jitender Dubey**
    Animal nutritional, and applied microbial sciences

22. **Sarah Hake**
    Plant, soil, and Microbial Sciences

23. **Theologis, Athanasios**
    Plant Biology

24. **Ed Buckler**
    Plant, soil and nutrition

USDA Scientists (Prior to 1953) NAS Members

Kenneth Bryan Raper

Kenneth Bryan Raper (1908-1987) was a mycologist, microbiologist, and botanist whose contributions to the medical and industrial applications of fungi of the genera *Aspergillus* and *Penicillium* stand among the outstanding achievements of twentieth-century science. Of equal importance was his identification of a cellular slime mold, *Dictyostelium discoideum,* in 1935 that led to four decades of research and publication on a group of organisms (*Dictyostelids* and *Acrasids*) that have wide applications in microbiology.

Kenneth Raper was born in Welcome, North Carolina on July 11, 1908. He gained his A.B. at the University of North Carolina (Chapel Hill 1929), A.M. at George Washington University (1931), and A.M. (1935) and Ph.D. (1936) at Harvard University. Later in his career he was awarded an Honorary Doctor of Science degree from the University of North Carolina. As a mycologist, he began his professional career with the United States Department of Agriculture (USDA) Bureau of Chemistry and Soils (1929-36) and Bureau of Plant Industry (1936-40). Here he met Dr. Charles Thom, who became his mentor and key collaborator in his work. Thom and Raper co-authored the classic monographs *A Manual of the Aspergilli* (1945) and *A Manual of the Penicillia* (1949).

From 1940 to 1953 Dr. Raper served as microbiologist at the USDA Northern Regional Research Laboratory (NRRL) in Peoria, Illinois. In 1940, upon a visit from British scientists Raymond Florey and Ronald Heatley, seeking to develop methods of large-scale penicillin production for the war effort, Raper and his associates initiated a research program at NRRL of historic importance. Beginning with a *Penicillium* strain from Alexander Fleming, the NRRL "Penicillin Team" went on to develop increasing yields of penicillin in submerged culture which was of critical therapeutic impact for World War II combat injuries and which launched the "Age of Antibiotics."

After an appointment as visiting professor at the University of Illinois (1946-53), Dr. Raper left the USDA in 1953 to become Professor of Bacteriology and Botany at the University of Wisconsin. He was William Trelease Professor from 1966 to 1979. During this stage of his career he pursued research into the life histories, cytology, and taxonomy of the *Dictyosteliaceae,* which culminated in the publication *The Dictyostelids* in 1984. He also published *The Genus Aspergillus* with Dorothy I. Fennell in 1965.

Dr. Raper served as chairman of the Executive Committee of the International Botanical Congress XI (1969), chairman and delegate to four General Assemblies of the International Union of Biological Sciences, trustee of the American Type Culture Collection (1948-62), and member of an Executive Committee of the National Research Council (1956-61). He was a

member of the National Academy of Science (1949), the American Academy of Arts and Sciences (1949), and the American Philosophical Society (1958). Among his many honors and distinctions, he received the USDA Distinguished Service Award (1947), the Distinguished Mycologist Award of the Mycological Society of America (1981), and was the first recipient of the Charles Thom Award from the Society of Industrial Microbiology (1967). Dr. Kenneth Raper died in 1987 at the age of 79.

Charles C. Thom

Charles Thom (1872-1956) was a mycologist whose work in the microbiology of dairy products and soil fungi was an important influence in setting rigorous standards in food handling and processing in the United States. Long associated with the United States Department of Agriculture (USDA), he conducted research in food toxicity and enforced standards of the Pure Food and Drug Act. Dr. Thom was an internationally recognized authority on molds used in cheese ripening and first described *Penicillium roqueforti* and *P. camemberti*, active ingredients of two popular cheeses. His studies of microfungi culminated in the publication of *The Aspergilli* (with Margaret B. Church, 1926) and *The Penicillia* (1930).

