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**EXPANSION OF THE DEPARTMENT OF MATHEMATICS AT
PRINCETON UNIVERSITY AND THE FOUNDING OF THE SCHOOL OF
MATHEMATICS AT THE INSTITUTE FOR ADVANCED STUDY: 1900-
1950**

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During the Second World War, the United States hosted an extreme range of scientific and technological advancements enacted by individuals both born in and outside of the borders of North America. Researchers paved the way with new and uncharted processes, and visions generated discoveries powerful enough to alter nature and civilizations. Physics, Chemistry, Biology, Engineering, Linguistics, and especially Mathematics presented a backbone supporting the efforts of women and men planning, and fighting for, the survival of early 20th Century Western culture. The minds of the scientists involved in the work leading to innovations such as atomic weapons, mechanical and digital computers, modern cryptology, and radar possessed thorough knowledge of the universal descriptions of movement in the known, physical universe: Mathematics. From 1900 to 1950 the United States of America housed multiple advanced research facilities in academic, military, and corporate spheres, yet a single city, Princeton, New Jersey, hosted two of the most prestigious institutions and provided a location for the expansive mathematical investigations taking place just before, during, and immediately after the Second World War. Princeton University and the Institute for Advanced Study housed, fed, and provided workspaces for an array of Mathematicians uncovering new research methodologies (resulting in the defeat of both the Nazi Party and the Empire of Nippon), the foundation for modern experimental Mathematics, and expansions of Theoretical and Applied Physics.

The existence of an entity as world-renowned as the Princeton University Department of Mathematics stems from the dynamic past of the institution overall. What is now Princeton University initially drew students from almost all of the pre-Revolution American Colonies (owing to a lack of an institution of higher education located between Yale, in Connecticut, and the College of William and Mary, in Virginia) thus assuring a wide diversity of backgrounds among students and faculty. Founded in 1746 as a Presbyterian school for the training of ordained Ministers, Princeton University began life in Newark, New Jersey as an all-male campus known as The College of New Jersey. The institution's founders hailed from a theological organization known as the New Lights: a controversial mixture of fellow Presbyterians disappointed with the Protestant congregations of the early/mid-18th Century. Local authorities banished the New Lights from the city of Philadelphia's synod in 1741, and Jonathon Dickenson (the future College of New Jersey's first President), with three other ministers, joined three lay workers (exiled from New York), and set about constructing a new school of higher education more suited to the New Light's views on The Divine. Of the seven founders, six graduated from Yale University, but said University's expulsion of fellow theologian David Brainerd indicated that a Yale-based model did not provide the organizational structure the New Lights desired.¹

By 1748 The College of New Jersey gained a powerful patron in then New Jersey Governor Jonathon Belcher: a man so passionately involved with the school that the politician all but adopted the College as a child. Nassau Hall, the College's first building (and the largest in the American Colonies) opened to students and faculty in 1756 and until the 19th Century stood as one of only two buildings on campus. The Revolutionary War saw The Battle of Princeton with shots fired inside Nassau Hall in 1777, and in 1783 brought the Continental Congress resided in Princeton for a short period while attempting to escape from Revolutionary War veterans seeking back-pay. An 1802 fire nearly destroyed Nassau Hall, and the College later provided a refuge for Southern pupils during the early stages of the Civil War, since the institution drew students from a wide range of geographies. In 1861 the College allowed Confederate students to withdraw without penalty in order to return home.²

Developments continued when the United States' first Museum of Natural History opened on the College of New Jersey's campus in 1856 and the first inter-college American football game took place in 1869 between the College and Rutgers. The year 1896 saw the College officially relabeled Princeton University following (in name) the relocation of the institution, in the late 18th Century, to the town of Princeton. Later President of the United States Woodrow Wilson arrived as the University's President in 1902, and enrollment grew drastically after the First World War, with Albert Einstein lecturing at Princeton for the first time in 1921. Henry Fine became Chair of the Department of Mathematics in 1903, and stayed on in the role, building the Department into a world-class unit, until retiring in 1928. The Rockefeller Foundation aggressively recruited eminent Mathematicians and Physicists from around the globe and brought to Princeton University both John von Neumann and Eugene Wigner. The following decade, in 1930, saw the founding of The Institute for Advanced Study (IAS): a radical, post-doctoral school designed without students and no classes.³

