Paul C. Mangelsdorf

1899–1989

BIOGRAPHICAL *Memoirs*

A Biographical Memoir by
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NATIONAL ACADEMY OF SCIENCES

PAUL CHRISTOPH **MANGELSDORF**

July 20, 1899–July 22, 1989

Elected to the NAS, 1945

By James A. Birchler

Paul Christoph Mangelsdorf made significant contributions to hybrid corn seed production, an understanding of the nutritional composition of maize, analysis of archeological maize discoveries, and botanical characterization of maize relatives and their hybrids. His passion during much of his career was for maize domestication. He served as president of the Genetics Society of America, the American Society of Naturalists, and the Society of Economic Botany. Together with E. C. Stakman of the University of Minnesota and R. Bradfield of Cornell University, he conducted an analysis of Mexican food production under the aegis of the Rockefeller Foundation. Their recommendation to form an agricultural research cooperative eventually led to the establishment of the Centro Internacional de Mejoramiento de Maiz y Trigo (CIMMYT), which further led to the Green Revolution. Mangelsdorf was elected to the Academy in 1945.

Paul Mangelsdorf was born on July 20, 1899, in Atchison, Kansas. His father operated a seed and greenhouse business, which influenced his career trajectory. He enrolled at Kansas State College (now Kansas State University) and graduated in 1921. During this time he was a research assistant for John H. Parker, who was involved with wheat breeding. After graduation he joined the Connecticut Agricultural Experimental Station as an assistant to Donald F. Jones and also entered Harvard University's graduate school to work with Edward M. East. He received his Sc.D. in 1925.

Mangelsdorf married Helen Parker in 1923. They had two sons, Paul Christoph and Clark Parker. Helen Mangelsdorf became an active participant in her husband's laboratory endeavors, collecting expeditions, and manuscript writing and editing.

According to John Doebley, Mangelsdorf told an amazing story about how he got into the graduate program at Harvard: He grew up in Kansas and had little experience of the outside world. At the time at Kansas State there were no admissions requirements, and

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the college sent recruiters out to farms and rural communities around the state to bring students to KSC. Mangelsdorf assumed this was how all higher education institutions operated, so he thought the only thing he needed in order to enroll at Harvard was a desire to do so. Accordingly, he wrote to Edward East, saying that he had decided to join the doctoral program at Harvard and that he would arrive on such and such a day and come to East's office at a specific time.

East kept this appointment out of curiosity about this brash-seeming young man and during their meeting informed him of the need to apply for admission and meet certain prerequisites. East asked Mangelsdorf whether he knew any foreign languages. The young man said that he knew German. East asked whether he knew French and asked him to translate a French paragraph, which he managed to do, having studied French in school. Then, East asked what other languages Mangelsdorf knew, to which he answered "none." East's response was that two foreign languages were hardly enough for a graduate student, as science was becoming quite international. Nevertheless, East allowed Mangelsdorf to enroll, and the rest, as they say, is history.

According to his former graduate student Garrison Wilkes, Mangelsdorf would also recount the story that he was named Paul Christoph (PC) because his mother wanted him to Preach Christ when he grew up. What he did instead, he said, was to Plant Corn. Following his training at Harvard for this career path, in 1927 Mangelsdorf took a job as an agronomist at the Texas Agricultural Experiment Station in College Station. There he worked on developing hybrid corn for Texas and, with other researchers, new varieties of wheat, oats, and barley.

In 1931 Mangelsdorf, together with G. S. Fraps published a paper in *Science* that had a significant impact on maize cultivation practices. This paper dealt with the production of vitamin A—or carotenoid—in corn kernels by the *yellow1* locus. Maize kernels homozygous for one form of the gene have a white appearance due to the lack of carotenoid pigment in the storage tissue of the kernel, the endosperm. Kernels homozygous for the other form are yellow, which results from production of carotenoids. By producing kernels with different amounts of the yellow form and feeding these to rats, they observed that an increasing dose of the yellow form of maize led to elevated pigment levels—indicating higher levels of vitamin A—and thus produced healthier rats. Because of this experiment, the commercial corn industry, which produces corn primarily used for animal feed, converted almost entirely to the yellow variety.

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In a response to the published hypothesis, George W. Beadle proposed in 1939 that a wild Mexican grass called teosinte with the same chromosome number as maize was the progenitor, based on crosses between maize and this grass that he had made while a graduate student at Cornell in 1932. Mangelsdorf and Reeves dismissed this idea, arguing that teosinte was instead a hybrid of wild maize and another related grass, Tripsacum, despite the fact that Tripsacum differs in chromosome number from maize. Today, however, it is generally accepted that teosinte is indeed the progenitor of corn, based on a large body of genetic, molecular, and archeological evidence as reviewed by Doebley (2004).

Nevertheless, in the process of studying maize domestication, Mangelsdorf and his colleagues defined many genetic and biogeographical aspects of both teosinte and Tripsacum. They produced numerous genetic crosses between these two species and corn and characterized the hybrids.