Charles Thom was born in Minonk, Illinois on November 11, 1872. He received his A.B. (1895) and A.M. (1897) at Lake Forest College and his Ph.D. (1899) at the University of Missouri, the first doctoral degree to be awarded by that institution. His early career as a botany teacher led to research at Woods Hole Biological Laboratory and a position as an assistant to George F. Atkinson at Cornell University. Upon Atkinson's recommendation he took a position with the USDA in 1904, where he remained until his retirement in 1942. His USDA career began with a 10-year stint at the Agricultural Experiment Station at Storrs, Connecticut to work on a project on mold-ripened cheese. His successes here contributed to the development of industrial processes for the manufacture of Camembert and Roquefort cheeses in the United States.

In 1913 he moved to Washington, D.C. to begin work as Mycologist in Charge of the Microbiological Laboratory, Bureau of Chemistry. He was then Head of the Division of Soil Microbiology, Bureau of Chemistry and Soils (1927-1934) and Bureau of Plant Industry (1934-1942). His research into the taxonomy of *Aspergillus* and *Penicillium*, his building a systematic collection of living mold cultures, and his correct identification of Alexander Fleming's penicillin-producing mold as *Penicillium notatum* formed a nucleus of wide-ranging studies that ultimately led to large-scale antibiotics production.

With the Division of Soil Microbiology Dr. Thom developed a practical method to control the devastating 'Texas Root Rot' of cotton. During World War II he became an important collaborator with the USDA Northern Regional Research Laboratory 'Penicillin Team,' charged

with the crucial project of developing methods to increase penicillin yield from various strains of *Penicillium*. Here he worked with his protégé, Dr. Kenneth Raper; together they published *Manual of the Penicillia* in 1949.

Dr. Thom was the American Delegate to the International Dairy Congress held in Paris, France in 1905. He worked with an organizing committee to create a graduate education program at the USDA. He attended the International Soil Congress in Oxford, England (1935) and was Vice President of the International Microbiological Congress in New York (1939). He was a National Academy of Sciences member (from 1937), a charter member of the Mycological Society of America (president, 1953), and president of the Society of American Bacteriologists (SAB) (1940). Lake Forest College awarded an Honorary Doctor of Science degree to him in 1936. Dr. Thom died at his home in Port Jefferson, New York on May 24, 1956 at age 83.

Lewis John Stadler

Stadler, Lewis John (1896-1954) was an American geneticist who did pioneering research on the effects of X rays upon mutation in plants.

Stadler was born in St. Louis, Missouri, in 1896. He earned a B.S. degree in agriculture at the University of Florida in 1917, an M.A. degree in 1918, and a Ph.D. degree in field crops in 1919 at the University of Missouri (UM) at Columbia. He joined the UM Department of Field Crops faculty in 1922 and remained there until 1954. He acted as visiting professor at the California Institute of Technology in 1940, and Yale University in 1950. Beginning in 1929, he simultaneously held an appointment with the U.S. Department of Agriculture.

Stadler concentrated upon the study of mutation in plants, especially corn. He studied the effects of X rays on the germinal material in plants and performed comparative studies of mutation caused by X rays and by ultraviolet rays. Stadler co-discovered the fact that X rays could cause mutations in barley and corn.

A mutation can affect an individual gene or an entire chromosome. A gene mutation occurs if there are slight chemical changes in DNA. A chromosome mutation occurs if the number or arrangement of chromosomes changes.

The University of Missouri-Columbia grew into a distinguished center for agricultural genetics research under Stadler. He helped attract top-level faculty members. Many of Stadler's students went on to outstanding careers.

Stadler earned many academic honors, including the presidencies of the Genetics Society of America (1939), American Society of Naturalists (1953), and Sigma Xi (1953).

Erwin Frink Smith: proved the existence of bacterial diseases in plants.

There is always a building called Smith Hall in many American universities, especially those with an agricultural college. That is in memory of Erwin Frank Smith. There is a bacterial genus called Erwinia, that also is in memory of Smith. From these instances, microbiologists would probably understand why Smith is an important figure in the history of microbiology.