The entire purpose for attending the IAS was (and is today) the freedom to research any topic without the restrictions of teaching or administrative duties: no grant obligations, no grading load, and no publication requirements. Scholars visiting the Institute receive an apartment, selected meals, and an office, collaborating with other visiting researchers and permanent faculty for the sole purpose of unfettered inquiry. Most visitors stay at the IAS for one to two years. Initially, the IAS resided entirely in Princeton University's Fine Hall (allowing Institute faculty and University faculty to mingle and collaborate freely) until, in 1939, the IAS relocated to an autonomous campus just outside the University's grounds. The 1933 appointment of Harold Dodds as Princeton University's President ushered an era of rapid development in the areas of Mathematics and Sciences to create a research center capable of rivaling any European center of knowledge.⁴

Dodds placed Princeton University's resources at the disposal of the President of the United States during World War II, and the institution's faculty and Graduate students engaged heavily in researching cryptography and atomic Physics. The latter endeavour culminated in several Professors' involvement in the Manhattan Project: the United States' successful efforts to engineer nuclear weapons. Following the end of the War, the 1947-1948 New Jersey State legislative session passed anti-discrimination laws regarding the admittance of students into institutions of higher education. The resulting alterations in the student body allowed academic access to the first Princeton African American graduate in 1949. The Princeton class of 1952 is regarded as the University's first student body to graduate without the full influence of the war

efforts, and post-war social changes led inexorably to the admittance of women as students in 1969 and the subsequent co-educational graduation of the class of 1973.⁵

Princeton University President Woodrow Wilson (taking the post in 1902) sought to bring in stars of mathematical and scientific acclaim for the betterment of the University and the prospects of American research ingenuity. By 1925, the Princeton Department of Mathematics rated in the top-five national programs, while the total of Princeton National Research Fellows quickly rose to number one in the nation in Mathematics. The budding greatness, however, of Princeton University rests on a humble history, dating to 1683 when a settler named Henry Greenland opened a tavern near the intersection of the main roads, and amidst the small commercial hub the village of Prince-Town formed. The College of New Jersey eventually relocated from Newark to Princeton in 1752 thus cementing changes in academic style. The changes turned drastic when the Institute for Advanced Study's first Director, Abraham Flexner, formulated the first plans for building a faculty, even as the IAS lacked independent facilities, requiring space in Princeton's Nassau Hall. An early faculty member of the IAS, Oswald Veblen, encouraged large numbers of the early Institute faculty to engage in outdoors activities to offset the cerebral, indoor pursuits of research. In 1936 the financial backers of the IAS acquired 256 acres of land, and during the following few years the Institute's holdings grew to 610 acres, encompassing the surrounding woodlands: an area presently under the organization's protection and care.⁶

The fact that the IAS found a home at Princeton University at all is the result of efforts made by Henry Burchard Fine in 1905, when Fine gained appointment as Dean of the Faculty by (University) President Woodrow Wilson. The efforts of the Dean to expand the number of Princeton hard sciences Professors resulted in the recruitment of renowned researchers including Luther P. Eisenhart, Oswald Veblen, and George David Birkhoff, the last individual later becoming a prominent mathematical figure at Harvard University. The University eventually gained enough prominence to take control of the leading national Mathematics journal *Annals of Mathematics* from Harvard in 1911. Expansion of the Princeton faculty occurred again in 1928 when the University instituted the Scientific Research Fund and played host to prominent Mathematicians such as G.H. Hardy and Paul Dirac. The two gentlemen hailed from the University of Cambridge, with Dirac acting as Lucasian Professor of Mathematics. The death of Dean Fine in the same year paved the way for the creation of the Institute for Advanced Study.⁷

