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Preface

This booklet on some famous scientists of modern India was first brought out on the occasion of the Open House for school students at the Tata Institute of Fundamental Research, on 2 November 2003.

In this new revised edition, we have added a few more biographies and included a list of books for further reading.

All the material herein is from published sources. Needless to add, the list is not complete. We have only chosen those scientists who have been instrumental in building up the vast and rich scientific culture of modern India. All those chosen here have contributed immensely to science. Almost all have been great institution builders. With a few exceptions, all chose to remain and do their work in India.

The compelling factor for the choice of these few, from among the many in the country, is the time and circumstances under which they worked. Their achievements are nothing short of heroic. With no infrastructure and with little support from the Government of the day, they have built up world class scientific institutions and a scientific heritage we can be proud of. The institutions they built still stand proud and are rated highly by the scientific community here and abroad.

The purpose of bringing out such a booklet is to inform and, of course, inspire you - the student. While well-researched, comprehensive biographies of all these scientific personalities are available, they are not always accessible to the student. We hope that you enjoy reading the booklet, as much as we enjoyed preparing it for you.

We sincerely hope that one day your name will figure in such a booklet.

Please tell us your impressions of this booklet.

Science Popularisation and Public Outreach Committee
Tata Institute of Fundamental Research
November 2004



Sir Jagadish Chandra Bose

Sir Jagadish Chandra Bose (1858-1937)

Jagadish Chandra Bose was born on 30 November 1858, in Myemsingh, Faridpur, a part of the Dhaka District now in Bangladesh. He attended the village school till he was 11. He then moved to Kolkata where he enrolled in St. Xavier's. He was very much interested in Biology. However, Father Lafont, a famous Professor of Physics, inspired in Bose a great interest in Physics.

Having obtained his B.A. in physical sciences, twenty two year old Bose left for London, to obtain a medical degree. However, he kept falling ill and had to discontinue his plans to be a doctor. He then obtained his B.A. degree from Christ College, Cambridge.

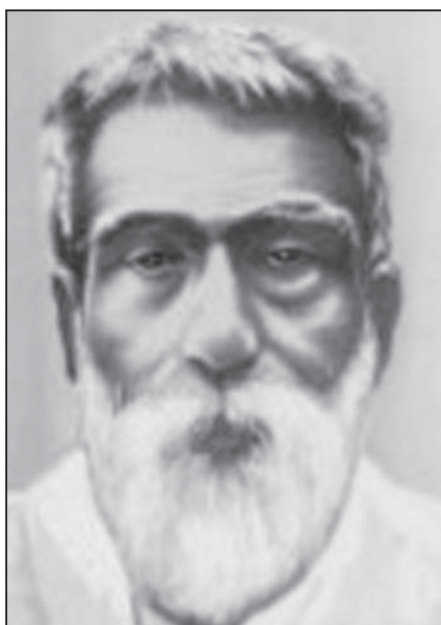
He returned to India in 1885 and joined Presidency College, Kolkata as an Assistant Professor of Physics, where he remained till 1915. There was a peculiar practice in the college at that time. The Indian teachers in the college were paid one third of what the British teachers were paid! So Bose refused his salary but worked for three years. The fourth year he was paid in full! He was an excellent teacher, extensively using scientific demonstrations in class. Some of his students, such as S. N. Bose went on to become famous physicists themselves.

During this period, Bose also started doing original scientific work in the area of microwaves, carrying out experiments involving refraction, diffraction and polarization. He developed the use of galena crystals for making receivers, both for short wavelength radio waves and for white and ultraviolet light. In 1895, two years before Marconi's demonstration, Bose demonstrated wireless communication using radio waves, using them to ring a bell remotely and to explode some gunpowder.

Many of the microwave components familiar today - waveguides, horn antennas, polarizers, dielectric lenses and prisms, and even semiconductor detectors of electromagnetic radiation - were invented and used by Bose in the last decade of the nineteenth century. He also suggested the existence of electromagnetic radiation from the Sun, which was confirmed in 1944.

Bose then turned his attention to response phenomena in plants. He showed that not only animal but vegetable tissues, produce similar electric response under different kinds of stimuli – mechanical, thermal, electrical and chemical.

Bose was knighted in 1917 and soon thereafter elected Fellow of the Royal Society, London, (both as physicist and biologist!). Bose had worked all along without the right kind of scientific instruments and laboratory. For a long time he had been thinking of building a laboratory. The result was the establishment of the Bose Research Institute in Kolkata. It continues to be a famous centre of research in basic sciences.