Smith was born in Gilbert Mills, New York, on January 21, 1854. The town was one with many flour mills. A very keen interest of his boyhood was the functioning of these mills. He wondered how God could run the mills. When he heard the grinding of the mill wheels he pictured in his mind a "prisoned God" at work! The mills also often had adjacent mill ponds. He liked to spend time on these mill ponds and their streams in the countryside. He always felt a consciousness of the presence of the Creator here, as well as in the grinding of the mill wheels. He also felt an obligation to serve his Creator, who had furnished the world and all that was in it.

Smith was left without his father at the beginning of the Civil War as his father, Ransellor King Smith, enlisted in Co. K. of the New York 184th Infantry. During those years, young Smith had the blessing of assistance by a schoolteacher friend, Miss Ida Holmes. Noting his love of nature, she guided him with the loan of books and magazines of a scientific nature. In addition, he read works by Tennyson, Dickens, and Longfellow. He chose science as his major interest, but his reading was so broad and his interest in all subjects so great that he had a difficult time selecting a major among such sciences as botany, chemistry, medicine, physics and geology.

He moved with his family to Hubbardston, Michigan, in 1870. He now was 16 years old and entered the public schools there. Later, the family moved to a farm near Ionia, the county seat. Smith now was 22 and appeared mature for this age, wearing a full beard. He entered the Ionia High School and was immediately recognized by the principal, Anson P. DeWolf, as an exceptionally intelligent student. In addition to his regular high school courses, he was granted permission to "come and go as the spirit moved him." In this way he soon mastered French on the side and also learned solid botany through tutoring by the local pharmacist, Charles F. Wheeler. (Wheeler was a gifted amateur botanist). His botany was so sinecure as just a year after graduating from high school, he published his first book, "The Flora of Michigan."

After some studies at the Michigan Agricultural College, he entered the University of Michigan and obtained his bachelor's degree in 1886. He immediately began graduate work and was granted the doctor's degree in 1889. His Ph.D. research work was on a plant disease, "peach yellow." He continued work on this for several years. At all times Smith was fortunate

in having advisors and colleagues who recognized his abilities. They gave him encouragement in his often irregular method of study and research. During this period he also married. His first wife was Charlotte May Buffet Smith, who had an extensive period of illness, dying in 1906. With her, he had a great love of nature, as well as the study of mycology and bacteriology. In 1915 he privately published a book dedicated to his wife entitled, "For Her Friends and Mine: A Book of Aspiration, Dreams and Memories."

In 1913 he again married. His second wife was Ruth Warren Smith. She was his confidant and assistant until he died.

In his initial work on peach yellows, he was not able to isolate and culture the mycotic agent. In 1892, he was greatly influenced by Dr. M. B. Waite, who had been an assistant in the laboratory of Dr. Jonathon Burrill and had learned from him the methods of pure culture in bacteria. He also studies the papers of Pasteur and in addition, learned to read papers in German and Italian. He also learned from Theobald Smith and Veronus A. Moore, who worked near him in the U.S. Department of Agriculture on diseases of animals.

This was early in the development of microbiology and not all scientists, especially botanists, were convinced that the diseases of plants were caused by bacterial and mycotic agents. One eminent scientist from Germany, Alfred Fisher, wrote a book entitled, "Vorlesungen uber Bakterien," (Lectures in Bacteriology). In this he stated that bacteria and molds had not been proven to cause plant diseases. Smith had both the needed experimental knowledge and the ability to write in German. He did not hesitate to engage Fisher in scientific debate. The debate, at this time, did not settle the question, but greatly enhanced the world opinion of Smith. The situation was that European scientists distrusted the American papers, while Americans accepted them and did not go along with the hypothetical ideas of the Europeans.

