Dark Hero of the Information Age: In Search of Norbert Wiener, The Father of Cybernetics

Reviewed by Michael B. Marcus

Dark Hero of the Information Age: In Search of Norbert Wiener, The Father of Cybernetics
Flo Conway and Jim Siegelman
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The thesis of this book is that Norbert Wiener, 1894–1964, was unknown outside the mathematical community until shortly after World War II. Then he invented cybernetics, which has the capacity to enormously transform the world for the better. The authors believe that since the promises of cybernetics have not been realized, Wiener is not the recognized genius of the Age of the Information, but its dark hero. And what, according to the authors, was the greatest of the forces that prevented the realization of the cybernetics utopia? It was a single person, Wiener's wife Margaret, née Engemann.

There are many points to be examined here. First of all, was the significance of Wiener's mathematical contributions really secondary compared to his latter work in naming and championing cybernetics? More significantly, what is cybernetics, and what does its implementation promise? Also, what did Margaret do and what good does it do us and Wiener's memory to dwell on it? And, finally, why is there such a continuing fascination with Norbert Wiener?

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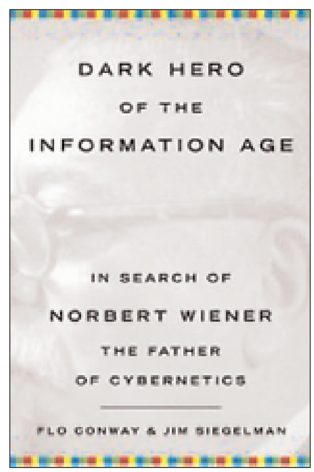

I'm sure that every reader of the *Notices* knows that Norbert Wiener was a child prodigy. He was "home schooled" for a few years, by his overbearing father, a professor of Slavic languages at Harvard, who continued to teach and torment him until he graduated from high school at eleven. Young Norbert graduated from Tufts in 1909, at fifteen, with a B.A. in mathematics. He received his Ph.D. in philosophy from Harvard in 1913 when he was eighteen years old.

Wiener spent his first postdoctoral year in Cambridge, England, studying mathematical logic with Bertrand Russell. As P. R. Masani writes in his biography of Wiener ([4], p. 55), "Russell urged Wiener to approach mathematical philosophy from the broadest standpoint, to concentrate not just on foundations but also to look at the frontiers of mathematics and theoretical physics. This advice not only brought Wiener into contact with G. H. Hardy…but it also exposed Wiener to Bohr's atomic theory, the work of J. W. Gibbs on statistical mechanics, and the Einstein-Smoluchowski papers on Brownian motion." (Most of the biographical details of Wiener's life in this review are taken from

Masani's biography.) Because Russell was to be away from Cambridge in the spring of 1914, he sent Wiener off to Göttingen, where he took courses with David Hilbert, Edmund Husserl, and Edmund Landau. One must marvel at the education Wiener received and that he was able to absorb it. This must account for his enormous breadth later on and his willingness to consider questions in so many different areas of science.

In 1915 Wiener returned to Harvard as an assistant and docent lecturer in the philosophy department. But he didn't continue with cushy appointments at prestigious universities. After this academic-year appointment he had a teaching job at a minor branch of the University of Maine and subsequently worked as a writer for the *Encyclopedia Americana* and as a journalist. During World War I he worked as a "computer" at the U. S. Army proving grounds in Aberdeen, Maryland, and was even a private in the Army for a short time in 1918. In 1919, largely on the recommendation of W. F. Osgood of Harvard, Wiener was offered a one-year instructorship in mathematics at the Massachusetts Institute of Technology. MIT was not a prestigious research institute in 1919. The mathematics department was a service department for the engineering school.

At this point the miracles began to happen. Wiener had become increasingly interested in analysis during the years between his docent lectureship at Harvard and his appointment to MIT. After some work in functional analysis, in which he defined and studied what are now referred to as Banach spaces, he made Brownian motion mathematically rigorous by obtaining a measure, now called Wiener measure, on the space of continuous functions with the sup–norm that is supported on functions of Lip $1/2 - \epsilon$ (for any $0 < \epsilon < 1/2$) and that satisfies the conditions of independent increments and normality of Einstein's model for Brownian motion. Wiener's rigorous development of Brownian motion was done prior to Kolmogorov's systematic description of stochastic processes.

