

## Burton Yoshiaki Endo 1926–2005

Burton Yoshiaki Endo, former nematologist with the United States Department of Agriculture (USDA) and an outstanding authority in the ultrastructure of nematodes and nematode-plant interactions, died 5 January 2005. He is survived by his wife Helen Endo, daughters Martha Hess and Carol Ann Endo, and two brothers, four sisters, and seven grandchildren. His first wife, Joyce Stephens Endo, died in 1985.

Burt was born on 5 February 1926, in Castroville, California. The fifth child of nine siblings, his appreciation for agriculture probably originated in his family's Depression-era production of vegetables on the land near their rental house; the vegetables were eaten by the family and sold at local markets. Burt's life, like more than 100,000 Americans of Japanese ancestry, was radically changed in 1942 when his family was ordered to sell all of its possessions within 3 weeks and report to an "assembly center" for transportation to a Japanese relocation camp. On 4 July the entire family arrived at a camp in Poston, Arizona, where they were housed in two 20-x-25-foot rooms. Sadly, Burt's mother died of cancer in the camp.

The camp experience changed Burt's life in an unexpected way. Arriving as a 15-year-old destined to apprentice as a carpenter under a prominent cabinet-maker, Burt was exposed to young men planning to attend college. He made the brave decision to enter the college preparatory program in the camp's high school. He later credited his teachers for their guidance and inspiration in choosing this direction for his life. He left Poston with a high school diploma, a clearance to live in the eastern United States, a train ticket, \$25, and the determination to enter an agricultural college. With the assistance of the American Friends Service Committee, he found such a school in Iowa State College, which, unlike some other colleges, was willing to accept evacuees.

Burt's college education was interrupted by two events. After only 1 quarter at Iowa State, he had to move to Haddonfield, New Jersey, because his older brother was drafted into the armed forces and Burt needed to help his motherless family for 2 years. He finally received a B.S. in Horticulture from Iowa State in 1951. The second interruption came 1 month later, when Burt himself was inducted into the U.S. Army. He attended Anti-Aircraft Artillery School and served as a radar specialist in California for 2 years.



In 1953, Burt enrolled at North Carolina State University, where he received an M.S. in Horticulture in 1955. His involvement with nematodes began shortly after the soybean cyst nematode was discovered in the United States for the first time in North Carolina in 1954. Burt was offered the position of "Agent Nematologist" by A. L. Taylor of the USDA, which provided funding for Burt while he pursued a Ph.D. in Plant Pathology. Burt wrote that when he told Mr. Taylor that he knew very little about nematodes, the response was "That's all right; we're all learning." Burt became involved with J.N. Sasser in some of the first experiments on chemical control of *Heterodera glycines*—while completing a doctoral dissertation on the ecology of *Pratylenchus brachyurus*.

Immediately after receiving his Ph.D. in 1958, Burt was transferred to Jackson, Tennessee, to work with James Epps in evaluating germplasm resistant to *H. glycines*. A year later, as a result of A. L. Taylor's encouragement, Burt began investigating aspects of the biology of *H. glycines*. Initially, he studied the desiccation and survival of the nematode at different temperatures and humidities. But soon he became involved in light

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microscopic studies of the interactions of this nematode with soybean roots. While in Jackson, Dr. Endo was the first scientist to study the morphological and cellular changes as *H. glycines* develops in both susceptible and resistant soybean roots.

Previously, while riding to Washington, D.C. with his family in 1946 to view the famous Japanese cherry blossoms, Burt had passed the buildings of the Beltsville Agriculture Research Center (BARC) and commented to his family, "I wish I could work there some day." His wish became reality when he was transferred to Beltsville in 1963. He took electron microscopy courses at the University of Maryland and the University of California (Berkeley) and began applying the procedure to the investigations of nematode-plant interactions, for which he became internationally famous.

Working closely with excellent electron microscopists at Beltsville (especially William Wergin and Jean Adams), Dr. Endo concentrated on the ultrastructure of the interactions between the soybean cyst nematode and soybean roots in both resistant and susceptible plants. He also used electron microscopy to make several fundamental ultrastructural discoveries about the development and life cycle of this species and the root-knot nematode.

As a result of research excellence, Dr. Endo was appointed chairman of the Plant Protection Institute at Beltsville in 1974. He served in that capacity until the reorganization of BARC in 1987. In this role, he coordinated, supervised, and directed the research activities of more than 50 research scientists plus 100 support staff in numerous disciplines within plant pathology and entomology. He organized frequent social events to promote the interactions of scientists and administrators. He strongly believed in the value of basic research and its potential to improve the economic conditions of farmers throughout the world. Under Burt's guidance, research activities within the Plant Protection Institute thrived, and Beltsville was regarded as an international leader in all areas of plant protection.