Smith's work covered a wide range of plant diseases and was done with very painstaking exactness. His work and that of his assistants was later proven to be essentially correct and was accepted. He had a highly analytical mind and great ability to organize and synthesize knowledge. His work in plant pathology culminated in a three volume treatise published in 1905, 1911 and 1914. The later part of his life was devoted to cancer, particularly that of crown gall. He worked on all phases of its tumorisity and morphology. He was far ahead of his time and convinced that both plant and animal tumors and cancers had similar etiologies. In 1913, he received a certificate of honor from the American Medical Association for his work on "Cancer in Plants." This is worth noting. Recognition of cancer in plants has often not received the interest of either scientists or the public.

Smith was not only a scientist but also a leader in his field. He was president, at different times, of the following associations: Society for Plant Morphology and Physiology (1902);

Society of American Bacteriologists (1906); American Association for the Advancement of Science, Section G (1906); Botanical Society of America (1910); American Phytopathological Society (1916); and the American Association for Cancer Research (1925). He also was elected a fellow of the American Academy of Arts and Sciences and made a member of the National Academy of Sciences. Although others worked on microbial diseases of plants, his work, under the auspices of the USDA was the most outstanding. Great credit should be given to him for leadership and ingenuity in furthering the work in agriculture.

Typical of the honors given him was the dinner given in his honor by the American Phytopathological Society. One hundred and seventy-two signatures of scientists were affixed to a plaque which read, "To Erwin Frank Smith, scientist, linguist, poet and friend, who for forty years has devoted his life's service to the broad field of pathology, in grateful appreciation we the members of the American Phytopathological Society dedicate this testimonial."

Smith thought of himself as the "Pasteur" of plant microbiology. He was a deep student of Pasteur's work and also published material on Pasteur. He wrote several papers on Pasteur and translated into English Emile Duchlaux's, "Pasteur: Historie d'une," (Pasteur: History and Spirit). (It is believed that evidence of his love of Pasteur is reflected in the beard that he wore).

Smith died on April 6, 1927, in his own home in Washington DC. He was 73 years old and survived by his second wife of 13 years. His interest in science is demonstrated by his desire to have his ashes scattered over the waters of Woods Hole Laboratory, from a promontory where he loved to sit and think of science. He wrote his own epitaph, "Be the my scroll; lies one beneath this sod to whom all nature voiced the living God."

His work continues as the pioneering foundation of plant pathology.

(Courtesy of Dr. King-Thom Chung, The University of Memphis)

<u>Leland Ossian Howard (Chief Bureau Entomology)</u>

Remembered (1) for his taxonomic work on parasitic insects, (2) for his part in the encouragement of biological control of insects, (3) for the early stimulus he gave to the subject of medical entomology, (4) for his foreign contacts in economic entomology, and (5) for his leadership in portraying the insect problem.

<u>Arnold Kent Balls</u>

During his twenty years of service with the U.S. Department of Agriculture he conducted outstanding research for that department in both basic and applied aspects of food enzymes.

Balls and his associates developed methods of purifying and crystallizing enzymes. Throughout his long and productive scientific career, Balls' prime interest was the understanding of the chemical nature of enzymes and their mechanisms of action. He very successfully applied the basic knowledge toward improvement and preservation of food products and other agricultural commodities. Thus, the knowledge gained from his work on the action of papain found wide practical application in the tenderizing of meat. His work on the oxidation-reduction of the proteinases of flour has provided useful information for the processing of wheat and to the baking industry in general. The investigations on the changes occurring in egg white contributed important knowledge pertaining to the problem of egg preservation. Application of the information obtained from the basic research of enzyme action by Balls and his coworkers resulted in more than twenty industrial patents in the area of food technology.

Sewall Wright

American biologist Sewall Wright (1889–1988) was an influential pioneer in the field of evolutionary genetics. Upon receiving his doctorate from Harvard, Wright moved to Washington where he became senior animal husbandman in the U.S. Department of Agriculture (USDA) from 1915 to 1925. There he took over the analysis of a colony of guinea pigs, some of which had been sib-mated for many generations. Wright's analysis of the effects of inbreeding and hybridization are classic. At the same time he continued his studies of coat color inheritance. This was the period in which Wright began to make major theoretical advances. He worked out the consequences of various mating systems, and his studies on quantitative inheritance, along with those of R. A. Fisher, became the foundation for scientific animal breeding. During this period Wright also developed what he later called the "shifting balance theory."

