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—Sketch by Roger Jaffe

Evelyn Maisel Witkin
1921-
American geneticist

Evelyn Maisel Witkin is a specialist in bacterial mutation who has published more than forty-five papers in journals such as *Proceedings of the National Academy of Sciences, Bacteriological Reviews,* and *The Cold Spring Harbor Symposia of Quantitative Biology.* Her research focused on the genetic effects of radiation, spontaneous and induced mutation in bacteria and the enzymatic repair of DNA damage.

Witkin was born in New York City on March 9, 1921, the daughter of Joseph Maisel and the former Mary Levin. After completing high school, she attended New York University, from which she received her bachelor of arts degree magna cum laude in 1941. She then did her graduate work at Columbia University and received her master of arts degree in 1943 and her Ph.D. in 1947. Between 1947 and 1949 Witkin did postdoctoral research at the American Cancer Society. On July 9, 1943, she was married to Herman A. Witkin, with whom she had two children, Joseph, born in 1949, and Andrew, born in 1952. Witkin's husband died in July of 1979.

Begins Teaching Career

In 1950 Witkin accepted an appointment as a member of the genetics department at the Carnegie Institute in Washington, D.C., a post she held until 1955. She was then appointed to the faculty at the Downstate Medical Center of the State University of New York (SUNY) in Brooklyn. She remained at SUNY until 1971, rising to the rank of professor of medicine. In 1971 Witkin became professor of biological sciences at Douglass College of Rutgers University. Eight years later she was named Barbara McClintock Professor of Genetics at Douglass. On her retirement in 1991, she was made Barbara McClintock Professor Emerita.

In addition to her role as a teacher, Witkin also served as editor of the journal *Microbial Genetics* from 1950 to 1964 and as a member of the editorial board of *Mutation Research* since 1960. Among the honors accorded Witkin have been the Prix Charles Leopold Mayer of the French Academy of Sciences in 1977 and the Lindback Award in 1979. She was also elected to membership in the National Academy of Sciences.

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—Sketch by David E. Newton

Edward Witten
1951-
American mathematical physicist

Edward Witten's work combines physics with advanced mathematical techniques, and he has made major contributions to the field of theoretical physics. Many consider him not only the most brilliant physicist of his generation but a rival to greats such as **Albert Einstein** and Isaac Newton. He is best known for his work on a unified theory of physics called superstring theory, which theorizes that the universe is composed of extremely small particles called strings and posits the existence of ten dimensions.

Witten was born on August 26, 1951, in Baltimore, Maryland. He is the son of Louis W. Witten, a gravitational physicist who is currently at the University of Cincinnati in Ohio. Witten went to a Baltimore Hebrew school as a child and then attended Brandeis University near Boston, Massachusetts. He graduated

with a degree in history in 1971, although his real interest was linguistics. After graduation he wrote articles for such publications as the *Nation* and the *New Republic.* In 1972 he worked on George McGovern's campaign for president as an aide to a legislative assistant, but he decided against a career in journalism or politics in favor of returning to school. He was still considering whether to study physics or mathematics when he entered the doctoral program at Princeton University; he earned his master's degree in physics in 1974 and his Ph.D. in 1976.

In 1977 Witten was named junior fellow of the Society of Fellows at Harvard University. Despite receiving several offers from other universities, Witten returned to Princeton in 1980, where he was named full professor in the department of physics at the age of twenty-eight. Although highly respected by his students, Witten's behavior occasionally made him seem otherworldly. Habits such as frequent long pauses for thought during his unusually soft-spoken lectures caused some students at Princeton refer to him as "The Martian."

Witten's early research remained relatively close to traditional physics. He studied electromagnetism, as well as the forces that hold the nuclei of atoms together and the forces responsible for nuclear decay. While a professor at Princeton, Witten excelled in developing new approaches to describing the universe with quantum theory. By 1982 he had become very interested in supersymmetry—a theory which describes how matter and energy particles can be interchanged. In that year he was awarded a MacArthur Fellowship, an honor he earned for his many original theoretical proposals. By the mid 1980s, Witten found himself increasingly drawn to the search for a unified theory in physics, one which would explain all the forces in the universe with a single set of rules. Traditional theories of physics lack a single model that explains all the observed forces in this way.

To search for a unified theory, Witten studied the fundamental building blocks of everything from atoms to the cosmos. He used advanced mathematics, which allowed him to describe these fundamental building blocks using more dimensions than the four used in traditional physics, and in doing so he drew on the work of a number of mathematicians and theoretical physicists who had preceded him. In 1918, a German physicist named Theodor Kaluza attempted to use a fifth dimension to explain inconsistencies between gravity and other laws of nature, particularly electromagnetism. The principal difficulty with Kaluza's theory was that it did not explain why the fifth dimension was not observable. In 1926, the Swedish mathematician Oskar Klein elaborated on Kaluza's theory by explaining a possible reason for failures to find the fifth dimension. He suggested the fifth dimension was so compact or "rolled up" that it existed, in effect, between subatomic particles and was thus too small to be seen by any known technology. The combination of these two ideas is called the Kaluza-Klein theory, and Witten used it in his effort to develop an understanding of the characteristics shared by all the forces found in nature.

