

# Ramanujan, Erdos, Feynman: The Eternal Golden Triad

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*“Talent hits a target no one else can hit; Genius hits a target no one else can see.”*

—Arthur Schopenhauer

‘Genius’ seems to be a very small word. We use it in many forms every day, but have we tried to analyze what it really means? Wikipedia says “**Genius** is something or someone embodying exceptional intellectual ability, creativity, or originality, typically to a degree that is associated with the achievement of unprecedented insight. There is no scientifically precise definition of genius, and indeed the question of whether the notion itself has any real meaning is a subject of current debate. The term is used in various ways: to refer to a particular aspect of an individual, or the individual in their entirety; to a scholar in many subjects (e.g. Leonardo DaVinci) or a scholar in a single subject (e.g. Albert Einstein or Nikola Tesla). Research into what causes genius and mastery is still in its early stages, but psychology already offers relevant insights.” The term genius is used for numerous persons in our day to day conversations without us thinking too deeply about it. But if we think beyond the usual connotations of the term it will become clear to us that only a select few of the people are what we can term real ‘genius’. Sachin Tendulkar much like Sir Donald Bradman is a batting genius. There is no doubt about it. Albert Einstein is perhaps the only man in entire history with whom the term genius fits in perfectly. Another example that comes to my mind is that of Adolf Hitler. No doubt, Hitler did terrible things, but he was an evil genius if we consider the definition of the term mentioned above. Thus, genius is not only associated with good things per se. In this piece we give a brief account of the genius of three classic men. These are men who are unparalleled in the history of human scientific endeavour.

**Ramanujan:** Every Indian, no matter whatever is his mathematical prowess or his profession knows about a certain gentleman born in Erode, Tamil Nadu on 22<sup>nd</sup> December 1887 – S. Ramanujan. The modern Indian tradition in mathematics got a jolting shift with the advent of the sheer genius of Ramanujan. No man ever had achieved what he achieved in his 32 years on the earth and no other mathematician is likely ever to achieve such exalting fame and recognition living for such a short span of time. Born in a very poor Tamil family, his father worked in a cloth merchant’s shop and his mother who had a huge impact upon his childhood was a simple housewife. Making both ends meet, they somehow managed to scrape by. Ramanujan had tenacity for mathematics that could only be called haunting even at a very young age. He read books meant for college students and excelled at them, even furthering the results given there on his own. It came as no surprise when he passed his matriculation with flying colours.

Ramanujan entered the Govt. College of Kumbakonam and then tragedy struck-almost. The greatest misfortune for geniuses like Ramanujan is that they are very often so far ahead of their times that it takes mere mortals years to catch up with them, At college Ramanujan neglected every other subject apart from Mathematics and failed in all of them miserably. A genius like him could not even muster up an F.A. degree. He dropped out of college, all the while doing his mathematics and showing it to people who he

hoped would understand its value. But alas, India didn't have a mind as great as his to recognise what they had been blessed with. Fortunately, there were enough good willing gentlemen in the then Madras, who helped Ramanujan with a job and enough spare time to do his mathematics.

In the meantime, his mother married him to an eleven year old, Janaki. With the added burden of a new wife, Ramanujan searched for a job and finally got one at the Madras Port Trust office as a clerk; a position which in no way reflected his true potential. Undeterred he continued on his sway over modern mathematics and derived a plethora of results for himself. At the suggestion of various people he decided to send his work to a few famous English mathematicians. The first three mathematicians whom he sent a letter didn't even bother to reply. At last one professor replied but with not enough enthusiasm. And then, Ramanujan wrote out a long letter to Prof. G.H. Hardy, a young British pure mathematician. The rest as they say is now mathematical folklore.

This letter is perhaps the most significant piece of mathematical importance for the modern world. It contained lots of results which were new, a few of the results mentioned there were false and a whole lot of them had already been derived by great mathematicians of the 18<sup>th</sup> and 19<sup>th</sup> century. Hardy at first dismissed the letter as that of a crank, but then something was bothering him, and he along with his frequent collaborator John E. Littlewood sat out to marvel at the content of the letter. Just a few minutes on, they knew that they had a genius at hand, perhaps a "second Newton". Hardy later said that the formulas mentioned in the letter must be true because if they weren't "then no one would have had the imagination to invent them."