Prafulla Chandra Ray

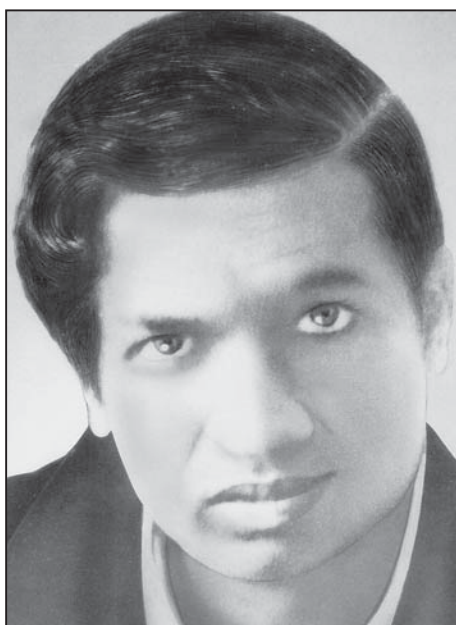
Prafulla Chandra Ray (1861-1944)

Prafulla Chandra was born on 2 August 1861 in Raruli-Katipara, a village in the District of Khulna (in present day Bangladesh). His early education started in his village school. He often played truant and spent his time resting comfortably on the branch of a tree, hidden under its leaves. After attending the village school, he went to Kolkata, where he studied at Hare School and the Metropolitan College. The lectures of Alexander Pedler in the Presidency College, which he used to attend, attracted him to chemistry, although his first love was literature. He continued to take interest in literature, and taught himself Latin and French at home. After obtaining a F.A. diploma from the University of Calcutta, he proceeded to the University of Edinburgh on a Gilchrist scholarship where he obtained both his B.Sc. and D.Sc. degrees.

In 1888, Prafulla Chandra made his journey home to India. Initially he spent a year working with his famous friend Jagadish Chandra Bose in his laboratory. In 1889, Prafulla Chandra was appointed an Assistant Professor of Chemistry in the Presidency College, Kolkata. His publications on mercurous nitrite and its derivatives brought him recognition from all over the world. Equally important was his role as a teacher - he inspired a generation of young chemists in India thereby building up an Indian school of chemistry. Famous Indian scientists like Meghnad Saha and Shanti Swarup Bhatnagar were among his students.

Prafulla Chandra believed that the progress of India could be achieved only by industrialization. He set up the first chemical factory in India, with very minimal resources, working from his home. In 1901, this pioneering effort resulted in the formation of the Bengal Chemical and Pharmaceutical Works Ltd.

He retired from the Presidency College in 1916, and was appointed as Professor of Chemistry at the University Science College. In 1921 when Prafulla Chandra reached 60 years, he donated, in advance, all his salary for the rest of his service in the University to the development of the Department of Chemistry and to the creation of two research fellowships. The value of this endowment was about two lakh rupees. He eventually retired at the age of 75. In Prafulla Chandra Ray, the qualities of both a scientist and an industrial entrepreneur were combined and he can be thought of as the father of the Indian Pharmaceutical industry.



Srinivasa Ramanujan

Srinivasa Ramanujan (1887-1920)

Ramanujan was born in Erode, a small village in Tamil Nadu on 22 December 1887. When he was a year old his family moved to the town of Kumbakonam, where his father worked as a clerk in a cloth merchant's shop. When he was nearly five years old, Ramanujan enrolled in the primary school. In 1898 he joined the Town High School in Kumbakonam. At the Town High School, Ramanujan did well in all subjects and proved himself an able all round scholar. It was here that he came across the book *Synopsis of Elementary Results in Pure Mathematics* by G. S. Carr. Influenced by the book, he began working on mathematics on his own, summing geometric and arithmetic series.

He was given a scholarship to the Government College in Kumbakonam. However his scholarship was not renewed because Ramanujan neglected all subjects other than mathematics. In 1905 he appeared for the First Arts examination which would have allowed him to be admitted to the University of Madras. Again he failed in all subjects other than mathematics, a performance he repeated in 1906 and 1907 too. In the following years he worked on mathematics, with only Carr's book as a guide, noting his results in what would become the famous *Notebooks*.

He got married in 1909 and started looking for a job. His search took him to many influential people, among them Ramachandra Rao, one of the founding members of the Indian Mathematical Society. For a year he was supported by Ramachandra Rao who gave him Rs. 25 per month. He started posing and solving problems in the Journal of the Indian Mathematical Society. His research paper on Bernoulli numbers, in 1911, brought him recognition and he became well known in Chennai as a mathematical genius. In 1912, with Ramachandra Rao's help, he secured the post of clerk in the accounts section of the Madras Port Trust. He continued to pursue mathematics and in 1913 he wrote to G. H. Hardy in Cambridge, enclosing a long list of his own theorems. Hardy immediately recognized Ramanujan's mathematical ability. On the basis of Hardy's letters, Ramanujan was given a scholarship by the University of Madras in 1913. In 1914, Hardy arranged for him to go to Trinity College, Cambridge.

Ramanujan's work with Hardy produced important results right from the beginning. In 1916 Ramanujan graduated from Cambridge with a Bachelor of Science by Research. In 1918, he was elected a Fellow of the Cambridge Philosophical Society, a Fellow of the Royal Society of London, and a Fellow of Trinity College, Cambridge, all in the same year! However, from 1917 onwards he was seriously ill and mostly bedridden. In 1919 he returned to India, in very poor health.

Ramanujan made outstanding contributions to analytical number theory, elliptic functions, continued fractions, and infinite series. His published and unpublished works have kept some of the best mathematical brains in the world busy to this day.



