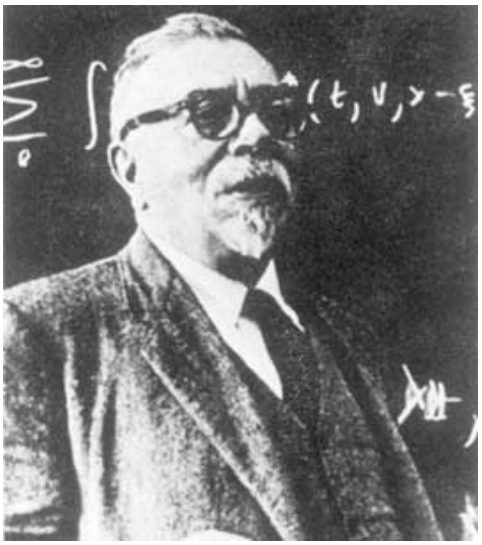
Norbert Wiener



With this short account we can only briefly touch on the life and career of one of the most colorful and eccentric mathematical geniuses of the 20th century, **Norbert Wiener** (November 26, 1894 – March 18, 1964). One could fill the available space with nothing but amusing stories about his legendary other-mindedness that significantly contributed to the stereotypical image of mathematics professors. He founded a new discipline – cybernetics the study of control and communication in animals and machines. This has had a powerful influence on a generation of post WWII scientists, inspiring a great deal of research into the potential to extend human capabilities with interfaces to sophisticated electronics. Wiener sought to understand the principles governing the relationship between computing machines and the human nervous system. While his vision was that of a society in which machines would free people from repetitive drudgery so they might have time for more creative pursuits, he also was concerned about the dangers of dehumanization and displacement. His predictions about the coming "automatic age" included his view that many machines would have "brains of brass and sinews of iron." He wrote in *The Human Use of Human Beings* (1950/1954):

> "… the machine … which can learn and can make decisions on the basis of its learning, will in no way be obliged to make such decisions as we should have made, or will be acceptable to us. For the man who is not aware of this, to throw the problem of responsibility on the machine, whether it can learn or not, is to cast his responsibility to the winds, and to find it coming back seated on the whirlwind."

A child prodigy, Norbert was the son of Russian-born Leo Wiener and Bertha Kahn, the daughter of a prominent American department store owner. Leo was a former medical and engineering student at the University of Warsaw and the University of Berlin, who, unhappy with both fields, immigrated to the United States in 1880. After working as a laborer in various cities, he landed a teaching job in Kansas City and eventually a position as a Professor of Modern Languages at the University of Missouri in Columbia where he met and married Bertha, and where Norbert was born. Shortly thereafter the family moved to Boston where Leo taught at various schools before becoming a Professor of Slavic Languages and Literature at Harvard. Norbert, who read fluently at three, credited his family and his father's extensive library of books on every imaginable subject for his own very wide interests.

Wiener went to the Peabody School when he was seven, but his reading at home put him far ahead of his older classmates in many areas and far behind in others. He was rather poor at the manipulative aspects of arithmetic, leading Leo to take him out of school so he could manage his son's education and systematically produce a genius. According to Norbert, Leo was a tyrannical taskmaster and a bully; every mistake had to be corrected as it was made. Norbert wrote: "My lessons often ended in a family scene. Father was raging, I was weeping and my mother did her best to defend me, although hers was a losing battle." In one of his books, Wiener dedicated it to his father, writing, "to my closest mentor and dearest antagonist." Wiener's eyesight was very poor, causing him to be ordered not to read for six months to give his eyes time to recover. In the interim, Leo taught Norbert to do mental mathematics - a skill that enabled him to see mathematics in nonverbal ways.