Hardy made fast arrangements to have Ramanujan come over to him at Cambridge University and he left no stone unturned to achieve this. At first Ramanujan was apprehensive about going abroad, being a devout Hindu Brahmin, he was not allowed to cross the seas. Fortunately for mathematics, Ramanujan relented and he set sail. Upon arriving at Cambridge both Hardy and Littlewood spared little time in polishing the genius of Ramanujan, and they formed a collaboration which has no parallel to this day in any field of human creativity. However, Ramanujan's health faltered and he was hospitalized on many occasions and finally he left for home again in 1919, after spending about half a decade in England and producing some of the most magical mathematics that the world has ever seen.

During his stay at Cambridge Ramanujan got a B.A by research degree from Cambridge University and perhaps remains the only man to get such a degree without an F.A. He was subsequently elected as a fellow of Trinity College, the first Indian to get that honour and then became the second Indian after Sir Ardaseer Cursetji to be elected to the Royal Society, the highest honour then for any mathematician to get. Ironically his candidature to the Society was vouched for by two of the mathematicians who had earlier not replied to his letters. Ramanujan was nursed in India by his wife, but fate had others plans and so on 26<sup>th</sup> April, 1920 he breathed his last at a house in Madras. The world had lost a brilliant man and mathematicians all over the world who were just beginning to appreciate his mathematics felt a terrible loss.

**Erdos:** Paul Erdős was born in Budapest, Hungary on March 26, 1913. His parents were both Jewish mathematicians from a vibrant intellectual community. His fascination with mathematics developed early—at the age of three, he could calculate how many seconds a person had lived. Both of Erdős's parents were high school mathematics teachers, and Erdős received much of his early education from them.

Erdős always remembered his parents with great affection. At 16, his father introduced him to two of his lifetime favorite subjects—infinite series and set theory. During high school, Erdős became an ardent solver of the problems proposed each month in KöMaL, the Mathematical and Physical Monthly for Secondary Schools. In 1934, at the age of 21, he was awarded a doctorate in mathematics. Because anti-Semitism was increasing, he moved that same year to Manchester, England, to be a guest lecturer. In 1938, he accepted his first American position as a scholarship holder at Princeton University. At this time, he began to develop the habit of travelling from campus to campus. He would not stay long in one place and travelled back and forth among mathematical institutions until his death.

Possessions meant little to Erdős; most of his belongings would fit in a suitcase, as dictated by his itinerant lifestyle. Awards and other earnings were generally donated to people in need and various worthy causes. He spent most of his life as a vagabond, travelling between scientific conferences and the homes of colleagues all over the world. He would typically show up at a colleague's doorstep and announce "my brain is open," staying long enough to collaborate on a few papers before moving on a few days later. He had his own idiosyncratic vocabulary: he spoke of "The Book", an imaginary book in which God had written down the best and most elegant proofs for mathematical theorems. Lecturing in 1985 he said, "You don't have to believe in God, but you should believe in The Book." He himself doubted the existence of God, whom he called the "Supreme Fascist" (SF). He accused the SF of hiding his socks and Hungarian passports, and of keeping the most elegant mathematical proofs to himself. When he saw a particularly beautiful mathematical proof he would exclaim, "This one's from The Book!". This later inspired a book entitled *Proofs from THE BOOK*. Also, all countries which he thought failed to provide freedom to individuals as long as they did no harm to anyone else were classified as imperialist and given a name that began with a lowercase letter. For example, the U.S. was "samland" (after Uncle Sam), the Soviet Union was "joedom" (after Joseph Stalin), and Israel was "israel". For his epitaph he suggested, "I've finally stopped getting dumber." (Hungarian: "Végre nem butulok tovább").

