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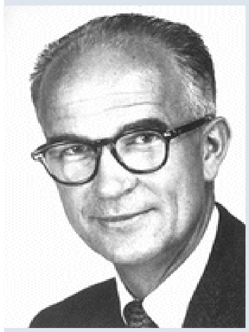

Physicist William Shockley (1910-1989) shared the 1956 Nobel Prize in physics for inventing the transistor. He was also involved in the controversial topic of the genetic basis of intelligence.

William Shockley was a physicist whose work in the development of the transistor led to a Nobel Prize. By the late 1950s, his company, the Shockley Transistor Corporation, was part of a rapidly growing industry created as a direct result of his contributions to the field. Shockley shared the 1956 Nobel Prize in physics with John Bardeen and Walter Brattain, both of whom collaborated with him on developing the point contact transistor. Later, Shockley became involved in a controversial topic for which he had no special training, but in which he became avidly interested: the genetic basis of intelligence. During the 1960s, he argued, in a series of articles and speeches, that people of African descent have a genetically inferior mental capacity when compared to those with Caucasian ancestry. This hypothesis became the subject of intense and acrimonious debate.

William Bradford Shockley was born in London, England, on February 13, 1910, to William Hillman Shockley, an American mining engineer, and May (Bradford) Shockley, a mineral surveyor. The Shockleys, living in London on a business assignment when William was born, returned to California in 1913. Shockley did not enter elementary school at the usual age, however, because, as he told Men of Spaceauthor Shirley Thomas, "My parents had the idea that the general educational process was not as good as would be done at home." As a result, he was not enrolled in public schools until he had reached the age of eight.

Shockley's interest in physics developed early, inspired in part by a neighbor who taught the subject at Stanford and by his own parents' coaching and encouragement. By the time he had completed his secondary education at Palo Alto Military Academy and Hollywood High School at the age of seventeen, Shockley had made his commitment to a career in physics. Shockley and his parents agreed that he should spend a year at the University of California at Los Angeles (UCLA) before attending the California Institute of Technology (Caltech), where he earned a bachelor's degree in physics in 1932. Offered a teaching fellowship at the Massachusetts Institute of Technology (MIT), Shockley taught while working on his doctoral dissertation, "Calculations of Wave Functions for Electrons in Sodium Chloride Crystals," for which he was awarded his Ph.D. in 1936. Shockley later told Thomas that this research in solid-state physics "led into my subsequent activities in the transistor field."

Upon graduation from MIT, Shockley accepted an offer to work at the Bell Telephone Laboratories in Murray Hill, New Jersey. An important factor in that decision was the opportunity it gave him to work with Clinton Davisson, who was to win the 1937 Nobel Prize in physics for proving Louis Victor de Broglie's theory that electrons assumed the characteristics of waves. Shockley's first assignment at Bell was the development of a new type of vacuum tube that would serve as an amplifier. But, almost as soon as he had arrived at Bell, he began to think of a radically new approach to the transmission of electrical signals using solid-state components rather than conventional vacuum tubes. At that time, vacuum tubes constituted the core of communication devices such as the radio because they have the ability to rectify (create a unidirectional current) and multiply electronic signals. They have a number of serious practical disadvantages, however, as they are relatively fragile and expensive, and have relatively short life-spans.

As early as the mid-1930s, Bell scientists had begun to think about alternatives to vacuum tubes in communication systems, and by 1939, Shockley was experimenting with semiconducting materials to achieve that transition. Semiconductors are materials such as silicon and germanium that conduct an electrical current much less efficiently than do conductors like silver and copper, but more effectively than do insulators like glass and most kinds of plastic. Shockley knew that one semiconductor, galena, had been used as a rectifier in early radio sets, and his experience in solid-state physics led him to believe that such materials might have even wider application in new kinds of communication devices.

The limited research Shockley was able to complete on this concept of alternative conductors was unsuccessful, largely because the materials available to him at the time were not pure enough. In 1940, war was imminent, and Shockley soon became involved in military research. His first job involved the development of radar equipment at a Bell field station in Whippany, New Jersey. In 1942, he became research director of the U.S. Navy's Anti-Submarine Warfare Operations Research Group at Columbia University, and served as a consultant to the Secretary of War from 1944 to 1945.

