John von Neumann

American mathematician

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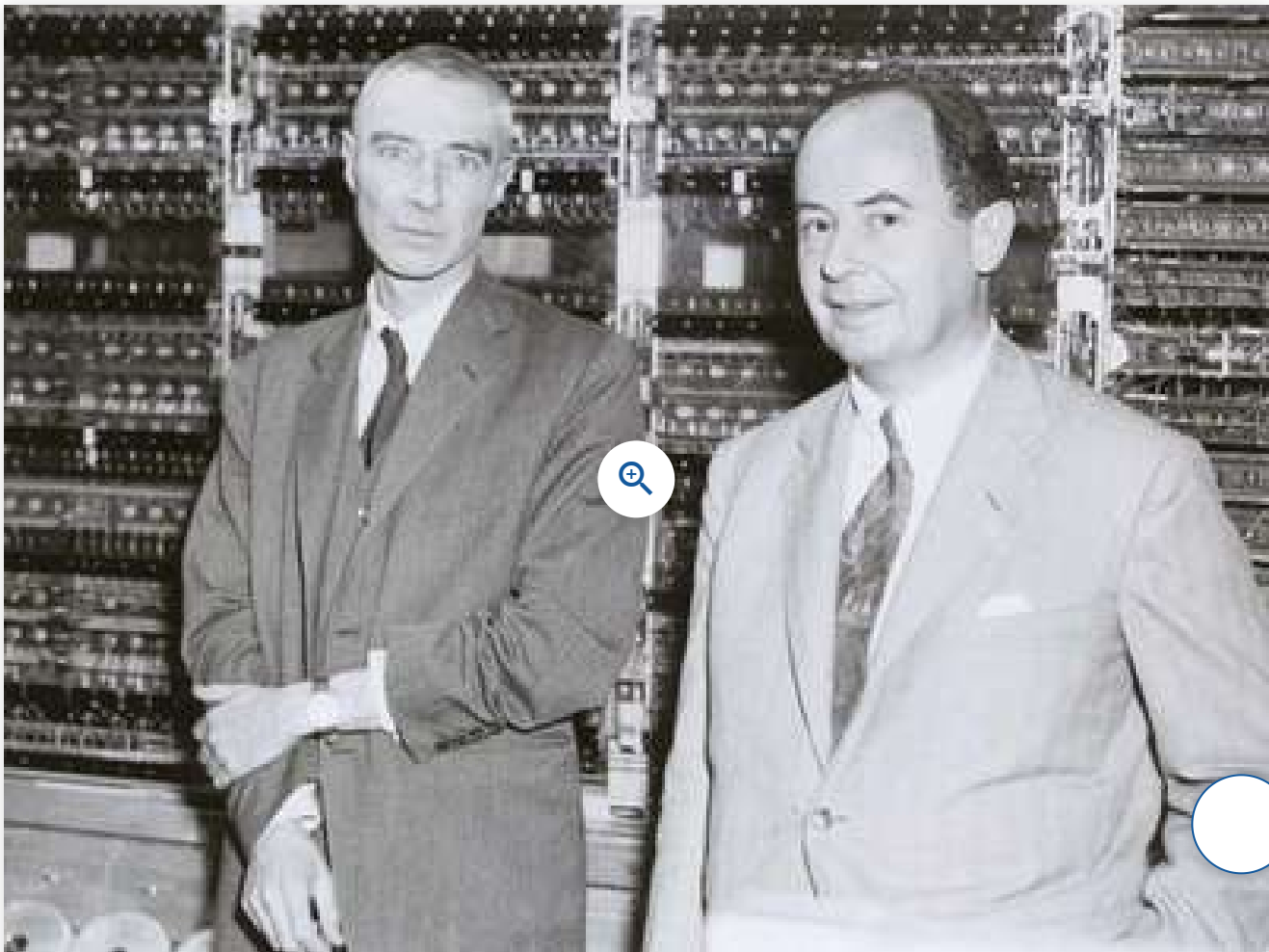
John von Neumann

John von Neumann

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Born: December 28, 1903 • Budapest • Hungary

Died: February 8, 1957 (aged 53) • Washington, D.C. • United States

Notable Works: "The Mathematical Foundations of Quantum Mechanics" • "The Theory of Games and Economic Behavior"   ...*(Show more)*

Subjects Of Study: game theory • mini-max theorem • set theory • von Neumann algebra • computer

Role In: Manhattan Project

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Budapest, Hungary—died February 8, 1957, Washington, D.C., U.S.), Hungarian-born American mathematician. As an adult, he appended *von* to his surname; the hereditary title had been granted his father in 1913. Von Neumann grew from child prodigy to one of the world's foremost mathematicians by his mid-twenties. Important work in set theory inaugurated a career that touched nearly every major branch of mathematics. Von Neumann's gift for applied mathematics took his work in directions that influenced quantum theory, automata theory, economics, and defense planning. Von Neumann pioneered game theory and, along with Alan Turing and Claude Shannon, was one of the conceptual inventors of the stored-program digital computer.

