Indian Scientists: The Saga of Inspired Minds

Indian scientists have played stellar roles in the development of science and technology. Their achievements created and strengthened the value of science and technology to deliver significant benefits that improve quality of life. Many of them achieved recognition world over for their path-breaking achievements that have made our country proud. However, many of them had to work under difficult conditions, including lack of facilities and funds and several other obstacles. They overcame these obstacles through ingenious ways and real grit. This volume brings together glimpses about inspiration that pervaded lives of 54 eminent Indian scientists; whose achievements laid the foundation for robust growth and development of science and technology in our country. Their lives are glowing examples of triumph over adversity, and will inspire youth aspiring to grow as scientists and technologists. Citizens too in all walks of life will be inspired by the leadership and vision of the scientists covered in this publication, for inclusive development.

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From the Hon'ble Prime Minister's Desk

Foreword

A rich past for a robust present and future: India's excellence inspires pursuits on frontiers of science and technology and societal benefits

Science and technology pursuits are unique platforms of applied public policy. I wish to highlight this by indicating four facets of such robustness.

1. Science and technology provide opportunities for citizens to excel in their respective fields and contribute to larger scale benefits for the country as a whole. Such benefits are relevant across sectors of economy and reinforce the fact that foundations of development are steeped in science and built on the intellectual capital of citizens.
2. Pursuit of knowledge for its own sake is another unique opportunity provided by this interface. This will open windows of opportunity for further investigations and enrich knowledge systems that could be used for common good. There are two important take-aways for policy makers in this context. One is the urgent need to recognize the pervasiveness of science in all spheres of our daily lives. The other is the fact that investments in science should not be seen through the perspective of business models that expect immediate returns. This paradigm is central to ensure common good that goes beyond profit motives. Applications of such knowledge systems could emerge in response to locally felt needs and heuristics through a continual integration of locally relevant socio economic systems.
3. Knowledge and its applications based on science and technology go beyond political boundaries across states and nations. India has provided significant leadership in several frontiers and consistently so for the benefit of people around the world. This also reflects India's spiritual richness about Samatha lokha sukhino bhavantu. (the whole universe shall live in comfort)
4. The path of excellence is often strewn with challenges that appear insurmountable on first sight. However success is assured when seekers of knowledge are tenacious and adhere to truth at all costs. Importantly insights arise from all people of all spheres of life. Age and clan are irrelevant in this landscape of excellence. Science and technology are therefore unique equalizers. Leaders with profoundly inclusive outlooks emerge

also from extremely trying circumstances. They inspire confidence in fellow travellers along the path of science and technology for common good. This underlines the relevance of excellence across time.

I wish to reinforce the above stated through insights on science and technology based citizen engagement I derived through my work in the field of community health. I had the blessing and the honour of serving India's heath agenda over several decades. I realize the importance of institutional mechanisms for citizen engagement and that they have to be adapted for local relevance. Importantly a robust enabling environment has to be established to fulfil the larger goals of common good. This enabling environment includes easy access to alternatives, knowledge about the use of alternatives and the confidence citizens derive on seeing the benefits of such interventions. In this context I am also aware of the rigour and intensity of efforts that guide developments. I am therefore in a position to appreciate the need to never trivialize the effort or its intent. Importantly I have felt the joy of inspiration I derived on seeing the work of my colleagues in the field of public health. Science and technology help decipher nature's strengths and opportunities for us to serve fellow citizens through applications.

I am inspired to also stimulate thinking on the foundations of excellence India stood and stands for and have created the present day superstructures of science and technology. Several of her citizens have demonstrated excellence as part of her rich past in science and technology. They created the context for growth that can be aligned with emerging challenges and opportunities. Human values of vision for a robust future with the scope for timely adaptation have been the hallmarks of such an excellence. I wish to therefore serve India's agenda of inclusiveness through the science and technology interface for the benefit of my fellow citizens through the snapshot presented in the following.

The present publication highlights the inspiration that ignited minds of people who evolved as exemplary scientists and technologists. These people personified excellence in science and technology. Their contributions are invaluable because they are relevant ever more in today's context of development and are designed to deliver with equal vehemence in the future too. The circumstances they grew up or worked in inspired and enabled them to recognize and tackle challenges.