In 1952, during the McCarthy anti-communist investigations, the U.S. government denied Erdős, a Hungarian citizen, a re-entry visa into the United States, for reasons that have never been fully explained. Teaching at Notre Dame at the time, Erdős could have chosen to remain in the country. Instead, he packed up and left, albeit requesting reconsideration from the Immigration Service at periodic intervals. The government changed its mind in 1963 and Erdős resumed including American universities in his teaching and travels. Hungary, then a Communist nation, was under the hegemony of the Soviet Union. Although it curtailed the freedom of its citizens, in 1956 it gave Erdős the singular privilege of being allowed to enter and exit Hungary as he pleased.

Erdős exiled himself voluntarily from Hungary in 1973 as a principled protest against his country's policy of denying entry to Israelis. During the last decades of his life, Erdős received at least fifteen honorary doctorates. He became a member of the scientific academies of eight countries, including the U.S. National Academy of Sciences and the UK Royal Society. Shortly before his death, he renounced his honorary degree from the University of Waterloo over what he considered to be unfair treatment of colleague Adrian Bondy. He died "in action" of a heart attack on September 20, 1996, at the age of 83, while attending a conference in Warsaw, Poland. Erdős never married and had no children. Erdős was one of the most prolific publishers of papers in mathematical history, comparable only with Leonhard Euler; Erdős published more papers, while Euler published more pages. He wrote around 1,525 mathematical articles in his lifetime, mostly with co-authors. He strongly believed in and practiced mathematics as a social activity, having 511 different collaborators in his lifetime.

In terms of mathematical style, Erdős was much more of a "problem solver" than a "theory developer". Joel Spencer states that "his place in the 20th-century mathematical pantheon is a matter of some controversy because he resolutely concentrated on particular theorems and conjectures throughout his illustrious career." Erdős never won the highest mathematical prize, the Fields Medal, nor did he coauthor a paper with anyone who did, a pattern that extends to other prizes. He did win the Wolf Prize, where his contribution is described as "for his numerous contributions to number theory, combinatorics, probability, set theory and mathematical analysis, and for personally stimulating mathematicians the world over". In contrast, the works of the three winners after were recognized as "outstanding", "classic", and "profound", and the three before as "fundamental" or "seminal".

Of his contributions, the development of Ramsey theory and the application of the probabilistic method especially stand out. Extremal combinatorics owes to him a whole approach, derived in part from the tradition of analytic number theory. Erdős found a proof for Bertrand's postulate which proved to be far neater than Chebyshev's original one. He also discovered an elementary proof for the prime number theorem, along with Atle Selberg, which showed how combinatorics was an efficient method of counting collections. Erdős also contributed to fields in which he had little real interest, such as topology, where he is credited as the first person to give an example of a totally disconnected topological space that is not zero-dimensional.

Throughout his career, Erdős would offer prizes for solutions to unresolved problems. These ranged from \$25 for problems that he felt were just out of the reach of current mathematical thinking, to several thousand dollars for problems that were both difficult to attack and mathematically significant. There are thought to be at least a thousand such outstanding prizes, though there is no official or comprehensive list. The prizes remain active despite Erdős's death; Ronald Graham is the (informal) administrator of solutions. Winners can get either a check signed by Erdős (for framing only) or a cashable check from Graham.

Erdős known as the wit of the world mathematical community breathed his last in 1996 when he suddenly felt sick while attending a conference at Warsaw. What Erdős achieved in his long lasting life was not just 1500 papers and over 500 collaborators, but a legacy that remains alive even today amongst the numerous lives he touched with his words, deeds and mathematics.

**Feynman:** [Richard Phillips Feynman](#) was an American physicist known for his work in the path integral formulation of quantum mechanics, the theory of quantum electrodynamics and the physics of the superfluidity of supercooled liquid helium, as well as in particle physics (he proposed the parton model). For his contributions to the development of quantum electrodynamics, Feynman, jointly with Julian Schwinger and Sin-Itiro Tomonaga, received the Nobel Prize in Physics in 1965. He developed a widely used pictorial representation scheme for the mathematical expressions governing the behavior of subatomic particles, which later became known as Feynman diagrams.