Theobald Smith

Theobald Smith (1859–1934). Smith was a pioneer epidemiologist, bacteriologist, and pathologist who made many contributions to medical science that were of far-reaching importance. He is best known for his work on Texas cattle fever, in which he and his colleagues discovered the protozoan agent and its means of transmission by ticks. This was the first time that an arthropod had been definitively linked with the transmission of an infectious disease.

Theobald Smith was born in 1859. He was the son of a German immigrant, who kept a small tailoring shop in Albany, New York. At age 18, Smith earned a tuition-free scholarship to Cornell University. He graduated from Cornell in 1881 with a Bachelor of Philosophy degree, and he received his MD at Albany Medical College in 1883. Realizing that his 2 years of study

had not prepared him for the practice of medicine, Smith returned to Cornell for graduate study. Smith's mentor at Cornell, Professor Simon Gage, helped him secure his first job at USDA's newly formed Bureau of Animal Industry (BAI) in Washington, DC. Smith also established a department of bacteriology at Columbian University (now George Washington University), where he taught from 1886 to 1895. This was the first department of bacteriology at a medical school in the United States.

When he went to Washington, Smith knew very little bacteriology. He had not been able go to Europe to study with men like Pasteur, Koch, or Virchow. Because he could read and speak German almost as well as English and he could read French easily, he was able to study the papers of these masters and teach himself. Within a year of his arrival in Washington, Smith introduced Koch's methods. At this time, he also began his life-long work on tuberculosis. At a later time, he successfully challenged Koch's concept that human and bovine tuberculosis were caused by the same organism.

Smith's work at BAI was extremely productive. BAI was created within the Department of Agriculture in 1884, when efforts by the states to stem the rising tide of animal diseases proved inadequate. The major problems were hog cholera, bovine pleuropneumonia, Texas cattle fever, turkey blackhead, and bovine tuberculosis. During his first 2 years at BAI, Smith discovered a new species of bacteria (*Salmonella enterica*, formerly called S*almonella choleraesuis*), which he thought was the cause of hog cholera. It was later shown that hog cholera was in fact a viral infection and Smith's bacillus was a constant but secondary invader. Although this genus of bacteria was discovered by Smith, Daniel E. Salmon, Smith's chief, claimed credit for the discovery, and the genus *Salmonella* is named after him. In 1886, Smith, collaborating with Salmon, presented the first proof that killed bacteria could be used to induce active immunity in experimental animals. This established the basis for the later development of protective immunization for human bacterial enteric diseases such as typhoid and cholera. Smith was the first person to use the fermentation tube to study bacterial physiology and classification, especially focusing on the details for differentiating aerobes, facultative anaerobes, or anaerobes and on characterizing fresh isolates thought to belong to these groups.

A few years after beginning his work at BAI, Smith turned his attention to Texas cattle fever, a devastating disease that destroyed 90% of herds in some affected areas. It occurred in northern cattle that came in contact with cattle from Texas during cattle drives to stockyards in Kansas, Missouri, Iowa, and Illinois. It was a problem of great economic and political importance. Cattle ranchers had long held a vague but persistent impression that ticks were in some manner the cause of the disease. Smith had the good sense to listen to the cattle ranchers and formulate a hypothesis based on these impressions that he tested with

searching experiments to subject it to scientific scrutiny. Some confusion exists about the part that Smith played in the Texas cattle fever discovery. Smith is widely cited as the sole person who discovered that ticks were the vectors of Texas cattle fever, when in fact, it was a collaborative effort of Smith with his colleagues, Fred L. Kilbourne and Cooper Curtice, both veterinarians. Smith never claimed this work as solely his own, even though popular accounts entirely credited him.