Wiener's interest in stochastic process and ergodic theory led him to consider stationary processes. Since these processes are not in $L^2(R^1)$ and hence not amenable to Fourier analysis he invented generalized harmonic analysis to study them. Problems in generalized harmonic analysis required new, deep, Tauberian theorems, which themselves required new results in Fourier series, all of which he discovered. Correlation functions are fundamental in generalized harmonic analysis. These were to be his foremost probe in the analysis of random phenomena in biology and communication theory in the years to come. In the mid-1930s he teamed up with the electrical engineer Y. W. Lee to essentially create statistical communication theory. This is only a survey of some of Wiener's mathematical contributions prior to World War II. In 1933 he was elected to the National Academy of Sciences.

During World War II Wiener worked with J. Bigelow on predicting the future position of aircraft, so that anti-aircraft guns would know where to aim. This led to his work in prediction theory and the closely related questions of filtering and extrapolation of stochastic processes. Moreover, beginning with his work with Lee, Wiener was also interested in constructing electrical devices to perform the operations he was analyzing. He had developed an interest in computers, stimulated by Vannevar Bush's work on constructing a machine to solve differential equations. He and Bigelow actually built a device to carry out the prediction to be used in anti–aircraft aiming. (In fact Wiener's theory was not practical. The amount of time an airplane could be observed was not long enough to make his brilliant theory superior to the simple deterministic model then being employed. It is significant that he, himself, pointed this out in his final report to the National Defense Research Committee.)

After the war Wiener devoted himself to applying his formidable mathematical talents to problems in biology, although not exclusively. He still produced some very good mathematics, perhaps the best being his papers with Masani on the prediction theory of multivariate stochastic processes. But he achieved fame and wide recognition outside the mathematical community by naming and popularizing cybernetics, "the science of control and communication in the animal and the machine". Wiener didn't leap from pure analysis to physiology. In 1933 he "became a regular participant in an interdisciplinary seminar on scientific method…the Philosophy of Science Club" ([4], p. 197), conducted by Arturo Rosenbleuth, a neurophysiologist, who was working at the Harvard Medical School. He wrote several papers with Rosenbleuth immediately following the war and dedicated his book *Cybernetics* [5] to him. As Masani also reports ([4], p. 218), Wiener first encountered Warren McCulloch at the neurophysiological meeting in New York in 1942 where Rosenbleuth was presenting their joint work with Bigelow on teleology. (Divulging the secret behind the relationship between Wiener and McCulloch is the height of Conway and Siegelman's investigative reporting. We'll get back to this later).

I called cybernetics the "science of control and communication in the animal and the machine" because this is the subtitle of Wiener's famous book [5], published in 1948. Actually, it is not clear to me what the definition of cybernetics really is, or whether it is a science. In his 1956 book [1], W. R. Ashby states that "Cybernetics is the general study of mechanism from the standpoint of functionality and behavior rather than internal structure and material." After presenting Ashby's definition, Masani ([4], p. 256) adds his own, rather unhelpful definition, "Cybernetics is the extension of the scientific methodology necessitated by the existence of processes for which time is Bergsonian."

Perhaps more helpful is what V. M. Glushkov wrote in 1969, (as reported in [4], p. 260):

> It is usual nowadays to define Cybernetics as the science of the general laws of data transformations in complex control systems and systems of information processing.
>
> When defining the subject of Cybernetics it is important to avoid two extremes. These are, first, including in Cybernetics everything which concerns control, and secondly attempting to reduce Cybernetics to a comparative study of the relation between control systems in engineering and those in living beings.

Unfortunately, the second, too narrow, description of cybernetics is the subtitle of Wiener's book.