During his lifetime, Feynman became one of the best-known scientists in the world. He assisted in the development of the atomic bomb and was a member of the panel that investigated the Space Shuttle Challenger disaster. In addition to his work in theoretical physics, Feynman has been credited with pioneering the field of quantum computing, and introducing the concept of nanotechnology. He held the Richard Chace Tolman professorship in theoretical physics at the California Institute of Technology. Feynman was a keen populariser of physics through both books and lectures, notably a 1959 talk on top-

down nanotechnology called *There's Plenty of Room at the Bottom* and *The Feynman Lectures on Physics*.

Feynman also became known through his semi-autobiographical books (*Surely You're Joking, Mr. Feynman!* and *What Do You Care What Other People Think?*) and books written about him, such as *Tuva or Bust!* Richard Phillips Feynman was born on May 11, 1918, in Far Rockaway, Queens, New York. The young Feynman was heavily influenced by his father, Melville, who encouraged him to ask questions to challenge orthodox thinking. From his mother, Lucille, he gained the sense of humour that he had throughout his life.

As a child, he delighted in repairing radios and had a talent for engineering. His younger sister Joan also became a professional physicist. By 15, he had learned differential and integral calculus. Before entering college, he was experimenting with and re-creating mathematical topics, such as the half-derivative, utilizing his own notation. In high school, he was developing the mathematical intuition behind his Taylor series of mathematical operators. He attended the Massachusetts Institute of Technology, where he received a bachelor's degree in 1939, and in the same year was named a Putnam Fellow. While there, Feynman took every physics course offered, including a graduate course on theoretical physics while only in his second year.

He obtained a perfect score on the graduate school entrance exams to Princeton University in mathematics and physics—an unprecedented feat—but did rather poorly on the history and English portions. Attendees at Feynman's first seminar included Albert Einstein, Wolfgang Pauli, and John von Neumann. He received a Ph.D. from Princeton in 1942; his thesis advisor was John Archibald Wheeler. Feynman's thesis applied the principle of stationary action to problems of quantum mechanics, inspired by a desire to quantize the Wheeler–Feynman absorber theory of electrodynamics, laying the groundwork for the "path integral" approach and Feynman diagrams, and was entitled "The Principle of Least Action in Quantum Mechanics".

At Princeton, the physicist Robert R. Wilson encouraged Feynman to participate in the Manhattan Project—the wartime U.S. Army project at Los Alamos developing the atomic bomb. Feynman said he was persuaded to join this effort to build it before Nazi Germany developed their own bomb. He was assigned to Hans Bethe's theoretical division, and impressed Bethe enough to be made a group leader. He and Bethe developed the Bethe–Feynman formula for calculating the yield of a fission bomb, which built upon previous work by Robert Serber.

Following the completion of his Ph.D. in 1942, Feynman held an appointment at the University of Wisconsin-Madison (UW) as an assistant professor of physics. After the war, Feynman declined an offer from the Institute for Advanced Study in Princeton, New Jersey and followed Hans Bethe, instead, to Cornell University, where Feynman taught theoretical physics from 1945 to 1950. Then Feynman opted for the California Institute of Technology (Caltech)—as he says in his book *Surely You're Joking Mr. Feynman!*—because a desire to live in a mild climate had firmly fixed itself in his mind while installing tire chains on his car in the middle of a snowstorm in Ithaca. Feynman did significant work while at Caltech, including research in Quantum electrodynamics.

The theory for which Feynman won his Nobel Prize is known for its accurate predictions. This theory was developed in the earlier years during Feynman's work at Cornell. He also developed Feynman diagrams, a

bookkeeping device which helps in conceptualizing and calculating interactions between particles in space-time, notably the interactions between electrons and their antimatter counterparts, positrons. These are just fragments of the enormous amount of work that Feynman did.

Feynman's legacy and genius as a theoretical physicist is beyond compare and is highly unlikely to be ever eclipsed by any other soul. Feynman is known for his exuberant style and approach to the subject and his sheer brilliance can give anyone a shiver. Feynman has inspired countless generations of mathematicians and physicists by his wit, humour, style and of course his works. For that and much more the world owes a debt to this genius.

Perhaps it's just fitting to say that the words Einstein used for Mahatma Gandhi would apply to Ramanujan, Erdos and Feynman too: "Generations to come and generations to go, will scarcely believe that such a one as he, had walked upon this earth in flesh and blood."

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