In 1940 Mangelsdorf joined the Harvard faculty as professor of economic botany. In 1945 he became director of the Botanical Museum, a post he held until 1967. In 1962 he was appointed Fisher Professor of Natural History. As director of the Botanical Museum he strengthened the areas of paleobotany and orchid taxonomy. From 1947 until 1966 he also was chairman of Harvard's Institute for Research in Experimental and Applied Botany and thus oversaw the Arnold Arboretum, the Atkins Garden and Research Laboratory in Cuba, the Bussey Institution, the Maria Moors Cabot Foundation for Botanical Research, and the Harvard Forest.

Before Mangelsdorf worked with them, East and Jones had solved a major problem in the production of hybrid corn. Hybrids, of course, are far superior in yield than inbred varieties. However, it was difficult to produce sufficient hybrid seed for sale to farmers by crossing different inbred lines, due to their inferior performance. East and Jones discovered that by making hybrids and then hybrids of these hybrids, they could produce much more seed. They named this procedure the double cross hybrid method. Despite this advance, however, production of hybrid corn remained cumbersome, because it was necessary to remove the male flowers from the plants that would eventually bear ears of hybrids.

To overcome this problem, Mangelsdorf and Jones developed and patented a method to facilitate the production of hybrid seed by employing cytoplasmic male sterility (cms) and nuclearly encoded restorers of fertility. The cms character was maternally inherited (and is now known to be a mutant form of the mitochondrial genome); it causes pollen abortion. Therefore, it could be used to eliminate the need to remove the male flowers during hybrid seed production. However, the hybrid plants need to be fertile themselves, and this Mangelsdorf and Jones accomplished by using the nuclearly inherited restorer of fertility in the paternal parent of the hybrids, which conferred fertility despite the hybrids' having inherited the cms character maternally. The proceeds from this patent now fund the Paul C. Mangelsdorf Professorship in Natural Science at Harvard.

Mangelsdorf participated with E. Wellhausen, L. M. Roberts, and E. Hernandez in collecting races of maize in Mexico. They assembled and cataloged varieties that were grown in different locales. Using this effort as a model, they eventually completed and characterized collections of races of corn from most parts of the Western Hemisphere. These collections continue to serve as a valuable source of genetic variation of corn for plant breeding and basic research.

Mangelsdorf was also involved in supporting and interpreting archeological finds of ancient maize, first at Bat Cave in New Mexico. Subsequently he was asked to analyze samples from La Perra and Infiernillo Caves in Mexico. Different "races" of maize were found in relatively close proximity to one another, demonstrating that distinct varieties had been cultivated in somewhat nearby locales. Further studies of several caves in Mexico and the southwestern United States revealed that early specimens, dated at the time to 4400 years BP, were clearly maize-like and resembled some extant races in Mexico. In digs from more recent strata, samples dated to about 1250 years BP illustrated the spread of a larger-ear variety with more kernel rows. On the other hand, samples from the Tehuacan Valley pushed back the existence of cultivated maize to at least 7000 years BP. Notably, the earliest corncobs described were soft and fragile, certainly generations removed from teosinte.

In 1941 Mangelsdorf became a consultant in agriculture to the Rockefeller Foundation, a relationship that continued until his retirement in 1968. The program that Mangelsdorf and fellow Rockefeller consultants initiated in Mexico evolved into CIMMYT and the related International Rice Research Institute (IRRI), which eventually spawned the Green Revolution. This effort was propelled by Norman Borlaug, who was awarded the Nobel Peace Prize in 1970 for his contributions to combating world hunger. CIMMYT and IRRI have continued to enhance production of crops that feed a substantial proportion of the world's population, which stands as a major legacy of the work of Mangelsdorf and his colleagues.

Mangelsdorf retired from Harvard in 1968 and moved to Chapel Hill, North Carolina, and continued his life's work at UNC. Harvard awarded him an honorary doctorate in 1977. He died in Chapel Hill on July 22, 1989, two days after his 90th birthday.

Mangelsdorf's driving force and scientific philosophy are perhaps best summarized by a passage from his biographical sketch from 1960, which resides in the Harvard University Archives:

> *In recent years all of my research has been concerned with exploring the corn plant as one of those unique biological systems, which man exploits on a grand scale to convert the energy of the sun, the carbon dioxide of the atmosphere and the minerals of the soil into food. Corn is one of perhaps not more than a dozen species of cultivated plants of worldwide importance—each one the principal source of food of millions of people—which quite literally stand between mankind and starvation. In this period of a rapidly expanding world population, botanists need to know as much about each of these plants as is known about the principal destructive agents of the world just as medical scientists, for example, know about man's most serious diseases, or engineers know about the world's bombers or guided missiles.*

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I have relied on information about Mangelsdorf's scientific contributions provided by the Harvard University Archives and from his book, *Corn, Its Origin, Evolution and Improvement*, 1974, Cambridge, MA: Harvard University Press.

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