In 1889, Smith described little bodies in the erythrocytes of infected cattle; he later recognized (1891) them as protozoa, which he eventually named *Piroplasma bigeminum* (now called *Babesia bigemina*). Following this discovery, Smith and Kilbourne conducted experiments in which they placed southern cattle in pens with northern cattle. In some instances, ticks were left on the infected animals; in other enclosures, the ticks were removed. The researchers also kept native cattle in fields in which infected ticks had been left on the ground. These transmission experiments established beyond question the role of ticks (*Boophilus* spp.) as the carrier of this disease. Smith's 301-page monograph about the laboratory and field experiments, BAI Bulletin No. One (1893), is regarded as one of the classics of medical literature. In these experiments, it was also demonstrated that the infection could pass in ticks from adults to nymphs, a new and extraordinary phenomenon of parasitism. This research was conducted by Curtice. Delineation of the tick's life cycle soon paved the way for control of the disease by dipping cattle to kill the ticks.

The discovery by Smith et al. that insects can transmit disease represents one of the fundamental steps forward that altered the entire course of medical science and public health. It presaged the discovery in the next few years of the insect transmission of trypanosomiasis of cattle (nagana) in 1895 by David Bruce, malaria in 1897 by Ronald Ross, yellow fever in 1900 by Walter Reed and his colleagues, and typhus in 1909 by Charles Nicolle.

In 1895, Smith reported that blackhead, an economically devastating enterohepatitis of turkeys, was caused by a protozoan called *Amoeba meleagridis* (now *Histomonas meleagridis*). Later, while at the Rockefeller Institute for Medical Research, Smith resolved the puzzle of transmission by discovering that embryonated eggs of the intestinal roundworm *Heterakis papillosa* (now *Heterakis gallinae*) could transmit the amoebas. This mechanism of transmitting a protozoan remains unique in the annals of parasitology.

<u>Bernard Ogilvie Dodge</u>

In 1920 he accepted an appointment as Plant Pathologist (in fruit diseases) in the Bureau of Plant Industry of the United States Department of Agriculture and spent eight satisfying years in Washington. Although Dodge was absorbed by the fungi as such, he became involved early

in the study of them as causes of diseases in plants—especially the rusts. Over a period of twenty-two years Dodge published twenty-five papers on the plant rusts, the first in 1915 and the last in 1936. At the Bureau of Plant Industry his attention turned to the rusts of the blackberry, dewberry, and raspberry. His observations on the systemic infection of these small fruits by the orange rusts illuminated the life cycles of these parasites and suggested methods of control. His investigations included also the stem blister-rust of pines which has species of oak as the alternate host, may apple rust, the scrub pine needle rust, hollyhock rust, and rust of *Sempervivum.* It was at USDA that Dodge initiated his studies of *Neurospora. Although Dodge considered himself primarily a mycologist and plant pathologist, his studies of Neurospora are regarded by many as his major work. His investigations laid the foundation for the use of Neurospora in the investigation of genetics and biochemical genetics on a world-wide basis. Beadle, in a letter to Dodge (November i1959) said, "Without your pioneer work, those of us who have made use of Neurospora never could have done what we did Neurospora has been good to many of us and it is your baby more than anyone else's. Thanks again for giving it to genetics." Edward L. Tatum (1959) wrote in his Nobel lecture, "I shall not enumerate the factors involved in our selection of this organism [Neurospora] for the production of chemical or nutritionally deficient mutants, but must take this opportunity of reiterating our indebtedness to the previous basic findings of a number of investigators. Foremost among these, to B. O. Dodge for this establishment of this ascomycete as a most suitable organism for genetic studies; and to C. C. Lindegren, who became interested in Neurospora through T. H. Morgan, a close friend of Dodge."*

By 1928 The New York Botanical Garden had decided that it required a plant pathologist to maintain the health of its living collections, and Dr. Dodge was appointed. He remained in this position until he retired in 1947 to become Plant Pathologist Emeritus and Consultant in Mycology.