Sir Chandrasekhara Venkata Raman

Sir C. V. Raman (1888-1970)

Chandrasekhara Venkata Raman was born at Tiruchirapalli in Tamil Nadu on 7 November 1888. His father was a lecturer in mathematics and physics so from the very beginning he was immersed in an academic atmosphere. Raman's academic brilliance was established at a very young age. He finished his secondary school education at the tender age of thirteen and entered the Mrs. A.V.N. College at Vishakapatnam, Andhra Pradesh. Two years later he moved to the prestigious Presidency College in Chennai.

When he was fifteen, he topped his class to receive his B.A. degree with honours in Physics and English. Raman continued his studies at the Presidency College and when he was barely eighteen, graduated at the top of his class and received his M.A. degree with honours.

Raman joined the Indian Audit and Accounts Service and was appointed the Assistant Accountant General in the Finance Department in Kolkata. In Kolkata, he sustained his interest in science by working in the laboratory of the Indian Association for the Cultivation of Science, in his spare time studying the physics of stringed instruments and Indian drums.

In 1917, Raman gave up his government job to become the Sir Taraknath Palit Professor of Physics at the Science College of University of Calcutta (1917-33). He made enormous contributions to research in the areas of vibration, sound, musical instruments, ultrasonics, diffraction, photoelectricity, colloidal particles, X-ray diffraction, magnetron, dielectrics, etc. In particular, his work on the scattering of light during this period brought him world-wide recognition.

In 1924 he was elected a Fellow of the Royal Society of London and a year later was honoured with the prestigious Hughes medal from the Royal Society. Four years later, at the joint meeting of the South Indian Science Association and the Science Club of Central College, Bangalore, he announced his discovery of what is now known as the *Raman Effect*.

He was knighted in 1929, and in 1930, became the first Asian scientist to be awarded the Nobel Prize for Physics for his discoveries relating to the scattering of light (the Raman Effect). In 1934, he became the Director of the newly established Indian Institute of Science at Bangalore, where he remained till his retirement. After retirement, he established the Raman Research Institute at Bangalore, where he served as the Director. The Government of India conferred upon him its highest award, the Bharat Ratna in 1954.



Meghnad Saha

Meghnad Saha (1893-1956)

Meghnad Saha was born on 6 October 1893 in Sheoratali village near Dhaka in present day Bangladesh. His father Jagannath Saha was a grocer in the village. After primary education, he was admitted to a middle school that was seven miles away from home. He stayed with a doctor near the school and had to work in that house to pay for his boarding and lodging. Overcoming all these difficulties, he stood first in the Dhaka middle school test, thus securing a Government scholarship and joined the Dhaka Collegiate School in 1905.

Great political unrest was prevailing in Bengal, caused by the partition of the province by the British against strong popular opinion. Meghnad Saha was among the few senior students who staged a boycott of the visit by the then Governor, Sir Bampfylde Fuller and as a consequence forfeited his scholarship and had to leave the institution. He then joined the Kisorilal Jubilee School where he passed the entrance test of the University of Calcutta standing first among students from East Bengal. He graduated from Presidency College with mathematics as his major.

He then joined the newly established Science College in Kolkata as a lecturer and pursued his research activities in physics. By 1920, Meghnad Saha had established himself as one of the leading physicists of the time. His theory of high-temperature ionization of elements and its application to stellar atmospheres, as expressed by the Saha equation, is fundamental to modern astrophysics; subsequent development of his ideas has led to increased knowledge of the pressure and temperature distributions of stellar atmospheres.

In 1920, Saha went to Imperial College, London and later to Germany. Two years later he returned to India and joined the University of Calcutta as Khaira Professor. He then moved to the University of Allahabad and remained there till 1938, establishing the Science Academy in Allahabad (now known as the National Academy of Science). In 1927, he was elected a Fellow of the Royal Society of London.

He returned to the University of Calcutta in 1938 where he introduced nuclear physics into the post-graduate physics curriculum. In 1947 he established the Indian Institute of Nuclear Physics (now known as the Saha Institute of Nuclear Physics). Later in his life, Saha played an active role in the development of scientific institutions throughout India as well as in national economic planning involving technology.



Satyendra Nath Bose

Satyendra Nath Bose (1894-1974)

Satyendra Nath Bose was born on New Years day, 1894 in Goabagan in Kolkata. His father was an accountant in Indian Railways. Satyendra Nath popularly known as Satyen Bose, did his schooling at Hindu School, Kolkata, and then joined Presidency College. He excelled in academics throughout his education – Intermediate, B.Sc. and M.Sc. with applied mathematics. His teacher at the Presidency College was Jagadish Chandra Bose - whose other stellar pupil was Meghnad Saha. Bose took his B.Sc. examination in 1913 and his M.Sc examination in 1915. He stood first in both the examinations, the second place going to Meghnad Saha.

He worked as a lecturer of physics in the Science College of the University of Calcutta (1916-21) and along with Meghnad Saha, introduced postgraduate courses in modern mathematics and physics. He derived with Saha, the Saha-Bose equation of state for a nonideal gas.

In 1921, Bose left Kolkata to become a Reader at the Dakha University. It was during this period that he wrote the famous paper on the statistics of photons. It was named *Bose statistics* after him and is now an integral part of physics. Paul Dirac, the legendary physicist, coined the term *boson* for particles obeying these statistics. Apart from this he did theoretical work on the general theory of relativity and also experimental work on crystallography, fluorescence, and thermoluminescence.

