= John von Neumann =

John von Neumann (/ v?n ?n??m?n / ; Hungarian : Neumann János Lajos , pronounced [?n?jm?n ?ja?no? ?l?jo?] ; December 28 , 1903 ? February 8 , 1957) was a Hungarian @-@ American pure and applied mathematician , physicist , inventor , computer scientist , and polymath . He made major contributions to a number of fields , including mathematics (foundations of mathematics , functional analysis , ergodic theory , geometry , topology , and numerical analysis) , physics (quantum mechanics , hydrodynamics and quantum statistical mechanics) , economics (game theory) , computing (Von Neumann architecture , linear programming , self @-@ replicating machines , stochastic computing) , and statistics .

He was a pioneer of the application of operator theory to quantum mechanics , in the development of functional analysis , and a key figure in the development of game theory and the concepts of cellular automata , the universal constructor and the digital computer . He published 150 papers in his life : 60 in pure mathematics , 20 in physics , and 60 in applied mathematics . His last work , an unfinished manuscript written while in the hospital , was later published in book form as The Computer and the Brain .

His mathematical analysis of the structure of self @-@ replication preceded the discovery of the structure of DNA . In a short list of facts about his life he submitted to the National Academy of Sciences , he stated " The part of my work I consider most essential is that on quantum mechanics , which developed in Göttingen in 1926 , and subsequently in Berlin in 1927 ? 1929 . Also , my work on various forms of operator theory , Berlin 1930 and Princeton 1935 ? 1939 ; on the ergodic theorem , Princeton , 1931 ? 1932 . "

During World War II he worked on the Manhattan Project , developing the mathematical models behind the explosive lenses used in the implosion @-@ type nuclear weapon . After the war , he served on the General Advisory Committee of the United States Atomic Energy Commission , and later as one of its commissioners . He was a consultant to a number of organizations , including the United States Air Force , the Army 's Ballistic Research Laboratory , the Armed Forces Special Weapons Project , and the Lawrence Livermore National Laboratory . Along with theoretical physicist Edward Teller , mathematician Stanislaw Ulam , and others , he worked out key steps in the nuclear physics involved in thermonuclear reactions and the hydrogen bomb .

= = Early life and education = =

Von Neumann was born Neumann János Lajos to wealthy Jewish parents of the Haskalah (in Hungarian the family name comes first and his given names equate to John Lewis in English) . His Hebrew name was Yonah . Von Neumann 's place of birth was Budapest in the Kingdom of Hungary which was then part of the Austro @-@ Hungarian Empire . He was the eldest of three children . He had two younger brothers : Michael , born in 1907 , and Nicholas , who was born in 1911 . His father , Neumann Miksa (English : Max Neumann) was a banker , who held a doctorate in law . He had moved to Budapest from Pécs at the end of the 1880s . Miksa 's father and grandfather were both born in Ond (now part of the town of Szerencs) , Zemplén County , northern Hungary . John 's mother was Kann Margit (English : Margaret Kann) ; her parents were Jakab Kann and Katalin Meisels . Three generations of the Kann family lived in spacious apartments above the Kann @-@ Heller offices in Budapest ; von Neumann 's family occupied an 18 @-@ room apartment on the top floor .

In 1913 , his father was elevated to the nobility for his service to the Austro @-@ Hungarian Empire by Emperor Franz Joseph . The Neumann family thus acquired the hereditary appellation Margittai , meaning of Marghita . The family had no connection with the town ; the appellation was chosen in reference to Margaret , as was those chosen coat of arms depicting three marguerites . Neumann János became Margittai Neumann János (John Neumann of Marghita) , which he later changed to the German Johann von Neumann .

Formal schooling did not start in Hungary until the age of ten . Instead , governesses taught von Neumann , his brothers and his cousins . Max believed that knowledge of languages other than

Hungarian was essential , so the children were tutored in English , French , German and Italian . By the age of 8 , von Neumann was familiar with differential and integral calculus , but he was particularly interested in history , reading his way through Wilhelm Oncken 's 46 @-@ volume Allgemeine Geschichte in Einzeldarstellungen . A copy was contained in a private library Max purchased . One of the rooms in the apartment was converted into a library and reading room , with bookshelves from ceiling to floor .

Von Neumann entered the Lutheran Fasori Evangelikus Gimnázium in 1911 . This was one of the best schools in Budapest , part of a brilliant education system designed for the elite . Under the Hungarian system , children received all their education at the one gymnasium . Despite being run by the Lutheran Church , the majority of its pupils were Jewish . The school system produced a generation noted for intellectual achievement , that included Theodore von Kármán (b . 1881) , George de Hevesy (b . 1885) , Leó Szilárd (b . 1898) , Eugene Wigner (b . 1902) , Edward Teller (b . 1908) , and Paul Erd?s (b . 1913) . Collectively , they were sometimes known as Martians . Wigner was a year ahead of von Neumann at the Lutheran School . When asked why the Hungary of his generation had produced so many geniuses , Wigner , who won the Nobel Prize in Physics in 1963 , replied that von Neumann was the only genius .