At nine Wiener was put in Ayer High School, where his classmates were seven years older. Leo continued to coach his son and when Norbert graduated from high school at age eleven he was well prepared for the next phase of his education at Tufts College. Although he excelled as a student, he was

still socially a child, and his time spent as an undergraduate was often unpleasant. He graduated from Tufts at fourteen with a degree in mathematics and then entered Harvard. Wiener toyed with the idea of studying zoology but this proved impossible due to his poor eyesight and coordination, which made him useless in the laboratory. He used a scholarship he won to attend Cornell in 1910 to study philosophy. After a year Wiener returned to Harvard, and, at the age of 18, received a Ph.D. for a dissertation on the boundary between philosophy and mathematics under the direction of Karl Schmidt. A Harvard traveling fellowship allowed Wiener to go to Cambridge to study with Bertrand Russell, who told him he needed to learn more mathematics and directed him to take courses with G.H. Hardy. Although Wiener was greatly influenced by Hardy, he came to view the latter's disdain and condescension of applications as "pure escapism."

In 1914 Wiener traveled to Göttingen to study differential equations with Hilbert and group theory with Landau. Back in the United States, Wiener taught philosophy at Columbia and Harvard, and mathematics at the University of Maine, worked for the General Electric Company, followed by a position as staff writer with Encyclopedia Americana, and then a year as a journalist for the *Boston Herald*. During World War I, he accepted an invitation from Oswald Veblen to do war work on ballistics at the Aberdeen Proving Ground in Maryland, where he helped formulate mathematical tables used to determine where guns should be aimed before firing. It was at this time that his interest in mathematics revived.

At the end of the war, he took a position as an instructor in mathematics at the Massachusetts Institute of Technology (MIT), which had just moved from the Boston side of the Charles River to the newly constructed buildings in Cambridge. At the time the mathematics department of MIT was primarily a service department to the engineering school and was not particularly distinguished. Through his intellectual virtuosity and curiosity, Wiener played a profound role in transforming MIT from a

technical school into a unique university, famous for scientific and technological training as well as research. Wiener did not attract the attention of more prestigious mathematics departments such as Harvard or Princeton, because he did not have a graduate degree in mathematics (and never would have one), had published nothing in mathematical journals, and was a miserable teacher. At the time of the appointment at MIT, Wiener was 24; by the time he was 30, he was at the top of the mathematical world. Two years shy of his fortieth birthday, the American Mathematical Society awarded him the Böcher Prize, which he shared with Marston Morse. Wiener passed through the various ranks, becoming a full professor in 1932, and remained on the MIT faculty until his retirement in 1960.

During the early 1920s Wiener frequently visited mathematicians in England, France and Germany. In 1926, he married Margaret Engermann and then set off for Europe as a Guggenheim scholar, his wife joining him after completing her teaching duties in modern languages at Juniata University in Pennsylvania. At MIT Wiener constructed a mathematical theory of Brownian motion, which led him to the theory of probability and the study of harmonic analysis. His work in these areas sparked his interest in how information was transmitted and processed, both in humans and machines. He felt that pure communication processes involved similar, definable elements, whether conducted by humans or machines. He reasoned that if these elements, or messages, once adequately defined, could be rigorously controlled, they could also be used to control both machines and human beings. It would then follow that by being able to modify behavior by learning from these processes, humans and machines both could evolve to higher levels of functioning.

Wiener coined the word *cybernetics* from the Greek *kybernetes*, meaning “steersman,” to describe both his theories and those arising from similar research by other noted scientists and mathematicians, among them Vannevar Bush, Claude Shannon, Alan Turing and John von Neumann. When a steersman moves a rudder, the course of his boat changes. When the steersman notes that the previous course

change is too much, he once again moves the rudder, in the opposite direction. It is the feedback of the steersman's senses that is the controlling agent that keeps the craft on its intended course. The term cybernetics led to numerous neologisms such as cyberspace. Wiener is responsible for the introduction into mathematics and science of the words: input, output, signal, signal-to-noise ratio, uncertainty, redundancy, bits and chunks of information, information processing, encoding, etc. He predicted the mass production of affordable computers for uses in businesses, but did not foresee how quickly industry would reduce the size and cost of computers so that they would find use in almost everything.