Bose spent about 10 months in Paris in 1924, doing research with Madame Curie and Louis de Broglie. Later he went to Berlin where he met Einstein. He returned to Dhaka in 1926 and became Professor. Shortly before Independence, Bose returned to Kolkata to become the Khaira Professor of Physics, a post he kept till 1956. He was elected Fellow of the Royal Society in 1958, and the Government of India named him a National Professor and awarded him the honor of Padma Vibhushan.



Shanti Swarup Bhatnagar

Shanti Swarup Bhatnagar (1894-1955)

Bhatnagar was born on 21 February 1894 at Bhera, in the district of Shapur in Punjab (now in Pakistan). When he was barely eight months old, his father passed away. He spent his next thirteen years under the care of his maternal grandfather in Bulandshahar in Uttar Pradesh. Under the influence of his grandfather, young Bhatnagar not only developed a taste for engineering and science but also became interested at a very early age in geometry and algebra and in making mechanical toys. In 1911, Shanti published a letter to the editor, in *The Leader*, Allahabad, on how to make a substitute for carbon electrodes in a battery using molasses and carbonaceous matter under pressure and heat.

Matriculating the same year, he joined the Dayal Singh College, Lahore. After finishing his intermediate examination in first division, Shanti joined the Forman Christian College and after his B.Sc and M.Sc degrees, he spent the next two years at the University of London earning his D.Sc. degree on the surface tension of oils, under the supervision of Professor F.G. Donnan.

Returning to India in 1921, he joined the Benares Hindu University as a Professor, remaining there till 1924. From 1924 to 1940 he served as the Director of the University Chemical Laboratories, Lahore, addressing problems in industrial and applied chemistry.

In August 1940, Bhatnagar took over as the Director of the newly created Directorate of Scientific and Industrial Research. This organisation became the Council of Scientific and Industrial Research, with Bhatnagar as its Director. Bhatnagar's tenure saw the setting up of 12 laboratories and the total number of CSIR laboratories today stands at 40.

The British Government conferred on him the Order of the British Empire and in 1941, he was made the Knight Bachelor. In 1943 he was elected a Fellow of the Royal Society and received the Padma Vibhushan (1954) from the Government of India.

Shanti Swarup Bhatnagar played a significant part along with Homi Bhabha, Prasanta Chandra Mahalanobis, Vikram Sarabhai and others in building of post-independence Science & Technology infrastructure and in the formulation of India's science policies.



Homi Jehangir Bhabha

Homi Jehangir Bhabha (1909-1966)

Homi Bhabha was born on 30 October 1909 in Mumbai. Son of a barrister, he grew up in a privileged environment. In Mumbai he attended the Cathedral & John Connon School and then Elphinstone College, followed by the Royal Institute of Science. After passing the Senior Cambridge Examination at the age of sixteen, he joined the Gonville and Caius College in Cambridge with an intention to pursue mechanical engineering. His mathematics tutor was Paul Dirac, and Bhabha became fascinated with mathematics and theoretical physics. He earned his engineering degree in 1930 and Ph.D. in 1934.

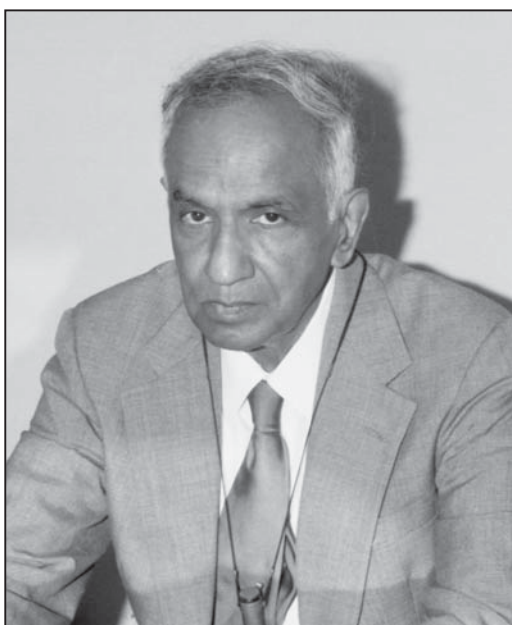
In 1937, together with W. Heitler, a German physicist, Bhabha solved the riddle about cosmic rays. Cosmic rays are fast moving, extremely small particles coming from outer space. When these particles enter the earth's atmosphere, they collide with the atoms of air and create a shower of electrons. Bhabha's discovery of the presence of nuclear particles (which he called *mesons*) in these showers was used to validate Einstein's theory of relativity making him world famous.

When the war broke out in Europe, Bhabha was on a holiday in India. In 1940, C.V. Raman, then head of the Physics Department, Indian Institute of Science, Bangalore, persuaded Bhabha to join the institute as a Reader in Physics and Bhabha decided to stay back in India. In 1941, Homi Bhabha was elected Fellow of the Royal Society, London, in recognition of his contributions to the field of cosmic rays, elementary particles and quantum mechanics.

