JOHN VON NEUMANN (December 28, 1903 – February 8, 1957)

by HEINZ KLAUS STRICK, Germany

As NEUMANN JÁNOS he was born in Budapest (in Hungary, surnames are written before given names), as JOHN VON NEUMANN he died in Washington D.C., one of the greatest mathematical geniuses of the twentieth century.

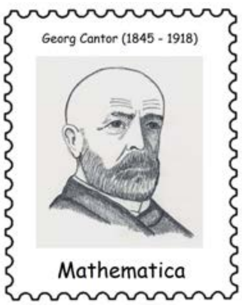
JÁNOS NEUMANN's father was a wealthy Jewish banker, who in 1913 was granted the noble title "Baron von" though he never used it. However, his son later placed great value on having the "von" in his name. Raised in a multilingual environment, it is said that the six-year-old JÁNOS was able to converse in ancient Greek. It is also told that he was able to divide one eight-digit number by another in his head and that a brief glance at a page of the telephone directory sufficed for him to memorize all its names and numbers. At the age of eight, he was already studying calculus, but he also read regularly in an encyclopaedia of history.

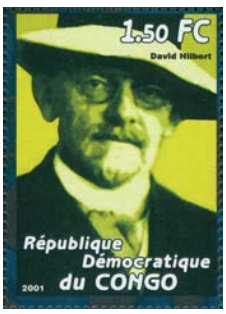
By the age of seventeen, that is, during his time as a pupil at a German-speaking *Lutheran gymnasium*, he published his first article in a mathematical journal. His father, however, did not wish his son to study mathematics, since such a course of study would not lead to amassing a fortune. Finally, he agreed to let JÁNOS study chemistry in Berlin, since following the end of the First World War, the anti-Jewish mood in Budapest had become dangerous. JÁNOS NEUMANN moved between the universities in Berlin, Budapest, and Zurich. At the same time as he completed his degree in chemistry in Zurich, he passed the mathematics examinations in Budapest with distinction, even though he had not been able to attend courses there systematically.

GEORGE PÓLYA (1887–1985), who had studied law, languages, literature, mathematics, physics, and philosophy in Budapest and was for a time a professor of mathematics in Zurich under whom JÁNOS studied, later confessed that JÁNOS NEUMANN was the only one of his students of whom he was "afraid"; hardly a lecture occurred at which every problem that PÓLYA posed had been solved by his "student" before the end of the lecture.

The work of GEORG CANTOR (1845–1918) had opened up a new field of mathematics at the end of the nineteenth century, namely set theory (today, it would be called naive set theory).

In 1901, BERTRAND RUSSELL (1872–1970) discovered a paradox that arises if one allows arbitrary sets into the theory: what is the set of all sets that do not contain themselves as elements? In his doctoral thesis, VON NEUMANN produced in 1925 a consistent axiomatic development of set theory.





(CANTOR drawing: © Andreas Strick)

With a fellowship from the Rockefeller Foundation, he worked with DAVID HILBERT (1862–1943) in Göttingen, then worked as private lecturer at the Universities of Berlin and Hamburg as their youngest lecturer. From 1930, he added to his European positions that of a guest lecturer at Princeton University. His fame as a mathematical genius spread throughout the world.

In 1933, he became, along with ALBERT EINSTEIN (1879–1955), one of the first five professors at the newly established *Institute for Advanced Study* in Princeton. In 1937, he became an American citizen.

In 1926, he worked on the mutually contradictory-seeming theories of the atomic physicists WERNER HEISENBERG (1901–1976) and ERWIN SCHRÖDINGER (1887–1961) and attempted to create a mathematical theory that encompassed both approaches: His *Mathematische Grundlagen der Quantenmechanik* (mathematical foundations of quantum mechanics) appeared in 1932.

This work gave a new impetus to the field of functional analysis, a branch of mathematics that deals generally with the properties of spaces of functions (VON NEUMANN algebra).

In 1936, he wrote an article on a new “logic” of quantum mechanics: Photons cannot pass through mutually perpendicular polarization filters, and according to “classical” logic, there should be no effect were one to add a third filter. If one places the third filter diagonally to the other two either in front of or behind them in the path of the photons, then indeed nothing changes. However, such is not the case if it is placed between the two filters.

JOHN VON NEUMANN is considered the founder of game theory. In 1928, he published an article on the “minimax theorem.” This mathematical theorem deals with a strategy by which the maximal losses of the players in a zero-sum game (that is, the total amount won equals the total amount lost) are kept to a minimum. In 1937, he generalized this work to questions about the equilibrium of supply and demand, and in 1944, he published, together with OSKAR MORGENSTERN (1902–1977), the standard text on economy *Theory of Games and Economic Behaviour*, in which, among other things, it is shown that even collective bargaining, strategic business decisions, and international conflicts can be described with the help of mathematical models.

In 1936, ALAN TURING (1912–1954) went to the *Institute for Advanced Study* in Princeton to complete his doctorate. In his famous work *On Computable Numbers with an Application to the Entscheidungsproblem*, he studied the computability of a mathematical problem (TURING machine).