The School of Mathematics formed the first branch of the IAS' staffing model in 1932 (later followed by the Schools of Natural Sciences, Historical Studies, and Social Science) and several of the first appointments came from the University of Princeton, a loss often felt dearly at the latter institution. Oswald Veblen and Hungarian John von Neumann (a professor of mathematical Physics since 1930), held positions at the University prior to Abraham Flexner's efforts to build a staff for the new Institute. Albert Einstein joined the IAS' faculty in the inaugural year, though Einstein, previously acting as a Visiting Professor, never held a permanent position at Princeton. Following Fine's death, Luther P. Eisenhart worked as Mathematics Department Head from 1929-1945, and under such tutelage Princeton produced more Ph.D. degrees in Mathematics than any other university in the States.⁸

The persecution of Jewish and foreign peoples by the German Nazi party in the 1930s caused a wave of refugee scholars to the United States and eventually placed the quality of advanced Mathematics research in the United States on-par with of long-established European

institutions of higher education. As a result, the first post-World-War-Two international Mathematics conference took place in Fine Hall in 1946.⁹ The modern-day Jones Hall, previously named Fine Hall after the devoted Dean, became the home of the University of Princeton's Department of Mathematics in 1930. The mathematics program eventually (after decades of growth) expanded outside the walls of the stately, old Fine Hall, and the new Fine Hall's construction began in 1969.¹⁰ The previous department home found a new name after Thoms D. and Niece Gwethalyn Jones: descendants of 1876 Princeton alumni lawyers. After Dean Fine's death in 1929, Thomas and Gwethalyn paid for the construction of a Mathematics building bearing the former Dean's name. On the relocation of the Princeton Department of Mathematics to the new Fine Hall, the previous home of the department bore the name of the structure's financial contributors.¹¹

The efforts of corporate moguls created a similar legacy for the Institute for Advanced Study when Louis Bamberger (a retail company executive from Newark, New Jersey) joined

Brother-in-law Louis M. Frank and salesman Felix Fuld, expanding the store chain before selling the corporation immediately prior to the Stock Market crash of 1929. Caroline Bamberger (Sister of Louis) married first Frank, then, following Frank's death, Fuld and the bond between company and family solidified. Abraham Flexner worked in the 1920s as a member of the Rockefeller Foundation and caught the attention of Bamberger and Fuld as plans gained momentum for an institution without research restrictions as both Bamberger and Fuld appreciated the need to conduct high level inquiry beyond the constraints of everyday life and routine academic duties. Abraham Flexner's 1910 Flexner Report acted as a critique of physician training in the United States and the document led Bamberger and Fuld to Flexner for guidance in creating the new institution.¹²

On May 20, 1930, the State of New Jersey approved the incorporation of The Institute for Advanced Study-Louis Bamberger and Mrs. Felix Fuld Foundation. The founding documents of the IAS stipulate that the organization is free from prejudice against race, religion, or sex. Just as Princeton University sought to expand the prestige of the faculty in the Department of Mathematics years earlier, so too did Abraham Flexner during the early days of the IAS' first School. The earliest faculty members included Oswald Veblen and Luther Eisenhart (the Princeton Department of mathematics Chair). Unfortunately, in 1930 no housing for the Institute's work existed, but Princeton University sacrificed not only personnel to the IAS' creation, but also office space: providing rooms in Fine Hall (later Jones Hall) for the IAS employees from 1933-1939. Eventually a singular building, Fuld Hall, came to fulfill the initial independent facilities for the IAS on May 22, 1939.¹³ The Common Room of said building acted (as today) as the central meeting point for IAS faculty and visiting scholars. The staff still serve tea and cookies in the Common Room for one hour every weekday and the event draws many of the Institute's researchers to discuss the latest developments of the in-depth work under way in the various Schools. IAS faculty and students (or members) often attended lectures at Princeton's Fine Hall after the opening of Fuld. Such a close relationship cemented a permanent link between the IAS and Princeton University, and many visitors to both the University and the Institute do not differentiate the two organizations as separate entities.¹⁴

Albert Einstein formally accepted an offer to join the Institute for Advanced Study in 1933, and in so doing, became the IAS' highest-profile employee. However, despite the acclaim Einstein received for work done on Special Relativity and photons in 1905 and General