Bhabha soon realized the need for an institute fully devoted to fundamental research, and wrote to J.R.D. Tata for funding. This resulted in the establishment of the Tata Institute of Fundamental Research (TIFR) in Mumbai in 1945, with Bhabha as the Director, a position he held until his death. In 1948, Homi Bhabha was appointed the Chairman of the International Atomic Energy Commission. Under his guidance, nuclear reactors like the Apsara, Cirus and Zerlina were built. He gained international recognition for his excellent work and served as the President of the first United Nations Conference on the Peaceful Uses of Atomic Energy, which was held in Geneva in 1955. He was the President of the International Union of Pure and Applied Physics from 1960 to 1963.

A multi-faceted personality, Bhabha was immensely fond of music, painting and writing. Some of his paintings are displayed in the British Art Galleries and the TIFR art collection today is rated as one of the best collections of contemporary Indian art in the country.

He is the recipient of the Adam's Award, Padma Bhushan, an Honorary Fellow of the American Academy of Arts and Sciences and Foreign Associate of the National Academy of Sciences in the United States.



Subramaniam Chandrasekhar

Subramaniam Chandrasekhar (1910-1995)

Subramaniam Chandrasekhar, a nephew of Sir C.V. Raman, was born on 19 October 1910 in Lahore, (now in Pakistan). His father was an officer in the Department of Audits and Accounts of the Indian Government Services. Chandrasekhar received his elementary education from his parents and private tutors when he was in Lahore. In 1918 Chandra moved to Chennai where he attended the Hindu High School finishing his secondary school education with honours. He then joined the Presidency College, there taking his Bachelor of Science degree in physics with honours.

His first scientific paper, *Compton Scattering and the New Statistics*, was published in the Proceedings of the Royal Society in 1928. On the basis of this paper he was accepted as a research student by R.H. Fowler at the University of Cambridge. On the voyage to England, he developed the theory of white dwarf stars, showing that a star of mass greater than 1.45 times the mass of the sun could not become a white dwarf. This limit is now known as the Chandrasekhar limit.

He obtained his doctorate in 1933. Soon after receiving his doctorate, Chandrasekhar was awarded the Prize Fellowship at Trinity College, Cambridge. In 1937, he accepted the position of Research Associate at the University of Chicago. Chandrasekhar stayed at University of Chicago throughout his career, becoming the Morton D. Hall Distinguished Service Professor in Astronomy and Astrophysics in 1952. In 1952 he established the *Astrophysical Journal* and was its editor for 19 years, transforming it from a local publication of the University of Chicago into the national journal of the American Astronomical Society. He became a US citizen in 1958.

He was elected Fellow of the Royal Society of London and in 1962 received the Society's Royal Medal. He also received the US National Medal of Science (1966). He was awarded the Nobel prize for Physics in 1983 for his theoretical work on the physical processes of importance to the structure of stars and their evolution. Chandra was a popular teacher who guided over fifty students to their Ph.D.s including some who went on to win the Nobel prize themselves!! His research explored nearly all branches of theoretical astrophysics and he published ten books, each covering a different topic, including one on the relationship between art and science.



Vikram Sarabhai

Vikram Sarabhai (1919-1971)

Vikram Sarabhai was born on 12 August 1919 at Ahmedabad. He had his early education in a private school, 'Retreat' run by his parents on Montessori lines. This atmosphere injected into the young boy the seeds of scientific curiosity, ingenuity and creativity. With a natural inclination towards physics and mathematics, Vikram Sarabhai did not get into his family business. After school and college in Gujarat, he went to England and obtained his tripos at St. John's College in 1939. He returned to India for a while and worked alongside Sir C.V. Raman in the field of cosmic rays, at the Indian Institute of Science in Bangalore, after which he returned to Cambridge, England for further research in the area and completed his Ph.D. in 1947.

He established the Physical Research Laboratory in Ahmedabad in 1948, in a few rooms at the M.G. Science Institute with Professor K.K. Ramanathan as Director. In April 1954, PRL moved into a new building and Dr. Sarabhai made it the cradle of the Indian Space Programme. At the young age of 28, he was asked to organise and create the ATIRA, the Ahmedabad Textile Industry's Research Association and was its Honorary Director during 1949-56. He also helped build and direct the Indian Institute of Management, Ahmedabad from 1962-1965.

Sarabhai pioneered India's space age by expanding the Indian Space Research Organization. India's first satellite Aryabhata launched in 1975, was one of the many projects planned by him. Like Bhabha, Sarabhai wanted the practical application of science to reach the common man. Thus he saw a golden opportunity to harness space science to the development of the country in the fields of communication, meteorology, remote sensing and education. The Satellite Instructional Television Experiment (SITE) launched in 1975-76, brought education to five million people in 2,400 Indian villages. In 1965, he established the Community Science Centre in Ahmedabad with a view to popularise science among children. His deep cultural interests led him, along with his wife Mrinalini Sarabhai, to establish Darpana Academy, an institution devoted to performing arts and propagation of ancient culture of India.

He was the recipient of the Bhatnagar Memorial Award for Physics in 1962, the Padma Bhushan in 1966, and was posthumously awarded the Padma Vibhushan. He was the Chairman of the Atomic Energy Commission in 1966, Vice-President and Chairman of the UN Conference on peaceful uses of outer space in 1968, and President of the 14th General Conference of the International Atomic Energy Agency. The International Astronomical Union named a crater in the moon (in the Sea of Serenity) after him, in honour of his contributions to science.