His presence in Princeton stimulated VON NEUMANN to work more energetically on automated computing machines. He analysed the existing designs for computers and developed them further in his famous paper *First draft on a Report on the EDVAC* (Electronic Discrete Variable Automatic Computer).

His crucial insight was that programs did not have to be hard wired, but could be stored just like data. We now speak of a computer having a *von Neumann architecture*, which describes a computer consisting of a processing unit, a control unit, input and output engines, and a common storage unit for program instructions and data (an architecture that remained unchanged until the very latest generation of personal computers).

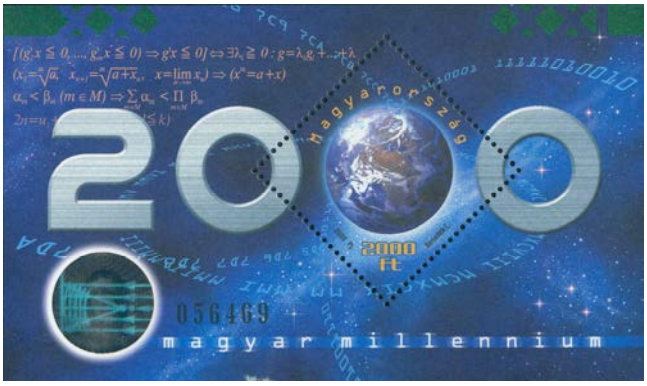
He also became interested in biological information processing and investigated neural networks (analogy between computers and brains).

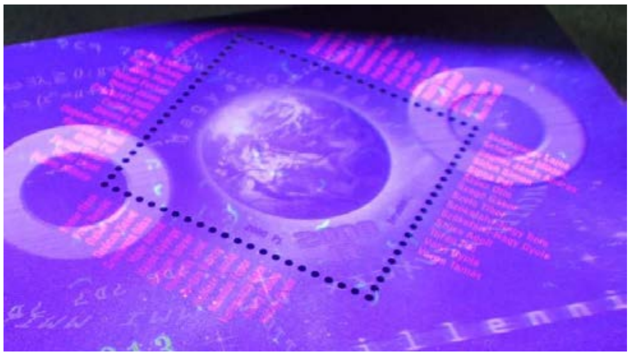
Beginning in 1937, von Neumann worked on mathematical problems with military applications, for example on the effectiveness of bombs as a function of the altitude at which they are detonated, developing in the process a theory of shock waves. The most important application of this work was seen in 1945 in the atomic bomb attacks on Hiroshima and Nagasaki. von Neumann was one of the leading participants in the Manhattan Project (creation of the first atomic bomb) as well as a member of the team that conceived the first hydrogen bomb. In this connection, he developed simulation techniques (*Monte Carlo methods*) and created an algorithm for generating pseudorandom numbers, the middle square method:

One begins with a four-digit integer whose square is an eight-digit integer, from which the middle four digits are extracted, and the process repeated. von Neumann rejected the objections of critics about the poor random qualities of the numbers so generated; it would soon be noticed, he said, if the simulation were unusable. Furthermore, “Anyone who considers arithmetical methods of producing random numbers is, of course, in a state of sin.”

In his lectures as a professor of mathematics, he is reported to have jumped erratically from point to point in presenting proofs and to have been rather chaotic at the blackboard. This did not bother him, and indeed, he voiced the provocative opinions, “In mathematics you don’t understand things, you just get used to them,” and, “If people do not believe that mathematics is simple, it is only because they do not realize how complicated life is.”

Toward the end of 1956, he was discovered to have developed cancer of the pancreas and bones, the result of his having been present at nuclear tests in the Pacific and having worked at the laboratories at Los Alamos. At the time of his death, John von Neumann had published over 150 scientific works, 60 each in pure and applied mathematics, and 20 in physics.





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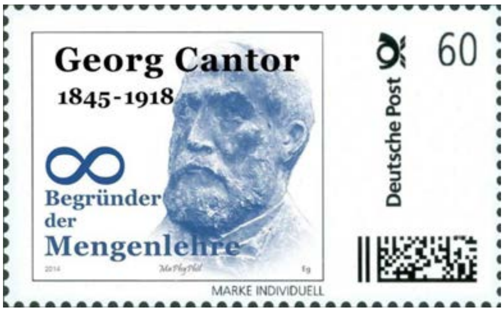

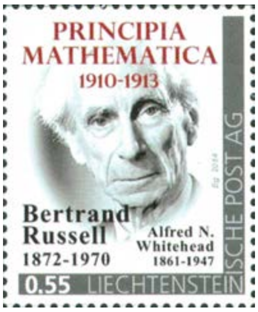

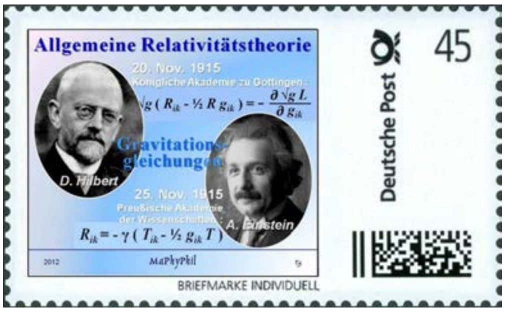

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