Although Max insisted von Neumann attend school at the grade level appropriate to his age , he agreed to hire private tutors to give him advanced instruction in those areas in which he had displayed an aptitude . At the age of 15 , he began to study advanced calculus under the renowned analyst Gábor Szeg? . On their first meeting , Szeg? was so astounded with the boy 's mathematical talent that he was brought to tears . Some of von Neumann 's instant solutions to the problems in calculus posed by Szeg? , sketched out on his father 's stationery , are still on display at the von Neumann archive in Budapest . By the age of 19 , von Neumann had published two major mathematical papers , the second of which gave the modern definition of ordinal numbers , which superseded Georg Cantor 's definition . At the conclusion of his education at the gymnasium , von Neumann sat for and won the Eötvös Prize , a national prize for mathematics .

Since there were few posts in Hungary for mathematicians , and those were not well @-@ paid , his father wanted von Neumann to follow him into industry and therefore invest his time in a more financially useful endeavor than mathematics . Von Neumann and his father decided that the best career path was to become a chemical engineer . This was not something that von Neumann had much knowledge of , so it was arranged for him to take a two @-@ year non @-@ degree course in chemistry at the University of Berlin , after which he sat the entrance exam to the prestigious ETH Zurich , which he passed in September 1923 . At the same time , von Neumann also entered Pázmány Péter University in Budapest , as a Ph.D. candidate in mathematics . For his thesis , he chose to produce an axiomatization of Cantor 's set theory . He passed his final examinations for his Ph.D. soon after graduating from ETH Zurich in 1926 . He then went to the University of Göttingen on a grant from the Rockefeller Foundation to study mathematics under David Hilbert .

= = Early career and private life = =

Von Neumann 's habilitation was completed on December 13 , 1927 , and he started his lectures as a privatdozent at the University of Berlin in 1928 . By the end of 1927 , von Neumann had published twelve major papers in mathematics , and by the end of 1929 , thirty @-@ two papers , at a rate of nearly one major paper per month . His reputed powers of memorization and recall allowed him to quickly memorize a column from the telephone book and recite the names . In 1929 , he briefly became a privatdozent at the University of Hamburg , where the prospects of becoming a tenured professor were better , but in October of that year a better offer presented itself when he was invited to Princeton University in Princeton , New Jersey .

On New Year 's Day in 1930 , von Neumann married Mariette Kövesi , who had studied economics at the Budapest University . Before his marriage he was baptized a Catholic . Max had died in 1929 . None of the family had converted to Christianity while he was alive , but afterwards they all did . Von Neumann and Mariette had one child , a daughter , Marina , who as of 2015 is a distinguished professor of business administration and public policy at the University of Michigan . The couple

divorced in 1937 . In October 1938 , von Neumann married Klara Dan , whom he had met during his last trips back to Budapest prior to the outbreak of World War II .

In 1933 , von Neumann was offered a lifetime professorship on the faculty of the Institute for Advanced Study when the institute 's plan to appoint Hermann Weyl fell through . He remained a mathematics professor there until his death , although he announced his intention to resign and become a professor at large at the University of California shortly before . His mother , brothers and in @-@ laws followed von Neumann to the United States in 1939 . Von Neumann anglicized his first name to John , keeping the German @-@ aristocratic surname of von Neumann . His brothers changed theirs to " Neumann " and " Vonneumann " . Von Neumann became a naturalized citizen of the United States in 1937 , and immediately tried to become a lieutenant in the United States Army 's Officers Reserve Corps . He passed the exams easily , but was ultimately rejected because of his age . His prewar analysis of how France would stand up to Germany is often quoted . He said : " Oh , France won 't matter . "

The von Neumanns , Klara and John , were active socially within the Princeton academic community . His white clapboard house at 26 Westcott Road was one of the largest in Princeton . He took great care over his clothing , and would always wear formal suits , once riding down the Grand Canyon astride a mule in a three @-@ piece pin @-@ stripe . Hilbert is reported to have asked at von Neumann 's 1926 doctoral exam : " Pray , who is the candidate 's tailor ? " as he had never seen such beautiful evening clothes .

Von Neumann liked to eat and drink ; his wife , Klara , said that he could count everything except calories . He enjoyed Yiddish and " off @-@ color " humor (especially limericks) . He was a non @-@ smoker . At Princeton he received complaints for regularly playing extremely loud German march music on his gramophone , which distracted those in neighbouring offices , including Albert Einstein , from their work . Von Neumann did some of his best work in noisy , chaotic environments , and once admonished his wife for preparing a quiet study for him to work in . He never used it , preferring the couple 's living room with its television playing loudly . Despite being a notoriously bad driver , he nonetheless enjoyed driving ? frequently while reading a book ? occasioning numerous arrests , as well as accidents . When Cuthbert Hurd hired him as a consultant to IBM , Hurd often quietly paid the fines for his traffic tickets .