C. R. Rao

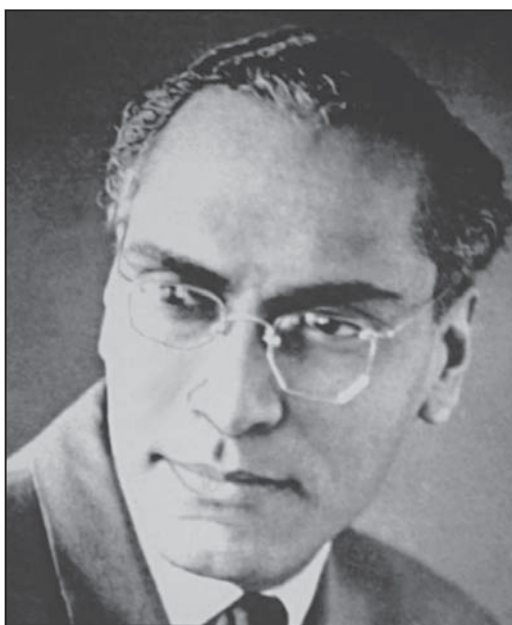
C. R. Rao (1920 -)

Calyampudi Radhakrishna Rao was born to C.D. Naidu and A. Laxmikantamma on 10 September 1920 in Huvvina Hadagalli in present day Karnataka. He was the eighth in a family of 10 children. After his father's retirement, the family settled down in Vishakapatnam in Andhra Pradesh. From his earliest years, Rao had an interest in mathematics. After completing high school he joined the Mrs. A.V.N. College at Vishakapatnam for the Intermediate course. He received his M.A. in Mathematics with first rank in 1940. Rao decided to pursue a research career in mathematics, but was denied a scholarship on the grounds of late submission of the application.

He then went to Kolkata for an interview for a job. He did not get the job, but by chance he visited the Indian Statistical Institute, then located in a couple of rooms in the Physics Department of the Presidency College, Kolkata. He applied for a one-year training course at the Institute and was admitted to the Training Section of the Institute from 1 January 1941. In July 1941 he joined the M.A Statistics program of the Calcutta University. By the time he passed the M.A. exam in 1943, winning the gold medal of the University, he had already published some research papers! In 1943 he joined ISI as a technical apprentice, doing research, teaching in the Training Section of the Institute and at Calcutta University and assisting Professor Mahalanobis in editing *Sankhya* the Indian Journal of Statistics.

In 1946 he was deputed to the Cambridge University on a project. While working full time on this, he also worked in the genetic laboratory of R.A. Fisher, the father of modern statistics and completed his Ph.D. under Fisher. By this time Rao had already completed some of the work which carries his name: Cramer-Rao inequality, Rao-Blackwell theorem, Rao's score test and Rao's orthogonal arrays. He returned to ISI in 1948 and in 1949 was made a Professor at the very young age of 29. He headed and developed the Research and Training Section of the ISI, and went on to become Director of the ISI. He became the associate editor of the *Sankhya* in 1964 and became the editor in 1972. He left ISI in 1978 and joined the University of Pittsburgh. In 1988 he moved to the Pennsylvania State University holding the Eberly Family Chair in Statistics and the Directorship of the Centre for Multivariate Analysis till 2001.

Dr. Rao is a Fellow of the Royal Society of London, and a Member of the National Academy of Sciences, U.S.A. He was awarded the Padma Vibhushan in 2001. The C.R. Rao Award for Statistics was instituted in his honor, to be given once in two years. In 2002 he was awarded the National Medal of Science of the U.S.A. The Advanced Institute of Mathematics, Statistics and Computer Science in the Osmania University Campus has been named after him.



K. Chandrasekharan

K. Chandrasekharan (1920 -)

Komaravolu Chandrasekharan was born on 21 November 1920 in Machilipatnam in modern-day Andhra Pradesh. He attended District Board School in Guntur District, Andhra Pradesh, and then High School at Bapatla, also in Guntur. He then obtained his M.A. in Mathematics from the Presidency College, Chennai and was a Research Scholar in the Department of Mathematics of the University of Madras during 1940-1943. During 1943-46 he was a part-time Lecturer at Presidency College and obtained his Ph.D. during this time under Ananda Rau, who was with Ramanujan in Cambridge. Chandrasekharan then went to the Institute for Advanced Study, Princeton, U.S.A.

In 1949, while he was in Princeton, he was invited by Homi Bhabha to join the School of Mathematics of the Tata Institute of Fundamental Research. An extraordinarily gifted organiser and administrator of science, he transformed the fledgling School of Mathematics of TIFR into a centre of excellence respected the world over. He initiated a very successful programme of recruitment and training of Research Scholars at TIFR. The programme continues to this day along the same lines that he set down. He put to excellent use his contacts with the leading mathematicians of the world, persuading many of them (like L. Schwartz, a Fields medalist, and C.L. Siegel) to visit TIFR and deliver courses of lectures over periods of two months and more. The lecture notes prepared out of these lectures and published by TIFR enjoy a great reputation in the world mathematics community to this day.