Conway and Siegelman finesse the issue of saying what cybernetics is by simply not defining it. They give an enthusiastic and exciting account of how Wiener's book came about at the behest of a French publisher and present a detailed description of its contents. They point out that "His new communication theory came together from opposite ends of the scientific universe: engineering and biology, thermodynamics and homeostasis, information and entropy, computing machines and nervous systems" (p. 173). It is certainly true that Wiener was very broad. But did he really invent a new science, or did he rather describe in a unified way the direction that research was heading during the postwar period? I have always thought of cybernetics as a point of view—a recognition that problems of communication and control throughout all disciplines of science, even economics and political science, have many common aspects and that it is useful for scientists to be aware of them.

Wiener was fifty-four years old when *Cybernetics* was published. He became an international figure who explained how the new technologies developed during the war would change people's lives. He used mathematical concepts as analogies to ponder religious, social, political, and economic concepts. His years of startling mathematical achievement were pretty much over. Conway and Siegelman's thesis rests on their remark, "But his greatest work lay ahead" (p. 128). I don't think so. Wiener was a great mathematical analyst. He was also a very moral and courageous man. He had a great deal to say. But like Einstein's his moral pronouncements were noticed only because of his previous achievements.

People's attitudes in the United States right after World War II were very different from what they are now. Scientists and scientific achievement were held in very high regard. It was not only the atomic bomb that won the war but sonar, radar, and the brilliance to crack the enemy's codes. For a while it was widely believed that taking an impersonal scientific approach was a better way to deal with society's problems than by leaving them in the hands of self-interested, indebted politicians (as though scientists couldn't also manage to be both self-interested and indebted). Wiener's book came upon this scene with a synthesis of all activity based on the ideas of message, noise, and control. Without diminishing the significance of his vision, it is fair to say that his was the next "new thing". His ideas were immediately extolled by the influential news weeklies.

Another aspect of the Wiener phenomenon that added to his popularity and underscored his sincerity was his morality. At the same time he extolled the enormous potential of science to do good, he also lamented its more likely uses for destruction. In the preface to *Cybernetics* he wrote

> Those of us who have contributed to the new science of Cybernetics thus stand in a moral position which is, to say the least, not very comfortable. We have contributed to the initiation of a new science which…embraces technical developments with great possibilities for good and evil. We can only hand it over to the world that exists about us, and this is the world of Belsen and Hiroshima. We do not even have the choice of suppressing these new technical developments. They belong to the age, *and the most we can do by suppression is to put the development of the subject into the hands of the most irresponsible and most venal of our engineers.* The best we can do is to see that a large public understands the trend and bearings of the present work and confine our personal efforts to those fields…most remote from war and exploitation. *As we have seen, there are those who hope that the good of a better understanding of man and society which is offered by this new field of work may anticipate and outweigh the incidental contributions we are making to the concentration of power (which is always concentrated, by its very conditions of existence, in the hands of the most unscrupulous). I write*

in 1947, and I am compelled to say that it is a very slight hope.

The passages I put in italics are deleted from this quotation on page 181 of Conway and Siegelman's book. The first one is replaced by ellipses. The second, more significant statement is not. I don't understand why, because, from other parts of the book, one gets the impression that Conway and Siegelman were attracted to Wiener in part by his political positions.

Warren McCulloch's educational background was much like Wiener's. He studied philosophy and mathematics and had a degree in medicine. (Unlike Wiener he was also somewhat of a bohemian.) "He [McCulloch] became a serious student of mathematical logic, and investigated the mathematico–logical aspects of schizophrenia and psychopathia while serving at the Rockland Hospital for the insane" ([4], p. 218). In 1942, the year McCulloch met Wiener, he was working with Walter Pitts, trying to understand the organization of the cortex of the brain. Pitts was a self-taught "genius", who had had a poor, troubled childhood in Detroit but who nevertheless attracted Bertrand Russell's attention and was encouraged by Russell to study mathematical logic. In 1942 Pitts was twenty years old. Pitts went to MIT in 1943 to study with Wiener. As Masani points out ([4], p. 219), "Both McCulloch and Pitts played an absolutely positive role in the evolution of Wiener's ideas in neurophysiology, especially on the problems of logical manipulation, Gestalt or pattern–recognition, gating, brain rhythms and sensory prosthesis."