Early life and education

Von Neumann grew up in an affluent, highly assimilated Jewish family. His father, Miksa Neumann (Max Neumann), was a banker, and his mother, born Margit Kann (Margaret Kann), came from a family that had prospered selling farm equipment. Von Neumann showed signs of genius in early childhood: he could joke in Classical Greek

and, for a family stunt, he could quickly memorize a page from a telephone book and recite its numbers and addresses. Von Neumann learned languages and math from tutors and attended Budapest's most prestigious secondary school, the Lutheran Gymnasium. The Neumann family fled Béla Kun's short-lived communist regime in 1919 for a brief and relatively comfortable exile split between Vienna and the Adriatic resort of Abbazia (now Opatija, Croatia). Upon completion of von Neumann's secondary schooling in 1921, his father discouraged him from pursuing a career in mathematics, fearing that there was not enough money in the field. As a compromise, von Neumann simultaneously studied chemistry and mathematics. He earned a degree in chemical engineering (1925) from the Swiss Federal Institute in Zürich and a doctorate in mathematics (1926) from the University of Budapest.
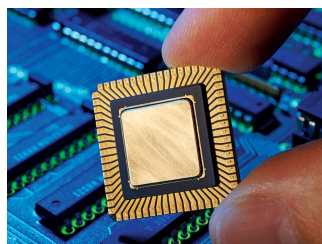
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European career, 1921–30

Von Neumann commenced his intellectual career at a time when the influence of David Hilbert and his program of establishing axiomatic foundations for mathematics was at a peak. A paper von Neumann wrote while still at the Lutheran Gymnasium ("The Introduction of Transfinite Ordinals," published 1923) supplied the now-convent definition of an ordinal number as the set of all smaller ordinal numbers. This neatly avoids some of the complications raised by Georg Cantor's transfinite numbers. Von

Neumann's "An Axiomatization of Set Theory" (1925) commanded the attention of

Hilbert himself. From 1926 to 1927 von Neumann did postdoctoral work under Hilbert at the University of Göttingen. The goal of axiomatizing mathematics was defeated by Kurt Gödel's incompleteness theorems, a barrier that was understood immediately by Hilbert and von Neumann. (*See also* mathematics, foundations of: Gödel.)

Von Neumann took positions as a *Privatdozent* ("private lecturer") at the Universities of Berlin (1927–29) and Hamburg (1929–30). The work with Hilbert culminated in von Neumann's book *The Mathematical Foundations of Quantum Mechanics* (1932), in which quantum states are treated as vectors in a Hilbert space. This mathematical synthesis reconciled the seemingly contradictory quantum mechanical formulations of Erwin Schrödinger and Werner Heisenberg. Von Neumann also claimed to prove that deterministic "hidden variables" cannot underlie quantum phenomena. This influential result pleased Niels Bohr and Heisenberg and played a strong role in convincing physicists to accept the indeterminacy of quantum theory. In contrast, the result dismayed Albert Einstein, who refused to abandon his belief in determinism. (Ironically, Irish-born physicist John Stewart Bell demonstrated in the mid-1960s that von Neumann's proof was flawed; Bell then fixed the proof's shortcomings, reaffirming von Neumann's conclusion that hidden variables were unnecessary. *See also* quantum mechanics: Hidden variables.)

By his mid-twenties, von Neumann found himself pointed out as a wunderkind at conferences. (He claimed that mathematical powers start to decline at age 26, after which experience can conceal the deterioration for a time.) Von Neumann produced a staggering succession of pivotal papers in logic, set theory, group theory, ergodic theory, and operator theory. Herman Goldstine and Eugene Wigner noted that, of all the principal branches of mathematics, it was only in topology and number theory that von Neumann failed to make an important contribution.

In 1928 von Neumann published "Theory of Parlor Games," a key paper in the field of game theory. The nominal inspiration was the game of poker. Game theory focuses on

the element of bluffing, a feature distinct from the pure logic of chess or the probability theory of roulette. Though von Neumann knew of the earlier work of the French mathematician Émile Borel, he gave the subject mathematical substance by proving the mini-max theorem. This asserts that for every finite, two-person zero-sum game, there is a rational outcome in the sense that two perfectly logical adversaries can arrive at a mutual choice of game strategies, confident that they could not expect to do better by choosing another strategy. (*See also* game theory: The von Neumann–Morgenstern theory.) In games like poker, the optimal strategy incorporates a chance element. Poker players must bluff occasionally—and unpredictably—in order to avoid exploitation by a savvier player.

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