During 1955-61, he was a member of the Executive Committee of the International Mathematical Union (IMU). He served as the Secretary of IMU during 1961-66 and as President during 1971-74. His initiatives over a long period of 24 years on this Committee were numerous and valued greatly. He served as the Vice President of the International Council of Scientific Unions during 1963-66 and as its Secretary General during 1966-70. He was a member of the Scientific Advisory Committee to the Cabinet, Government of India during 1961-66. He was awarded the Padma Shri in 1959, Shanti Swarup Bhatnagar Award in 1963 and the Ramanujan Medal in 1966.

He was responsible for the IMU sponsoring the International Mathematical Colloquium held every 4 years at the Tata Institute starting 1956. In 1957 on his initiative, TIFR published the *Notebooks of Srinivasa Ramanujan*.

In the fifties, Chandrasekharan held the editorship of the Journal of the Indian Mathematical Society. Thanks to his abilities at persuading some of the great names in the field to publish there, several great papers appeared in the journal during this period.

In 1965 he left TIFR and moved to Eidgenössische Technische Hochschule, Zurich.

He worked in the fields of number theory and summability. His mathematical achievements are first rate, but his contribution to Indian mathematics has been even greater.



Har Gobind Khorana

Har Gobind Khorana (1922 -)

Har Gobind Khorana was born in Raipur, Punjab, (now in Pakistan) on 9 January 1922. His father was a patwari, a village agricultural taxation clerk in the British-Indian system of government. Har Gobind did his schooling from the D.A.V. High School in Multan. He received his B.Sc. and M.Sc. degrees from the Punjab University in Lahore. Khorana lived in India until 1945, when the award of a Government of India Fellowship made it possible for him to go to England and he studied for a Ph. D. degree at the University of Liverpool.

Khorana spent a postdoctoral year (1948-1949) at the Eidgenössische Technische Hochschule in Zurich, and then joined Cambridge University, England in 1950, where he worked with Professors G.W. Kenner and Lord A.R. Todd. In 1952 he went to the University of British Columbia, Vancouver, Canada. The British Columbia Research Council offered at that time very little by way of facilities, but there was 'all the freedom in the world', to do what the researcher liked to do. He became the Alfred Sloan Professor of Biology and Chemistry at the Massachusetts Institute of Technology in 1970 and is at present an Emeritus Professor at the Department of Biology at MIT.

Dr. Har Gobind Khorana shared the Nobel Prize for Medicine and Physiology in 1968 with Marshall Nirenberg and Robert Holley for cracking the genetic code. They established that this code, the biological language common to all living organisms, is spelled out in three-letter words: each set of three nucleotides codes for a specific amino acid. Dr. Khorana was also the first to synthesize oligonucleotides (strings of nucleotides). Today, oligonucleotides are indispensable tools in biotechnology, widely used in biology labs for sequencing, cloning and genetic engineering.

Khorana has won many awards and honors for his achievements, amongst them the Padma Vibhushan, Membership of the National Academy of Sciences, USA as well as a Fellow of the American Association for the Advancement of Science.



G. N. Ramachandran

G. N. Ramachandran (1922-2001)

G. N. Ramachandran was born on 8 October 1922 in Ernakulam, Kerala. His father G. Narayana Iyer was the principal of Maharaja's college in Ernakulam. Ramachandran did his intermediate from Maharaja's college and his B.Sc. (Hons) in Physics from St. Joseph's College, Tiruchi. In 1942 he joined the Indian Institute of Science (IISc), Bangalore as a student in the Electrical Engineering department. However, under the influence of C.V. Raman, he shifted to Physics. He obtained his M.Sc. and then his Ph.D. in 1947, under Raman's supervision. He then went to the Cavendish Laboratory, Cambridge and obtained his second Ph.D degree under Prof. Wooster.

He returned to India in 1949 and joined IISc as an Assistant Professor. In 1952, at the young age of 30, he moved to Madras as the Head of the Physics Department at the University of Madras. On the suggestion of J.D. Bernal, the crystallographer and chemist, who visited the University in 1952, he started work on determining the structure of the protein collagen, the fibrous protein found in skin, bone and tendon. Based on the limited data available at the time, in 1954, he proposed, along with Gopinath Kartha, the triple-helix structure for collagen, later revised in the light of new data to the coiled coil structure for biomolecules. This was a fundamental advance in the understanding of biomolecular structures. He and his colleagues C. Ramakrishnan and V. Sasisekharan went on to develop methods to examine and assess structures of biomolecules, in particular peptides. In 1963, this resulted in the famous Ramachandran map, which is an indispensable tool in the study of molecular structures today. His contributions in the field of X-ray crystallography such as anomalous dispersion, new kinds of Fourier syntheses, and X-ray intensity statistics are also extremely important. His 1971 paper with A.V. Lakshminarayanan on three-dimensional image reconstruction was to have important applications in Computer Assisted Tomography. (The 1979 Nobel Prize in Physiology or Medicine was awarded to A.M. Cormack and Sir G.N. Hounsfield for their work in CAT).

In 1971 Ramachandran returned to Bangalore to set up the Molecular Biophysics Unit at the IISc which is today a major research centre.