Wiener wrote two papers with Pitts (along with Rosenbleuth and J. Garcia Ramos) and none with McCulloch. Nonetheless, Conway and Siegelman write, "McCulloch had promoted Wiener's theories and ideas [on cybernetics] with almost as much enthusiasm as Wiener himself" (p. 214). On the same page they also report that [in 1950 (or maybe 1951)], "Jerome Wiesner, who was now head of the Rad Lab [Radiation Laboratory at MIT], with Wiener's blessings, invited McCulloch to come to Cambridge to head up a major new research effort on the brain and its cybernetic connections." McCulloch did come to MIT, but before he did, Wiener abruptly broke off his relationship with him and Pitts and didn't even mention them in his otherwise detailed memoir [6].

During the time I was Wiener's graduate student assistant (1961–1963) I asked a faculty member, I don't remember who, why there was a conflict between Wiener and McCulloch. He said it had something to do with McCulloch having had an affair with Wiener's daughter. Beginning on page 225, Conway and Siegelman paraphrase a recollection of Jerome Lettvin, who as a medical doctor at Boston City Hospital had persuaded Pitts to study mathematics at MIT. Lettvin recalled that, during a visit with Rosenbleuth in Mexico City in 1960, Rosenbleuth told him "that Margaret told Wiener [in a letter written to him in 1951 while he was visiting Rosenbleuth in Mexico]…that the boys in McCulloch's group—Wiener's boys—had seduced his elder daughter [Barbara] during her stay at the McCulloch home in Chicago four years earlier…Margaret alleged that not one but 'more than one' of the boys had seduced the chaste nineteen-year-old during her first foray away from home and the protected environment of her boarding school." Conway and Siegelman present corroborating evidence that leaves little doubt that this story is true, although they do not claim to have seen the actual letter.

Margaret gets bashed in this book. Apparently she was enamored of Adolf Hitler long after a reasonable person of German descent should have been. Also she was very troubled by her daughters' sexuality and made many apparently false accusations about the girls' behavior. I first met Margaret and Wiener together in 1959 in Los Angeles. Of course I was very young then and never had more than a tangential relationship with them. Nevertheless they seemed like a loving couple to me. Wiener wrote, in 1953, in the dedication to [7], "To my wife under whose gentle tutelage I first knew freedom" ([4], p. 94).

My new wife and I had dinner with Margaret in Cambridge a couple of times in the year after Wiener's death. She gave me his academic gown to wear when I received my Ph.D. in 1965. I was fond of her, and I think Masani was also. He filled me in on what she was doing whenever we saw each other at meetings. Masani says nothing disparaging about Margaret in his biography of Wiener.

I knew Wiener well enough to know that he was fiercely loyal and really very manly, despite his awkward appearance. He would have been devastated by the way Margaret is treated in this book and fighting mad. I could have lived without knowing all the dirt on my hero's wife. I'm glad Wiener never had to read this book.

To be fair to the authors, their gossip is not spurious. They view the breakup of the research team of Wiener, Pitts, and McCulloch as a primary reason that cybernetics did not achieve the great success that they think was its destiny. But here I think that they are guilty of a misunderstanding of the nature of mathematical research that is prevalent among the nonmathematical public. That is, that mathematics, and perhaps scientific research in general, advances by the achievements of a very few extremely gifted individuals—people who are so deep that even their colleagues don't understand them. This is the viewpoint of the movie *Good Will Hunting* and the play *Proof*. In this view Wiener's separation from Pitts and McCulloch doomed their effort in using the principles of cybernetics to explain the workings of the brain. Of course, collaboration with Wiener would have been helpful. But McCulloch and Pitts were not dummies. They were tackling a problem that is still very far from a solution. There was enormous enthusiasm in the 1950s and 1960s for the revolutionary changes that would be brought about, not only by cybernetics, but also by artificial intelligence. Progress was made, and work is continuing. But the mysteries McCulloch and Pitts were trying to answer are amongst the deepest that exist.