String theory had been proposed earlier in the 1970s as a possible unified theory. String theory differed from traditional theories in two basic ways: the shape of the fundamental building blocks it proposed and the number of dimensions used to describe those blocks. According to theories of physics before quantum theory, the fundamental building blocks are tiny ball-shaped pieces of matter. These particles move in a world which is described with the four traditional dimensions of length, width, depth, and time. Forces such as gravity and electricity cause the particles to move. This view of the universe was revolutionized by quantum theory, which proposed that the fundamental building blocks are really locations where matter and energy become interchangeable. The existence of matter results from fields of energy, energy which exists in varying amounts with varying patterns of resonances. The problem with quantum theory, however, is that it cannot account for gravity, and string theory began as an effort to solve this problem. String theory proposes that the fundamental building blocks are mathematical curves or strings formed into loops and that these shapes can only be described with more than four dimensions. Different vibrations of the strings create the many types of matter and energy found in the universe; an example these theorists use is the way different vibrations of the strings on a musical instrument create many different sounds.

Witten first learned about string theory in 1975, and studying it allowed him to combine his unusual mathematical abilities with advanced theoretical physics. Little attention was given to string theory for many years after its introduction, and Witten played a major role in popularizing it among physicists. One problem with the theory was that it originally proposed the existence of twenty-six dimensions, a concept many physicists found difficult to accept. In the 1970s, two researchers combined string theory and supersymmetry into superstring theory, which only required ten dimensions. However, a ten-dimensional universe still had six dimensions more than most physicists were prepared to believe existed, so string theory remained relatively unpopular. In 1984, Witten wrote an important paper with **Luis Alvarez** which identified new anomalies in certain kinds of radioactive decay. Anomalies are mathematical inconsistencies or theoretical defects that yield unacceptable results. Witten and Alvarez first established that these anomalies were topological, or related to intrinsic geometric shapes. They then showed that the topology of these anomalies could only be studied

using ten dimensions but not using four dimensions. A paper written in response to theirs showed how string theory could explain the elements as well.

By 1985 Witten was completely committed to the study of string theory. He became its foremost proponent, writing nineteen papers about the theory in that year alone. Witten also won both the Einstein Medal and the New York Academy of Science's Award for Physics and Math Science in 1985. The following year the National Science Foundation awarded him its Alan T. Waterman Award for his work in elementary-particle physics and its application to cosmology. In an interview with *Scientific American* Witten remarked: "It was very clear that if I didn't spend my life concentrating on string theory, I would simply be missing my life's calling." A number of traditional physicists remain skeptical about the theory, primarily because the existence of ten dimensions is not substantiated by anything except mathematics. But Witten has observed, as quoted in the *New York Times Magazine,* that mathematical consistency has been "one of the most reliable guides to physicists in the last century."

Witten ended his teaching career in 1987 and joined the Institute for Advanced Study at Princeton, where research is the focus. To delve deeper into string theory Witten created a new technique which combined topology and quantum field theory, naming it topological quantum field theory. He applied his technique to the adjacent mathematical field of knot theory as well as to string theory. According to Witten, his discovery of new symmetries in knot theory using topological quantum field theory was his "single most satisfying piece of work." And for this work, Witten shared the Fields Medal, the most prestigious prize in mathematics, in 1990.

Witten is married to Chiara Nappi, who is also a physicist at Princeton University. They have three children. He is active in the Middle East peace movement through the Tel Aviv based International Centre for Peace in the Middle East, and he traveled to Jerusalem in order to attend their Emergency World Jewish Leadership Peace Conference. He is also a board member of Americans for Peace Now.

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—Sketch by David N. Ford

Georg Wittig
1897-1987
German chemist

Organic chemist Georg Wittig's investigations led him to discover in 1953 a chemical process for synthesizing complex compounds such as vitamin A, vitamin D derivatives, steroids, and biological pesticides. Because of this process, known as the Wittig reaction, such compounds can now routinely be synthesized. For his work in organic synthesis, and especially for the Wittig reaction, he shared the 1979 Nobel Prize in chemistry with **Herbert C. Brown.**

Georg Friedrich Karl Wittig was born on June 16, 1897, in Berlin, Germany, to Gustav Wittig, a professor of fine arts at the University of Berlin, and Martha (Dombrowski) Wittig. He went to grade school at the Wilhelms-Gymnasium in Kassel. In 1916 he enrolled at the University of Tübingen, but

NOTABLE TWENTIETH-CENTURY SCIENTISTS

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