He was elected Fellow of the Royal Society in 1977 and was awarded the Shanti Swarup Bhatnagar award. In 1999, The International Union of Crystallography awarded him the prestigious Ewald Prize, which is given only once in three years. He was the editor of Current Science between 1950 and 1957.



Harish Chandra

Harish Chandra (1923-1983)

Harish Chandra was born on 11 October 1923 in Kanpur, Uttar Pradesh. He attended school in Kanpur and then the University of Allahabad, where he studied theoretical physics. After obtaining his master's degree in 1943 he joined the Indian Institute of Science, Bangalore to work further with Homi Bhabha on theoretical physics. Dr. Bhabha arranged for Harish Chandra to go to Cambridge to work for his Ph.D. under the legendary Paul Dirac. In 1947 Dirac visited Princeton for one year and Harish Chandra worked as his assistant during this time. In Princeton he met and was greatly influenced by the great French mathematician Chevalley, giving up physics altogether and taking up mathematics. Harish moved to Columbia University after his year at Princeton.

In 1963, Harish Chandra was invited to become a permanent member of the Institute of Advanced Study at Princeton. He was appointed IBM-von Neumann Professor in 1968.

Harish Chandra received many awards in his career. He was a Fellow of both the Indian Academy of Sciences and the Indian National Science Academy. In 1974, he received the Ramanujan Medal from Indian National Science Academy. He was elected a Fellow of the Royal Society and also won the Cole prize from the American Mathematical Society in 1954 for his papers on representations of semisimple Lie algebras and groups.

Harish Chandra is quoted as saying that he believed that his lack of background in mathematics was in a way responsible for the novelty of his work:-

“I have often pondered over the roles of knowledge or experience, on the one hand, and imagination or intuition, on the other, in the process of discovery. I believe that there is a certain fundamental conflict between the two, and knowledge, by advocating caution, tends to inhibit the flight of imagination. Therefore, a certain naivete, unburdened by conventional wisdom, can sometimes be a positive asset.”

His profound contributions to the representation theory of Lie groups, harmonic analysis, and related areas left researchers a rich legacy that continues today.



M. K. Vainu Bappu

M. K. Vainu Bappu (1927-1982)

Manali Kallat Vainu Bappu was born on August 10, 1927 to a senior astronomer in the Nizamiah Observatory, Hyderabad. A brilliant student throughout, Vainu Bappu not only excelled in studies but took active part in debates, sports and other extra curricular activities. However, astronomy to which he was exposed from an early age, became his passion. Being a keen amateur astronomer, even as an undergraduate, he had published papers on variable star observations. After obtaining his Masters degree in Physics from Madras University, Vainu Bappu joined the prestigious Harvard University on a scholarship.

Within a few months of his arrival at Harvard, Vainu Bappu discovered a comet. This comet was named Bappu-Bok-Newkirk, after Bappu and his colleagues Bart Bok and Gordon Newkirk who worked out the details of this comet. He completed his Ph.D. in 1952 and joined the Palomar observatory on the prestigious Carnegie Fellowship. There, he and Colin Wilson discovered a relationship between the luminosity of particular kinds of stars and some of their spectral characteristics. This important observation came to be known as the Bappu-Wilson effect and is used to determine the luminosity and distance of these kind of stars.

He returned to India in 1953 and largely through his efforts, he set up the Uttar Pradesh State Observatory in Nainital. In 1960 he left Nainital to take over as the Director of the Kodaikanal Observatory. He modernised the facilities there and it is today an active centre of astronomical research. He however realised that the Kodaikanal Observatory was inadequate for making stellar observations and started searching for a good site for a stellar observatory. As a result of his efforts, a totally indigenous 2.3 meter telescope was designed, fabricated and installed in Kavalur, Tamil Nadu. Both the telescope and the observatory were named after him when it was commissioned in 1986.

He was awarded the Donhoe Comet-Medal (1949) by the Astronomical Society of the Pacific, elected as Honorary Foreign Fellow of the Belgium Academy of Sciences and was an Honorary Member of the American Astronomical Society. He was elected President of the International Astronomical Union in 1979.

Postscript

We hope that you have enjoyed reading the brief biographies we have compiled here. They are of scientists who played a stellar role in revolutionizing Indian science. Although this list is incomplete, it is also visibly lacking 50% of the population - women. *Why?*

This was a period of time in which very few women were present in the international arena of science - the Curies, Barbara McClintock, Rosalind Franklin, being some of the more famous exceptions. This was also a period of time in which the gender discrimination in access to education and opportunities was very stark in our country. Through this period of time most women did not have access to institutions of higher learning and laboratories, which prevented and completely isolated them from participation in the scientific revolution.

Without question, women have made substantial progress in science careers over the past 25 years. The number of women, including Indians, in the scientific arena has substantially increased though there is still a lot to do. It is in the hope that mind sets which hold women back start to vanish from science education that we ask you all, students of both sexes, parents and teachers, to take a good hard look at whether each of us contributes to the problem.

Women in Science web-sites:

<http://science.education.nih.gov/women/index.html>

http://www.nature.com/nature/debates/women/women_frameset.html

<http://www.humboldt.edu/~jlm12/fem-science.html>

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