John von Neumann was also involved in this research. Conway and Siegelman point out that he, Wiener, McCulloch, and about twenty others, including Margaret Mead, met in several closed conferences sponsored by the Josiah Macy Foundation to explore questions "at the junction between psychology and brain science" (p. 131). The conference series ran from 1942 to 1953. Its name evolved to "The Feedback Mechanisms and Circular Systems in Biology and Social Sciences Meeting". To Wiener's delight, after his book appeared, the group was happy to simply use the name "Cybernetics" to describe itself and its proceedings. But it seems clear that the goal of describing how the brain functions was too ambitious. Starting on page 243 Masani reprints a six-page letter that von Neumann wrote to Wiener in 1946 that points this out and suggests that perhaps they should first try to understand how viruses function.

Conway and Siegelman present a lot of interesting history about research funding in this period. A great deal of money was being pumped into artificial intelligence and very little into cybernetics. This, too, they blame for the absence of a cybernetics revolution. In fact, they are so convinced that great things would have occurred if only cybernetics were vigorously pursued that they deal with the absence of substantial results from the Soviet Union, where after initial hostility the government strongly supported cybernetics research, by saying that, "In the end, cybernetics did not give the Soviet Union the winning hand in the Cold War. …the socialist system's creed of centralized planning and rigid, top-down, authoritarian rule ran counter to the most basic principles of self-governing cybernetic systems" (p. 331). Rather than finding excuses for the limited advances resulting from cybernetics, perhaps the authors might have recognized that the translation of mathematical results into concrete social advances takes a very long time and follows devious paths and that it is impossible to predict which discoveries will eventually have a significant effect on society.

Ten years before Masani's biography of Wiener appeared, Steve Heims [2] wrote a joint biography of Wiener and von Neumann, with an interesting, but I think fallacious, hypothesis (see [3]). That is, that the political positions these men took were reflected in the nature of the mathematics that they created. (In Cold War terminology, Wiener was a dove and von Neumann a hawk.) Heims' book concentrates on Wiener as a man opposed to militarism and powerful institutions, Masani's book on Wiener the mathematician and philosopher, and the book under review on Wiener's work in cybernetics. I think that a mathematician who is unfamiliar with Wiener's life and work would most enjoy Masani's book and Wiener's autobiographies [7, 6]. But both Heims' book and this book are well worth reading. Conway and Siegelman have dug up a lot of interesting material on the early days of cybernetics, and they certainly capture the enthusiasm of the early years of our information age. They also uncover many facts about Wiener's life that were not commonly known.

I think that the next biography of Wiener should be written by an historian of the mid-twentieth century who would study Norbert Wiener along with other scientific public intellectuals, like Linus Pauling, Leo Szilard, Benjamin Spock, and Phillip Morrison. I admire these figures because they spoke out against militarism. However, the other side had equally eloquent spokesmen, such as Edward Teller and John von Neumann. Why are scientists absent from public discourse today? It seems that the only people we read about, other than politicians and entertainers, are those who either make, lose, or steal a great deal of money. To compare public discourse today with that during Wiener's prime is to see how drowned our society is by materialism and superstition.

Rather than end on a discouraging note, let us return to Wiener himself. He was really a wonderful man. This is what he wrote about mathematics in 1933, when he was thirty-nine years old.

> Mathematics is a subject worthy of the entire devotion of our lives. We are serving a useful place in the community by our training of engineers, and by our development of the tools of future science and engineering. Perhaps no particular discovery that we make may be used in practice; nevertheless, much of the great bulk of mathematical knowledge will be, and we are contributing to that bulk, as far as lies in us.
>
> Moreover, a clearly framed question which we can not answer is an affront to the dignity of the human race, as a race of thinking beings. Curiosity is a good in itself. We are here but for a day; tomorrow the earth will not know us, and we shall be as though we never were. Let us then master infinity and eternity in the one way open to us;

> through the power of the understanding. Knowledge is good with a good which is above usefulness, and ignorance is an evil, and we have enlisted as good soldiers in the army whose enemy is ignorance and whose watchword is Truth. Of the many varieties of truth, mathematical truth does not stand lowest. ([4], p. 341)

There was nothing "dark" about Norbert Wiener's mathematics or his morals.

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