Some had the advantage of wealth in early life, while many faced dire challenges right at start and as they continued to grow. Importantly they did not rest on endowments or feel deterred. This is an important take away from the snapshots articulated in this publication. They defined new frontiers of knowledge and their applications acknowledged and validated world over. Many of them also laid the foundations for a surging India in the form of institutions engaged in research and development including academies. This was essential to sustain the zeal and momentum instilled by their robust leadership and vision. The other take away pertains to the interface of science, technology and innovation with public policy for inclusive growth. It is about the need to foster basic / fundamental science and applications with equal emphasis and that science is seen a public good that is universal. Transformational changes along paths of development harmonize culture and national agenda aligned with developmental aspirations of citizens. This reinforces the fact that science and pursuit of science and technology are steeped in reason and openness. The link with public policy is about the form and function of impacts of science and technology on the overall quality of life. Institutions are meant to build capacities to establish local relevance and sustain the character and momentum of transitions. This aspect of human and institutional development cannot be trivialized.

Scientists and technologists covered in this volume gave their best till the very end of their active life. They innovated to give their best and inspired others too. Their efforts have set the context for us to optimize on our circumstances. Most of them were born in undivided India and some chose India as their final destination. A majority of them continued to work from our country while some moved to other places. Their origins and paths of dedication and exemplary virtues at work were common. They consistently exhibited tenacity of purpose, patriotism and inclusiveness. They demonstrated value based governance of science for equity and justice that makes science an asset that is to be shared for the benefit all people. We are grateful for the impetus they provided. We will sustain the zeal to further consolidate India's leadership in science, technology and innovation for inclusive growth.

We are aware of some leading publications on similar lines. The booklet on scientists (2004) by the Science Popularisation and Public Outreach Committee, Tata Institute of Fundamental Research November 2004 is a case in point. The Department of Science and Technology in 2013 contextualized progress and India's preparedness to sustain

leadership in science and technology. These and several others provide valuable insights on the architecture and landscape of leadership and growth of science and technology in our country. Current Science's special accounts titled Living Legends are a classic source of information on prevailing excellence.

The present publication is yet another attempt to bring India's rich recent history of leadership in science and technology to inspire the present and emerging generations of leaders. This is aligned with principles of public engagement with science to comprehend strengths and opportunities for growth. The inspiration embedded in the snapshots will serve this purpose. We take this opportunity to also salute the leaders cited in this publication. People associated with them in various capacities also receive our salutations. The chapters are authored by well-known science communicators. They have drawn upon information and wisdom from various published sources and rearticulated them with a specific focus on the inspiration that ignited and sustain action. Vigyan Prasar has served its mandate as a facilitator by bringing these communicators together through its framework for value added science and technology communication. Its own staff members too have contributed to this initiative. I join the authors in saying: We dedicate this effort to our nation.

(Dr Harsh Vardhan)
Hon'ble Union Minister
for Science & Technology and Earth Sciences,
Government of India

Preface

Greatest of advances, discoveries, inventions and innovations in science rarely follow a linear logic. The minds that produce the greatest conceptual advances are unique and supported by favourable circumstances offered by the society that surrounds them. One moment of inspiration is often built on hard labour of many decades. India's Science, Technology and Innovation Policy is indeed designed to create such enabling circumstances to accelerate progress in these areas. India's Policy has created adequate scope to develop and implement appropriately aligned plans and programmes to fulfil her developmental aspirations through robust outputs and outcomes. Two important related objectives will also be met in this process. They are to 1. Consolidate her innate strengths to innovate and 2. Create newer opportunities for inclusive growth. The Ministry of Science and Technology, Government of India through its departments and related institutions develops strategically important mechanisms to deliver immediate and long term benefits to create and sustain these transitions.

Engagement with stakeholders is an important element of governance for inclusive growth. An important objective of such an engagement with stakeholders right from the secondary school level to scientists is to inspire, stimulate and strengthen interest and infuse the zeal to take up science and technology pursuits at the cutting edge.

The present publication reveals some important facets of development of science and technology in our country from the perspective of inspiration and tenacity of purpose demonstrated by some of the scientific minds of the past. They tackled insurmountable odds at times in the professional and personal lives, drawing strength through this inspiration and established themselves as leaders in their respective fields. They created India's niche in important and newer frontier areas of science and technology. Many such leaders also contributed directly to social needs and in this process exhibited exemplary patriotism. While inspirational moments are few and far between, it is necessary to create the necessary eco system to foster these opportunities.

They established and nurtured important scientific institutions, many of which continue to serve us even today. We are able to deliberate on such successes only because of the milieu for learning and investigations they created. This excellence could be sustained with leadership that followed the prime movers.

The effort that went into developing this publication is dedicated as a tribute to many scientists and technologists who laboured with creative zeal to enrich the society we live in. They demonstrated the fact that pursuit of knowledge opens newer windows of opportunities to learn and comprehend dynamics of nature and related physical, chemical, biological, and engineering and technology systems. These are integrated with equal emphasis into holistic approaches for development. Scouting and mentoring with appropriate training and capacity building to build human resources are central to development. Leadership defines appropriate synergies that are relevant across time.