Relativity completed in 1915, the succeeding years held more media fame from political and social causes than scientific breakthroughs. Einstein spent the remaining years at the IAS (until 1955) working to create a Unified Field Theory (also known as Quantum Gravity): a bridge between the tiny parameters of Quantum Mechanics and the large-scale nature of Relativity. Einstein, though initially a supporter of atomic weapons research in the late 1930s, deplored the atomic bombings of 1945 and regretted the earlier enthusiasm for the Manhattan Project. As the faculty of the School of Mathematics at the IAS fully rounded out, Oswald Veblen took the lead as the Department's primary advisor to Director Flexner (though to the present day no Department heads exist at the IAS), advising that only post-Doctoral students gain admittance to the IAS, a move Flexner strongly supported.¹⁵

In the 1940s, prior to the end of the Second World War, Hungarian science superstar John von Neumann accepted a faculty position at the IAS. Von Neumann, born in 1903, joined as the youngest Professor at the Institute (again, having previously worked at Princeton University), and eventually led the construction of the first prototype digital computer in the basement of Fuld Hall. Kurt Gödel (a researcher famed for illustrating the gaps in the foundations of Arithmetic), a close friend of Einstein, joined, not as a faculty employee, but as a member of the first group of visiting scholars, though Gödel received a Professorship at the IAS in 1953. Beginning in 1943 John von Neumann, in stark contrast to Einstein's views, worked extensively on the Manhattan Project at Los Alamos in the New Mexico desert. Von Neumann's previous studies with German Mathematician David Hilbert (formulator of the foundations of Geometry) before arriving in the United States placed the former in a position of high popular regard for social fame as much as any sense of scientific ability.¹⁶ A final addition to the early holders of Professorships at the IAS consisted of Herman Weyl, a German Mathematics Professor from the famed University of Göttingen in Lower Saxony.

Weyl caught the attention of Abraham Flexner early in the formation of the IAS, after extending Weyl an offer of faculty employment, Flexner received a rejection from the German Mathematician. Weyl did not see the need to leave a position at the prestigious University of Göttingen, though the rise of the Nazi Party made the ability to remain employed ever more difficult. The stress of the political situation and breakdown of general society in Germany, coupled with family distress, quickly caused Weyl to suffer a nervous breakdown and visit a sanitarium for an extended period. Weyl, finally realizing the dire nature of the plight of central Europe, reached out to Flexner hoping to find another offer of an appointment at the Institute to gain asylum in the United States. Abraham Flexner reacted cautiously, concerned that Weyl no longer possessed the mental capabilities to attempt advanced Mathematics, but in the end, Oswald Veblen prevailed over Flexner's misgivings. Veblen impressed upon Frank Aydelotte (the individual seemingly tapped to replace Flexner as Institute Director) to make the case for Weyl's admittance into the faculty. In 1933, Weyl finally received and accepted a position as a faculty member at the Institute for Advanced Study.¹⁷

Not all cases of Institute recruitment focused on such dire circumstances and, despite the exclusive environment of the IAS, not all offers succeeded. Freeman Dyson (currently Professor Emeritus in the School of Natural Sciences at the IAS) wrote letters to family members regarding Richard Feynman, a young prodigy of Physics previously involved in the Manhattan Project and a visiting member of the Institute. Feynman visited the IAS but turned down a faculty appointment from J. Robert Oppenheimer (Institute Director from 1947-1966 and former director of the Manhattan Project), painting the IAS as snobby and sterile in scientific scope.¹⁸ Niels

Bohr, the famous Danish Physicist, however moved the family home to the United States in 1943 and established a multi-generational reputation at the IAS. Bohr and Einstein interacted frequently and argued about questions of principles, especially regarding how to describe the completeness of the physical world. While still in Europe from 1910-1920 Bohr worked to make discoveries in spectral lines and the nature of electron shells while the Dane's Brother, Harold, worked with Flexner to help German scholars to the safety of the States in the 1940s. Niels Bohr's first visit to the IAS came in 1948 and continued until the final visit in 1958. Bohr's great-grandson eventually worked at the IAS on the incompatibility of Einstein's Theory of General Relativity with basic parameters of Quantum Mechanics.¹⁹

