Edward Lorenz, father of chaos theory and butterfly effect, dies at 90

April 16, 2008

Edward Lorenz, an MIT meteorologist who tried to explain why it is so hard to make good weather forecasts and wound up unleashing a scientific revolution called chaos theory, died April 16 of cancer at his home in Cambridge. He was 90.

A professor at MIT, Lorenz was the first to recognize what is now called chaotic behavior in the mathematical modeling of weather systems. In the early 1960s, Lorenz realized that small differences in a dynamic system such as the atmosphere--or a model of the atmosphere--could trigger vast and often unsuspected results.

These observations ultimately led him to formulate what became known as the butterfly effect--a term that grew out of an academic paper he presented in 1972 entitled: "Predictability: Does the Flap of a Butterfly's Wings in Brazil Set Off a Tornado in Texas?"

Lorenz's early insights marked the beginning of a new field of study that impacted not just the field of mathematics but virtually every branch of science--biological, physical and social. In meteorology, it led to the conclusion that it may be fundamentally impossible to predict weather beyond two or three weeks with a reasonable degree of accuracy.

Some scientists have since asserted that the 20th century will be remembered for three scientific revolutions--relativity, quantum mechanics and chaos.

"By showing that certain deterministic systems have formal predictability limits, Ed put the last nail in the coffin of the Cartesian universe and fomented what some have called the third scientific revolution of the 20th century, following on the heels of relativity and quantum physics," said Kerry Emanuel professor of atmospheric science at MIT. "He was also a perfect gentleman, and through his intelligence, integrity and humility set a very high standard for his and succeeding generations."

Born in 1917 in West Hartford, Conn., Lorenz received an AB in mathematics from Dartmouth College in 1938, an AM in mathematics from Harvard University in 1940, an SM in meteorology from MIT in 1943 and an ScD in meteorology from MIT in 1948. It was while serving as a weather forecaster for the U.S. Army Air Corps in World War II that he decided to do graduate work in meteorology at MIT.

"As a boy I was always interested in doing things with numbers, and was also fascinated by changes in the weather," Lorenz wrote in an autobiographical sketch.

Lorenz was a member of the staff of what was then MIT's Department of Meteorology from 1948 to 1955, when he was appointed to the faculty as an assistant professor. He was promoted to professor in 1962 and was head of the department from 1977 to 1981. He became an emeritus professor in 1987.

Lorenz, who was elected to the National Academy of Sciences in 1975, won numerous awards, honors and honorary degrees. In 1983, he and former MIT Professor Henry M. Stommel were jointly awarded the $50,000 Crafoord Prize by the Royal Swedish Academy of Sciences, a prize established to recognize fields not eligible for Nobel Prizes.

In 1991, he was awarded the Kyoto Prize for basic sciences in the field of earth and planetary sciences. Lorenz was cited by the Kyoto Prize committee for establishing "the theoretical basis of weather and climate predictability, as well as the basis for computer-aided atmospheric physics and meteorology." The committee added that Lorenz "made his boldest scientific achievement in discovering 'deterministic chaos,' a principle which has profoundly influenced a wide range of basic sciences and brought about one of the most dramatic changes in mankind's view of nature since Sir Isaac Newton."

During leaves of absence from MIT, he held research or teaching positions at the Lowell Observatory in Flagstaff, Ariz.; the Department of Meteorology at the University of California at Los Angeles; the Det Norske Meteorologiske Insitutt in Oslo, Norway; and the National Center for Atmospheric Research in Boulder, Colo.

An avid hiker and cross-country skier, Lorenz was active up until about two weeks before his death, his family said.

Lorenz is survived by three children, Nancy, Edward and Cheryl, and four grandchildren.

A memorial service will be held at 3 p.m. Sunday, April 20, at the Swedenborg Chapel, 50 Quincy St., Cambridge. The MIT News Office will update this announcement as more details become available.

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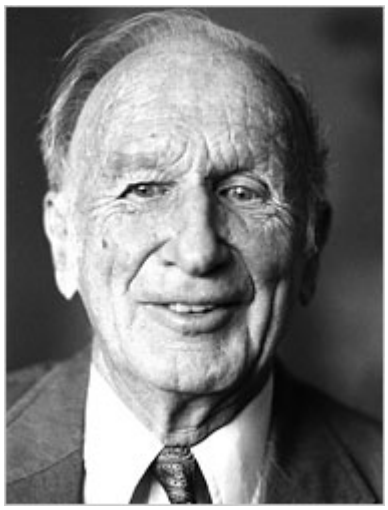

M.I.T. News Office

Edward N. Lorenz

The cause was cancer, said his daughter Cheryl Lorenz.