In 1945, Shockley returned to Bell Labs as director of its research program on solid-state physics. Together with John Bardeen, a theoretical physicist, and Walter Brattain, an experimental physicist, Shockley returned to his study of semiconductors as a means of amplification. After more than a year of failed trials, Bardeen suggested that the movement of electric current was being hampered by electrons trapped within a semiconductor's surface layer. That suggestion caused Shockley's team to suspend temporarily its efforts to build an amplification device and to concentrate instead on improving their understanding of the nature of semiconductors.

By 1947, Bardeen and Brattain had learned enough about semiconductors to make another attempt at building Shockley's device. This time they were successful. Their device consisted of a piece of germanium with two gold contacts on one side and a tungsten contact on the opposite side. When an electrical current was fed into one of the gold contacts, it appeared in a greatly amplified form on the other side. The device was given the name transistor (*for trans* fer re *sistor*). More specifically, it was referred to as a point contact transistor because of the three metal contacts used in it.

The first announcement of the transistor appeared in a short article in the July 1, 1948 edition of the *New YorkTimes.* Few readers had the vaguest notion of the impact the fingernail-sized device would have on the world. A few months later, Shockley proposed a modification of the point contact transistor. He suggested using a thin layer of P-type semiconductor (in which the charge is carried by holes) sandwiched between two layers of N-type semiconductor (where the charge is carried by electrons). When Brattain built this device, now called the junction transistor, he found that it worked much better than did its point contact predecessor. In 1956,

the Nobel Prize for physics was awarded jointly to Shockley, Bardeen, and Brattain for their development of the transistor.

Shockley left Bell Labs in 1954 (some sources say 1955). In the decade that followed, he served as director of research for the Weapons Systems Evaluation Group of the Department of Defense, and as visiting professor at Caltech in 1954-55. He then founded the Shockley Transistor Corporation to turn his work on the development of the transistor to commercial advantage. Shockley Transistor was later incorporated into Beckman Instruments, Inc., and then into Clevite Transistor in 1960. The company went out of business in 1968.

In 1963, Shockley embarked on a new career, accepting an appointment at Stanford University as its first Alexander M. Poniatoff Professor of Engineering and Applied Science. Here he became interested in genetics and the origins of human intelligence, in particular, the relationship between race and the Intelligence Quotient (IQ). Although he had no background in psychology, genetics, or any related field, Shockley began to read on these topics and formulate his own hypotheses. Using data taken primarily from U.S. Army pre-induction IQ tests, Shockley came to the conclusion that the genetic component of a person's intelligence was based on racial heritage. He proposed that people of African ancestry were inherently less intelligent than those of Caucasian lineage. He also surmised that the more "white genes" a person of African descent carried, the more closely her or his intelligence corresponded to that of the general white population. He ignited further controversy with his suggestion that inferior individuals (those whose IQ numbered below 100) be paid to undergo voluntary sterilization.

The social implications of Shockley's theories were, and still are profound. Many scholars regarded Shockley's whole analysis as flawed, and they rejected his conclusions. Others were outraged that such views were even expressed publicly. Educators pointed out the significance of these theories for their field, a point pursued by Shockley himself when he argued that compensatory programs for blacks were doomed because of their inherent genetic inferiority. For a number of years, Shockley could count on the fact that his speeches would be interrupted by boos and catcalls, provided that they were allowed to go forward at all.

During his life, Shockley was awarded many honors, including the U.S. Medal of Merit in 1946, the Morris E. Liebmann Award of the Institute of Radio Engineers in 1951, the Comstock Prize of the National Academy of Sciences in 1954, and the Institute of Electrical and Electronics Gold Medal in 1972 and its Medal of Honor in 1980. He was named to the National Inventor's Hall of Fame in 1974. Shockley remained at Stanford until retirement in 1975, when he was appointed Emeritus Professor of Electrical Engineering. In 1933, Shockley had married Jean Alberta Bailey, with whom he had three children, Alison, William, and Richard. After their 1955 divorce, Shockley married Emily I. Lanning. He died in San Francisco on August 11, 1989, of prostate cancer.

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