Alan M. Turing

Born June 23, 1912, London, England
Died June 7, 1954, Wilmslow, Cheshire

Alan Mathison Turing British mathematician and logician, who made major contributions to mathematics, cryptanalysis, logic, philosophy, and biology and to the new areas later named computer science, cognitive science, artificial intelligence, and artificial life.

Early life and career

The son of a British member of the Indian civil service, Turing entered King's College, University of Cambridge, to study mathematics in 1931. After graduating in 1934, Turing was elected to a fellowship at King's College in recognition of his research in probability theory. In 1936 Turing's seminal paper On Computable Numbers, with an Application to the Entscheidungsproblem [Decision Problem] was recommended for publication by the American mathematician-logician Alonzo Church, who had himself just published a paper that reached the same conclusion as Turing's. Later that year, Turing moved to Princeton University to study for a Ph.D. in mathematical logic under Church's direction (completed in 1938).

The Entscheidungsproblem seeks an effective method for deciding which mathematical statements are provable within a given formal mathematical system and which are not. In 1936 Turing and Church independently showed that in general this problem has no solution, proving that no consistent formal system of arithmetic is decidable. This result and others—notably the mathematician-logician Kurt Gödel's incompleteness theorems—ended the dream of a system that could banish ignorance from mathematics forever. (In fact, Turing and Church showed that even some purely logical systems, considerably weaker than arithmetic, are undecidable.) An important argument of Turing's and Church's was that the class of lambda-definable functions (functions on the positive integers whose values can be calculated by a process of repeated substitution) coincides with the class of all functions that are effectively calculable—or computable. This claim is now known as Church's thesis—or as the Church-Turing thesis when stated in the form that any effectively calculable function can be calculated by a universal Turing machine, a type of abstract computer that Turing had introduced in the course of his proof. (Turing showed in 1936 that the two formulations of the thesis are equivalent by proving that the lambda-definable functions and the functions that can be calculated by a universal Turing machine are identical.) In a review of Turing's work, Church acknowledged the superiority of Turing's formulation of the thesis over his own, saying that the concept of computability by a Turing machine "has the advantage of making the identification with effectiveness…evident immediately."

Code breaker

In the summer of 1938 Turing returned from the United States to his fellowship at King's College. At the outbreak of hostilities with Germany in September 1939, he joined the wartime headquarters of the Government Code and Cypher School at Bletchley Park, Buckinghamshire. The British government had just been given the details of efforts by the Poles, assisted by the French, to break the Enigma code, used by the German military for their radio communications. As early as 1932, a small team of Polish mathematician-cryptanalysts, led by Marian Rejewski, had succeeded in reconstructing the internal wiring of the type of Enigma machine used by the Germans, and by 1938 they had devised a code-breaking machine, code-named Bomba (the Polish word for a type of ice cream). The Bomba depended for its success on German operating procedures, and a change in procedures in May 1940 rendered the Bomba virtually useless. During 1939 and the spring of 1940, Turing and others designed a radically different code-breaking machine known as the Bombe. Turing's ingenious Bombes kept the Allies supplied with intelligence for the remainder of the war. By early 1942 the Bletchley Park cryptanalysts were decoding about 39,000 intercepted messages each month, which rose subsequently to more than 84,000 per month. At the end of the war, Turing was made an officer of the Order of the British Empire for his code-breaking work.

Computer designer

In 1945, the war being over, Turing was recruited to the National Physical Laboratory (NPL) in London to design and develop an electronic computer. His design for the Automatic Computing Engine (ACE) was the first relatively complete specification of an electronic stored-program general-purpose digital computer. Had Turing's ACE been built as planned, it would have had considerably more memory than any of the other early computers, as well as being faster. However, his colleagues at NPL thought the engineering too difficult to attempt, and a much simpler machine was built, the Pilot Model ACE.

In the end, NPL lost the race to build the world's first working electronic stored-program digital computer—an honour that went to the Royal Society Computing Machine Laboratory at the University of Manchester in June 1948. Discouraged by the delays at NPL, Turing took up the deputy directorship of the Computing Machine Laboratory in that year (there was no director). His earlier theoretical concept of a universal Turing machine had been a fundamental influence on the Manchester computer project from its inception. Turing's principal practical contribution after his arrival at Manchester was to design the programming system of the Ferranti Mark I, the world's first commercially available electronic digital computer.

Artificial intelligence pioneer

Turing was a founding father of modern cognitive science and a leading early exponent of the hypothesis that the human brain is in large part a digital computing machine. He theorized that the cortex at birth is an “unorganised machine” that through “training” becomes organized “into a universal machine or something like it.” A pioneer of artificial intelligence, Turing proposed (1950) what subsequently became known as the Turing test as a criterion for whether a machine thinks.

Though he was elected a fellow of the Royal Society in March 1951, Turing's life was about to suffer a major reversal. In March 1952 he was prosecuted for homosexuality, then a crime in Britain, and sentenced to 12 months of hormone “therapy”—a treatment that he seems to have borne with amused fortitude. Judged a security risk by the British government, Turing lost his security clearance and his access to ongoing government work with codes and computers. He spent the rest of his short career at the University of Manchester, where he was appointed to a specially created readership in the theory of computing in May 1953.

From 1951 Turing had been working on what is now known as artificial life. He wrote “The Chemical Basis of Morphogenesis,” which described some of his research on the development of pattern and form in living organisms, and he used the Ferranti Mark I computer to model chemical mechanisms by which genes could control the development of anatomical structure in plants and animals. In the midst of this groundbreaking work, Turing was discovered dead in his bed, poisoned by cyanide. A homemade apparatus for silver-plating teaspoons, which included a tank of cyanide, was found in the room next to his bedroom. The official verdict was suicide, but no motive was ever discovered.

Additional Reading

Sara Stoney Turing, Alan M. Turing (1959), written by Turing's mother, gives an interesting account of Turing's life. Ted Gottfried, Alan Turing: The Architect of the Computer Age (1996), is a short, clear biography written with high school students and the general reader in mind. Andrew Hodges, Alan Turing: The Enigma (1983, reissued 1992), is a well-written account of Turing's life and his diverse scientific ideas. F.H. Hinsley and Alan Stripp (eds.), Codebreakers: The Inside Story of Bletchley Park (1994), presents the fascinating story of efforts to break the German codes.