

Srinivasa Ramanujan Aiyangar I

Encyclopedia.com

Complete Dictionary of Scientific Biography COPYRIGHT 2008 Charles Scribner's Sons
8-10 minutes

(*b* Erode, near Kumbakonam, Tanjore district, Madras province, India, 22 December 1887; *d.* Chetput, near Madras, India, 26 April 1920)

mathematics.

Ramanujan belonged to a Brahman family, but his father was poor and served as a bookkeeper in the firm of a cloth merchant in Kumbakonam. At the age of seven, after two years in [elementary school](#), he transferred to the high school at Kumbakonam. In 1897 he placed first in the Tanjore primary examination. Ramanujan early studied some trigonometry on his own; real enthusiasm for the subject arose in 1903, when he was able to borrow an English text, Carr's *Synopsis of Pure Mathematics*. From then on, mathematics was nearly his only interest. He jotted down his results in a notebook which he carried with him and showed to people who were interested.

Quiet and meditative, Ramanujan was very fond of numerical calculations and had an unusual memory for numbers. In 1904 he won a fellowship at Government College, Kumbakonam. His excessive devotion to mathematics and neglect of English, a fundamental subject, led to his failure to be promoted. He returned to the college after traveling but could not graduate. He briefly attended a college in Madras, then returned to Kumbakonam, where he again failed. For several years he had no definite occupation but continued to record his mathematical results.

In 1909 Ramanujan married and was compelled to earn a living. He went to Ramaswami Aiyar, the founder of the Indian Mathematical Society, then deputy collector in the little town of Tirukkoyilur, to ask for a minor clerical job. He was sent on to Seshu Aayar, one of Ramanujan's former teachers, and obtained a substitute office job for a few months. He was then recommended to Ramachandra Rao, collector of Nellore, eighty miles north of Madras, who was interested in mathematics; he later described Ramanujan at the time of the interview:

A short uncouth figure, stout, unshaved, not over-clean, with one conspicuous feature—shining eyes—walked in with a frayed notebook under his arm. He was miserably poor.—He opened his book and began to explain some of his discoveries. I saw quite at once that there was something out of the way; but my knowledge did not permit me to judge whether he talked sense or nonsense. Suspending judgment, I asked him to come over again, and he did. And then he had gauged my ignorance and shewed me some of his simpler results. These transcended existing books, and I had no doubt he was a remarkable man. Then, step by step, he led me to elliptic integrals and hypergeometric series and at last his theory of divergent series not yet announced to the world converted me. I asked him what he wanted. He said he wanted a pittance to live on so that he might pursue his researches.

Rao was convinced that a job as a clerk was not the answer to Ramanujan's troubles and sent him back to Madras, where Rao supported him for a while and tried unsuccessfully to get a fellowship for him. When this did not succeed, Ramanujan in 1912 found a job in the office of the Madras Port Trust. At this time he began his mathematical publication in the *Journal of the Indian Mathematical Society*. His first paper, "Some Properties of Bernoulli's Numbers," was followed by a number of brief communications on series and infinite products and a geometric approximate construction of π .

Encouraged by influential friends interested in his mathematical work, Ramanujan began a correspondence with G. H. Hardy of Cambridge, one of the world's foremost specialists in analytic [number theory](#). In his first letter Ramanujan mentioned his investigations on the distribution of primes and then added more than 100 theorems he had found in various parts of mathematics. Hardy was duly impressed and invited Ramanujan to come to England but, being a Brahman, he had scruples about leaving India. Instead a two-year fellowship was arranged for him at the University of Madras.

Hardy was disappointed and continued to attempt to persuade Ramanujan to come to Cambridge. When his colleague E. H. Neville lectured in Madras, he approached the young man and this time obtained his consent. Very favorable fellowship arrangements were made, and Ramanujan was admitted to Trinity College in 1914. He developed rapidly under the guidance of Hardy and Littlewood, who also helped him to publish his papers in English periodicals. Aside from the dozen papers in the *Journal of the Indian Mathematical Society*, questions proposed, and notes from the proceedings of meetings, Ramanujan published twenty-one papers during his five-year stay in Europe, several of them in collaboration with Hardy.

It was inevitable that a large portion of Ramanujan's results from his notebooks consisted of rediscoveries; he had never had systematic training in mathematics or access to a good library. To quote Hardy: "What was to be done in the way of teaching him modern mathematics? The limitations of his knowledge were as startling as its profundity." He worked with modular equations and theorems of complex multiplication, yet had no notion of doubly periodic functions; he worked with analytic [number theory](#) and had only the vaguest idea of what a function of a complex variable was. Most of the theorems in the notebooks were not proved in the standard sense but were only made plausible: "His ideas as to what constituted a mathematical proof were of the most shadowy description. All his results, new or old, right or wrong, had been arrived at by a process of mingled argument, intuition and induction, of which he was entirely unable to give any coherent account." Ramanujan's investigations on the distribution of primes suffered particularly from these weaknesses and therefore contributed little to the development of the general theory.

Ramanujan's first paper published in Europe, "Modular Equations and Approximations to π " contained a number of peculiar and very good approximations to π , many of them by means of square root expressions. Of greater systematic interest is his long memoir "Highly Composite Numbers," in which he derived some important properties of these numbers. Ramanujan returned to the question of the average number of prime divisors of a number in a paper written with Hardy, 'The Normal Number of Prime Factors of a Number n .'

The part of Ramanujan's work that stimulated most contributions from later mathematicians is probably his study of the partition of numbers into summands. From MacMahon's extensive numerical calculations of the number $p(n)$ of partitions of a number n , Ramanujan conjectured that these integers must have simple congruence properties with respect to small primes and their powers. He was able to prove some of these results by means of formulas from the theory of elliptic functions; others have been derived later. These papers by Ramanujan on partitions were followed by a joint paper with Hardy on the asymptotic value of $p(n)$. Their result was remarkable, since not only did their formula give good approximations to the values already calculated but also seemed to give an exact expression for $p(n)$; Rademacher later established that this was correct.

Ramanujan's other work comprised a variety of topics, mainly of a combinatorial nature. He wrote on the representation of integers as the sum of squares and on the lattice points inside a circle; in function theory he produced several papers on definite integrals, as well as on elliptic, hypergeometric, and modular functions.

In 1917 Ramanujan fell ill, possibly with tuberculosis; and the remainder of his stay in England was spent in several sanatoriums. In 1918 he was elected a fellow of the [Royal Society](#) and in the same year a fellow of Trinity College. These high distinctions seemed to improve his health and stimulate his mathematical production. Nevertheless, since the English climate did not seem to be beneficial, it was decided to send him back to India. An annual allowance of £250 for five years was awarded him by the University of Madras, with prospects of a later professorship.

Ramanujan returned to Madras in April 1919 in a precarious state of health. A difficult patient who refused medical aid, he went for a while to his home district but was prevailed upon to return to Madras for treatment. Until his last days he continued his mathematical research.

BIBLIOGRAPHY

Ramanujan's works have been brought together in *Collected Papers of Srinivasa Ramanujan*, G. H. Hardy, P. V. Seshu Aiyar, and B. M. Wilson, eds. (Cambridge, 1927), and *Notebooks of Srinivasa Ramanujan*, 2 vols. (Bombay, 1957).

See also G. H. Hardy, *Ramanujan. Twelve Lectures on Subjects Suggested by His Life and Work* (Cambridge, 1940).

Oystein Ore