Von Neumann 's closest friend in the United States was mathematician Stanislaw Ulam . A later friend of Ulam 's , Gian @-@ Carlo Rota , wrote : " They would spend hours on end gossiping and giggling , swapping Jewish jokes , and drifting in and out of mathematical talk . " When von Neumann was dying in hospital , every time Ulam would visit he would come prepared with a new collection of jokes to cheer up his friend . He believed that much of his mathematical thought occurred intuitively , and he would often go to sleep with a problem unsolved , and know the answer immediately upon waking up .

= = Mathematics = =

= = = Set theory = = =

The axiomatization of mathematics , on the model of Euclid 's Elements , had reached new levels of rigour and breadth at the end of the 19th century , particularly in arithmetic , thanks to the axiom schema of Richard Dedekind and Charles Sanders Peirce , and geometry , thanks to Hilbert 's axioms . But at the beginning of the 20th century , efforts to base mathematics on naive set theory suffered a setback due to Russell 's paradox (on the set of all sets that do not belong to themselves) . The problem of an adequate axiomatization of set theory was resolved implicitly about twenty years later by Ernst Zermelo and Abraham Fraenkel . Zermelo ? Fraenkel set theory provided a series of principles that allowed for the construction of the sets used in the everyday practice of mathematics , but they did not explicitly exclude the possibility of the existence of a set that belongs to itself . In his doctoral thesis of 1925 , von Neumann demonstrated two techniques to exclude such sets ? the axiom of foundation and the notion of class .

The axiom of foundation proposed that every set can be constructed from the bottom up in an ordered succession of steps by way of the principles of Zermelo and Fraenkel . If one set belongs to another then the first must necessarily come before the second in the succession . This excludes the possibility of a set belonging to itself . To demonstrate that the addition of this new axiom to the others did not produce contradictions , von Neumann introduced a method of demonstration , called the method of inner models , which later became an essential instrument in set theory .

The second approach to the problem of sets belonging to themselves took as its base the notion of class , and defines a set as a class which belongs to other classes , while a proper class is defined as a class which does not belong to other classes . Under the Zermelo ? Fraenkel approach , the axioms impede the construction of a set of all sets which do not belong to themselves . In contrast , under the von Neumann approach , the class of all sets which do not belong to themselves can be constructed , but it is a proper class and not a set .

With this contribution of von Neumann , the axiomatic system of the theory of sets avoided the contradictions of earlier systems , and became usable as a foundation for mathematics , despite the lack of a proof of its consistency . The next question was whether it provided definitive answers to all mathematical questions that could be posed in it , or whether it might be improved by adding stronger axioms that could be used to prove a broader class of theorems . A strongly negative answer to whether it was definitive arrived in September 1930 at the historic mathematical Congress of Königsberg , in which Kurt Gödel announced his first theorem of incompleteness : the usual axiomatic systems are incomplete , in the sense that they cannot prove every truth which is expressible in their language . Moreover , every consistent extension of these systems would necessarily remain incomplete .

Less than a month later , von Neumann , who had participated at the Congress , communicated to Gödel an interesting consequence of his theorem : that the usual axiomatic systems are unable to demonstrate their own consistency . However , Gödel had already discovered this consequence , now known as his second incompleteness theorem , and he sent von Neumann a preprint of his article containing both incompleteness theorems . Von Neumann acknowledged Gödel 's priority in his next letter . He never thought much of " the American system of claiming personal priority for everything . "

= = = Ergodic theory = = =

Von Neumann made foundational contributions to ergodic theory , in a series of articles published in 1932 . Of the 1932 papers on ergodic theory , Paul Halmos writes that even " if von Neumann had never done anything else , they would have been sufficient to guarantee him mathematical immortality " . By then von Neumann had already written his famous articles on operator theory , and the application of this work was instrumental in the von Neumann mean ergodic theorem .

= = = Operator theory = = =

Von Neumann introduced the study of rings of operators , through the von Neumann algebras . A von Neumann algebra is a * -algebra of bounded operators on a Hilbert space that is closed in the weak operator topology and contains the identity operator . The von Neumann bicommutant theorem shows that the analytic definition is equivalent to a purely algebraic definition as an algebra of symmetries . The direct integral was introduced in 1949 by John von Neumann . One of von Neumann 's analyses was to reduce the classification of von Neumann algebras on separable Hilbert spaces to the classification of factors .

= = = Measure theory = = =