Despite his administrative workload, Dr. Endo maintained an active research career, to which he was able to devote greater energy upon his return to the laboratory bench as a full-time researcher in 1987. He pursued cytochemical and ultrastructural examinations of the infection sites of root-knot and cyst nematodes and discovered many tissue and cellular changes in hosts during the infection process. Burt made many key discoveries about the structure of the nervous, reproductive, digestive, neurosensory, and neurosecretory systems of these species as well as their interactions with resistant and susceptible host plants. He discovered ciliated neural terminals under the anterior cuticle of nematodes, which function as tactoreceptors. He demonstrated that neurosecretory materials produced by the amphidial gland nerve processes are involved in the formation of a feeding plug at the feeding site of the soy-

bean cyst nematode. His detailed observations of the stylet in molting soybean cyst nematode juveniles provided the first ultrastructural descriptions of the process of stylet formation. His detailed observations of the secretory granules in the esophageal glands of root-knot nematodes and of the muscles that control their release are being used by nematologists exploiting the molecular aspects of nematode secretions to develop novel methods of nematode control.

As Dr. Endo approached the end of his career, he broadened his studies to include the ultrastructure and development of other nematode species. He conducted comparative studies of the entomopathogenic nematodes *Steinernema* and *Heterorhabditis*, learning much about them and how they carry their bacterial symbionts that kill insect pests. He also examined the ultrastructure of the filarial nematode *Onchoerca volvulus*, the second most important cause of blindness in the world.

In addition to collaborating with researchers in many states, Burt had professional research collaborations with investigators in Egypt, England, Germany, Israel, and Japan. He retired in 1995 with nearly 100 research publications. After retirement, Dr. Endo continued to work for a few years as an unsalaried collaborator. During this period, he completed a mammoth compilation of some of his best work on the soybean cyst nematode, titled "An Atlas on the Ultrastructure of the Soybean Cyst Nematode." An appreciation of the extent of Dr. Endo's research can be obtained from a physical description of the materials he consumed. His research involved 25,000 electron microscopy copper grids; the 37,000 photographic negatives, which if laid end to end, would extend 3 miles.

Dr. Endo was a member of several professional societies. Even throughout retirement, he was a constant presence at meetings of the Society of Nematologists (SON) and the European Society of Nematologists (ESN). He served SON as secretary for 3 years and then as vice-president and president. A charter member of SON, Burt was one of the three directors of the Society named on the official Articles of Incorporation. Honors bestowed upon Dr. Endo included Fellowship (1988) and Honorary Membership (2004) in SON and fellowship in ESN (1996). The Helminthological Society of Washington bestowed upon him its Anniversary Award in 1997; he is only the third plant nematologist to receive this honor. In 2002, he received the Henry A. Wallace Award from the College of Agriculture of Iowa State University, recognizing his contributions to agriculture.

Burt Endo's success resulted from his observational skills, attention to detail, enthusiasm, curiosity, and willingness to unselfishly interact with his colleagues. A soft-spoken yet outgoing man, Burt tremendously enjoyed discussing research with others. Wherever he traveled or whenever a nematologist visited

Beltsville, Burt regarded nematologists as part of his family. His research publications were authoritative and comprehensive, thoroughly placing his ultrastructural discoveries within the context of the biological observations of others. Burt took particular pride when someone would comment favorably about the quality of his images. He was especially conscientious about sending his manuscripts to several colleagues before journal submission; Burt placed great value upon their opinions. His selflessness was exemplified in one case where a colleague reviewing a paper revealed that a graduate student was pursuing a similar project. Burt withheld the paper from submission until the graduate student's research was completed and both manuscripts were ready for submission.

Dr. Endo enjoyed the relationships in his personal life. He met his first wife, Joyce, while both were students in North Carolina; one daughter was born in North Carolina and a second in Tennessee. Like Burt's mother, Joyce died (in 1985) of cancer. In 1990, he married Helen Patchen and acquired a second family to which he grew close. Despite not having a son, Burt

was active in the Boy Scouts and served as a leader for more than 30 years, working with boys in North Carolina, Tennessee, and Maryland. He was also active in Rotary International.

In the last few years of his life, Burt wrote a small series of memoirs titled "Crossroads of Life," which I was privileged to read for comment. He distributed these memoirs to his relatives and friends, stating that his writing was "a way of thanking those who made it possible to have such a happy family life and opportunities to enjoy and make contributions to society in a career as a plant pathologist." In turn, we nematologists thank him for his scientific contributions. Those of us who knew Burt fondly remember our interactions with such an inquisitive and personable colleague.

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