During WWII, Wiener worked on the problem of pointing a gun to fire at a moving target. His studies in controlling mechanisms helped develop new programs for ballistics guidance based on theories of feedback. He recognized the fundamental relationship between two basic problems – communication and control. Wiener asserted that a machine that changes its responses based on feedback is a machine that learns. By the end of 1946 he decided he would no longer participate in weapons-related research. His research before, during and after the war led to the publication of *Cybernetics, or Control and Communication in the Animal and Machine* (1948). In it, Wiener described a world focused on information, rather than energy; and on digital and numeric processes, not machine or analog. His theories largely predicted the future development of computers. He was convinced that biology, even sociology and anthropology, would be as profoundly affected by cybernetics as electronics theory or computer engineering. Wiener expressed his view of the central importance of information in human life:

> "Information is a name for the content of what is exchanged with the outer world as we adjust to it, and make our adjustment felt upon it. The process of receiving and of using information is the process of our adjusting to the contingencies of the outer environment, and of our living effectively with that environment. The needs and complexity of modern life make greater

demands on this process of information than ever before…. To live effectively is to live with adequate information. Thus, communication and control belong to the essence of man's inner life, even as they belong to his life in society."

Besides cybernetics, Wiener contributed new ideas to widely divergent subjects, including mathematical prediction theory and quantum theory. Applying his theoretical description of Brownian movement to quantum phenomena, he showed how quantum theory, to the extent it is based on probability, is consistent with other branches of science. No single discipline was large enough to hold all his interests. While recuperating from a fall, he spurred the development of an improved prosthetic arm. He and Mexican cardiologist Arturo Rosenblueth studied the rhythms of the human heart. With electrical engineer and future MIT president Jerome Wienser, he developed a glove for deaf persons that sensed vibrations.

Wiener was extremely near-sighted, physically clumsy, arrogant, moody and suspicious. He was noted for his goatee, three-piece suits and ever-present cigars. Hans Freudenthal described him:

"In appearance and behavior, Norbert Wiener was a baroque figure, short, rotund, and myopic, combining these and many qualities in extreme degree. His conversation was a curious mixture of pomposity and wantonness. He was a poor listener. His self-praise was playful, convincing, and never offensive. He spoke many languages but was not easy to understand in any of them. He was a famously bad lecturer."

Wiener wrote two excellent autobiographies, *Ex-Prodigy: My Childhood and Youth* (1953) and *I Am a Mathematician* (1956). In *The Human Use of Human Beings* (1950), Wiener warned of the dangerous implications of cybernetics and automation, and feared might automation cause mass unemployment.

He reminded the scientific community of their special responsibilities regarding the apocalyptic weaponry they had created. He felt that in order for mathematicians to be effective they needed to realize how their efforts affect the changing nature of society and to develop a sense of social responsibility. A few weeks before his death, Wiener was awarded the National Medal of Science. He died during a trip to Stockholm, Sweden on March 18, 1964.

There are many stories, perhaps apocryphal, illustrating Wiener's lack of concern for mundane things because his mind was occupied on more esoteric items. Here's just one: Once a student who wished to approach Wiener, but was too shy to do so, walked into the MIT post office and found that Wiener was standing at a table staring at a piece of paper and appearing deep in thought. Seeing the great man's intense concentration, the student was about to leave when Wiener whirled around and almost ran into him. The latter exclaimed, "Why, Professor Wiener!" Wiener slapped his hand to his forehead and said, "Wiener, yes that's it."

As an undergraduate, I read Wiener's *Cybernetics*, but the combination of my inexperience and his chaotic writing style made the going very difficult. *The Human Use of Human Beings* was more digestible but disturbing, for it portrayed automation as a bogeyman. Perhaps it was my youthful optimism about the potential of the theory he had described and for which he coined its name, but I felt he was being unduly gloomy. In some respects he seemed like those who predicted that the Industrial Revolution would cause economic and social disaster. But there were such disasters, horrible disasters, as related in the works of Charles Dickens and others. It was not the technology, per se, that Wiener was warning about, but rather the unwise way people might use it. Fortunately, his dire prophecies were for the most part not realized, but he was right to issue the warning, reminding people of their responsibility to one another because progress for some may be a calamity for others.

Quotation of the Day: "Granted an urge to create, one creates with what one has." – Norbert Wiener