Oscar Wallace Greenberg, a Graduate student at Princeton University from 1952-1956, recounts the final years and perspectives of Einstein's life before the latter died of a heart attack in 1955. Greenberg worked with Einstein and the Professor's research assistant, Buria Kauffman, striving to bridge gravity and electromagnetism. The graduate student introduced Einstein at the latter's final seminar and recalls that Oppenheimer sought to restrict student access to the famous Physicist, creating an enlarged sense of isolation for the famous German Physicist. Modest throughout life, when asked what advice aspiring Physicists need most, Einstein simply replied: "Who am I to say?"²⁰ Regarding the opportunities afforded to burgeoning scientists, the gender gap between women and men in the hard Sciences is an issue only (relatively) recently addressed. Princeton University makes efforts to attempt to close the void in at least some manner with the Women and Mathematics program (WAM). The funding for the project arrives via the National Science Foundation, and the organization aims to counteract the lopsided gender demographics entering formal mathematical training. WAM encourages female research, mentoring opportunities, and collaboration across fields.²¹

Mathematics possesses the attributes of a science and of a language because the processes of theorems and proofs offer realms of discovery and experimentation while symbols (for actions such as Arithmetic) and numbers represent quantities for investigation into the movement of particles. Languages such as English present an opportunity to describe the concrete in abstract, conceptual ways while Mathematics provides a dual means of investigation as the subject studied and the laboratory for the experiment. Princeton University and the Institute for Advanced Study provided (and still provide) leading examples of cutting-edge thought during a period of world crises. Through the continued pursuit of mathematical research, Princeton, New Jersey offers a home for the future of science and technology in the United States of America.

NOTES

¹Don Oberdorfer, *Princeton University: The First 250 Years* (Princeton, NJ: The Trustees of Princeton University, 1995), 11, 14.

²*Ibid.*, 22, 28, 30, 56, 60.

³*Ibid.*, 65, 78, 81, 91, 96, 117, 125.

⁴*Ibid.*, 126-127.

⁵*Ibid.*, 128, 137-138, 144, 145, 184.

⁶George Dyson, "The Tavern and the Meeting House," The Institute for Advanced Study, accessed April 5, 2019, <https://www.ias.edu/ideas/2009/george-dyson-tavern-and-meeting-house>.

⁷"Mathematics," Princeton University, accessed April 5, 2019, <http://etcweb.princeton.edu/CampusWWW/Companion/mathematics.html>.

⁸*Ibid.*

⁹*Ibid.*

¹⁰"Fine Hall," Princeton University, accessed April 5, 2019, http://etcweb.princeton.edu/CampusWWW/Companion/fine_hall.html.

¹¹"Jones Hall," Princeton University, accessed April 5, 2019, http://etcweb.princeton.edu/CampusWWW/Companion/jones_hall.html.

¹²Linda G. Arntzenius, *Images of America: Institute for Advanced Study* (Charleston, SC: Arcadia Publishing, 2011), 9-11, 19.

¹³*Ibid.*, 22-24, 27.

¹⁴Albert Tucker (Fine Hall), interview by William Aspray, *The Princeton Mathematics Community in the 1930s*, April 11, 1984, https://web.archive.org/web/20121026124014/http://www.princeton.edu/~mudd/finding_aids/mathoral/pmc30.htm.

¹⁵Arntzenius, *Images*, 30, 32, 39, 43.

¹⁶*Ibid.*, 47, 52, 54, 59, 60.

¹⁷Steve Batterson, *Pursuit of Genius: Flexner, Einstein, and the Early Faculty at the Institute for Advanced Study* (Wellesley, MA: A.K. Peters. Ltd., 2006), 136, 153, 155, 145, 146-148.

¹⁸Freeman J. Dyson, "Of Historical Note: Richard Feynman," The Institute for Advanced Study, accessed April 5, 2019, <https://www.ias.edu/ideas/2011/dyson-of-historical-note>.

¹⁹Kelly Devine Thomas, "The Bohr Family at IAS," The Institute for Advanced Study, accessed April 5, 2019, <https://www.ias.edu/ideas/2009/bohr-family-at-ias>.

²⁰Oscar Wallace Greenberg, "Visits with Einstein and Discovering Color in Quarks," The Institute for Advanced Study, accessed April 5, 2019, <https://www.ias.edu/ideas/2015/greenberg-color>.

²¹"Women and Mathematics," The Institute for Advanced Study, 2019, <https://www.math.ias.edu/wam>.

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