In discovering “deterministic chaos,” Dr. Lorenz established a principle that “profoundly influenced a wide range of basic sciences and brought about one of the most dramatic changes in mankind’s view of nature since Sir Isaac Newton,” said a committee that awarded him the 1991 Kyoto Prize for basic sciences.

Dr. Lorenz is best known for the notion of the “butterfly effect,” the idea that a small disturbance like the flapping of a butterfly’s wings can induce enormous consequences.

As recounted in the book “Chaos” by James Gleick, Dr. Lorenz’s accidental discovery of chaos came in the winter of 1961. Dr. Lorenz was running simulations of weather using a simple computer model. One day, he wanted to repeat one of the simulations for a longer time, but instead of repeating the whole simulation, he started the second run in the middle, typing in numbers from the first run for the initial conditions.

The computer program was the same, so the weather patterns of the second run should have exactly followed those of the first. Instead, the two weather trajectories quickly diverged on completely separate paths.

At first, he thought the computer was malfunctioning. Then he realized that he had not entered the initial conditions exactly. The computer stored numbers to an accuracy of six decimal places, like 0.506127, while, to save space, the printout of results shortened the numbers to three decimal places, 0.506. When typing in the new conditions, Dr. Lorenz

had entered the rounded-off numbers, and even this small discrepancy, of less than 0.1 percent, completely changed the end result.

Even though his model was vastly simplified, Dr. Lorenz realized that this meant perfect weather prediction was a fantasy.

A perfect forecast would require not only a perfect model, but also perfect knowledge of wind, temperature, humidity and other conditions everywhere around the world at one moment of time. Even a small discrepancy could lead to completely different weather.

Dr. Lorenz published his findings in 1963. “The paper he wrote in 1963 is a masterpiece of clarity of exposition about why weather is unpredictable,” said J. Doyne Farmer, a professor at the Santa Fe Institute in New Mexico.

The following year, Dr. Lorenz published another paper that described how a small twiddling of parameters in a model could produce vastly different behavior, transforming regular, periodic events into a seemingly random chaotic pattern.

At a meeting of the American Association for the Advancement of Science in 1972, he gave a talk with a title that captured the essence of his ideas: “Predictability: Does the Flap of a Butterfly’s Wings in Brazil Set Off a Tornado in Texas?”

Dr. Lorenz was not the first to stumble onto chaos. At the end of the 19th century, the mathematician Henri Poincaré showed that the gravitational dance of as few as three heavenly bodies was hopelessly complex to calculate, even though the underlying equations of motion seemed simple. But Poincaré’s findings were forgotten through the first three-quarters of the 20th century.

Dr. Lorenz’s papers also attracted little notice until the mid-1970s.

“When it finally penetrated the community, that was what started people to really start to pay attention to this and led to tremendous development,” said Edward Ott, a professor of physics and electrical engineering at the University of Maryland. “He demonstrated a chaotic model in a real situation.”

Born in 1917 in West Hartford, Conn., Edward Norton Lorenz received a bachelor’s degree in mathematics from Dartmouth College in 1938 and a master’s degree in math from Harvard in 1940. He worked as a weather forecaster during World War II, leading him to pursue graduate studies in meteorology; he earned master’s and doctoral degrees in meteorology from the Massachusetts Institute of Technology in 1943 and 1948.

Dr. Lorenz was a staff member of M.I.T.’s meteorology department from 1948 to 1955, when he became an assistant professor. He was promoted to professor in 1962 and served as head of the department from 1977 to 1981. He became an emeritus professor in 1987.

In addition to his daughter Cheryl, of Eugene, Ore., Dr. Lorenz is survived by another daughter, Nancy Lorenz of Roslindale, Mass; a son, Edward H. Lorenz of Grasse, France; and four grandchildren. His wife, Jane, died in 2001.

Dr. Lorenz remained active almost to the end of his life, in both research and outdoor activities.

“He was out hiking two and one-half weeks ago,” Cheryl Lorenz said, “and he finished a paper a week ago with a colleague.”