The inspiration that moulded leaders in science and technology presented in this book and the inspiration we can derive from them is invaluable. The dedication and discipline they exhibited should be emulated. The Ministry of Science and Technology dedicates this volume to our country. We invite the attention of our fellow citizens to the excellence the cited scientists / technologists and institution builders stood for. Importantly any of us too could derive such inspiration and contribute to our country's development in a telling manner. Importantly there are lessons in the lives of great scientists that are relevant for all of us. Each of us indeed has the potential to rise to the same heights.

(Prof Ashutosh Sharma)
Secretary DST

Introduction

The present publication highlights the inspiration that ignited minds of people who evolved as exemplary scientists and technologists. These people personified excellence in science and technology. Their contributions are invaluable because they are relevant ever more in today's context of development and are designed to deliver with equal vehemence in the future too. The circumstances they grew up or worked in inspired and enabled them to recognize and tackle challenges.

Some had the advantage of wealth in early life, while many faced dire challenges right at start and as they continued to grow. Importantly they did not rest on endowments or feel deterred. This is an important take away from the snapshots articulated in this publication. They defined new frontiers of knowledge and their applications acknowledged and validated world over. Many of them also laid the foundations for a surging India in the form of institutions engaged in research and development including academies. This was essential to sustain the zeal and momentum instilled by their robust leadership and vision.

The other take away pertains to the interface of science, technology and innovation with public policy for inclusive growth. It is about the need to foster basic / fundamental science and applications with equal emphasis and that science is seen a public good that is universal. Transformational changes along paths of development harmonize culture and national agenda aligned with developmental aspirations of citizens. This reinforces the fact that science and pursuit of science and technology are steeped in reason and openness. The link with public policy is about the form and function of impacts of science and technology on the overall quality of life. Institutions are meant to build capacities to establish local relevance and sustain the character and momentum of transitions. This aspect of human and institutional development cannot be trivialized.

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The chapters are authored by well known science communicators. They have drawn upon information and wisdom from various published sources and rearticulated them with a specific focus on the inspiration that ignited and sustain action. We dedicate this effort to our nation.

Rintu Nath, R Gopichandran
& Manish Mohan Gore

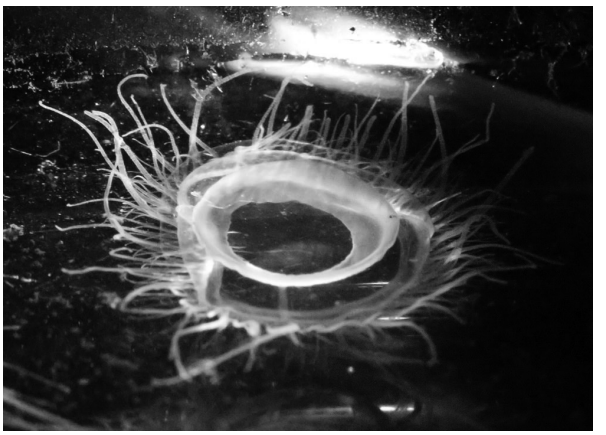
Shankar Purushottam Agharkar

Shankar Purushottam Agharkar (18 November 1884 – 2 September 1960) is known for his exemplary achievements in the field of Botany. His fascinating life story is a village boy's determination to pursue science and research against all odds. He is credited with laying the first building blocks of such premier scientific institutions like the National Institute of Sciences, now known as the Indian National Science Academy, the Indian Science Congress Association, and the Maharashtra Association for Cultivation of Science (MACS) in Pune.

His humungous zeal and enthusiasm prevailed despite such odds as the World War and teething problems including the paucity of funds in running institutions. His name still lives on with the Agharkar Research Institute in Pune, as it does in the several new species of plants and animals he discovered. He was born on 18 November 1884, in Malvan, a remote village in Ratnagiri district of Maharashtra. His father served as an overseer in the Public Works Department and was frequently transferred.

Agharkar accordingly changed schools ever so often. A new place meant learning a new language. He even went to schools that hardly had teachers, and if they did, they hardly taught. At least at one such school, Agharkar is known to have taken up the responsibility of teaching his classmates because the teachers would not do their job. Eventually, Agharkar passed matriculation from the Government High School at Dharwar, joined the Elphinstone College, Bombay (now Mumbai) from where he passed the BA degree in first class with botany, zoology and geology as optional subjects. In 1909, after an MA degree, also from Elphinstone College, he joined as a lecturer in the biology department of the college.

He put his leisure time during holidays and between teaching sessions to good use and derived the passion for research. He ventured into the nearby Western Ghats



Fresh water jellyfish – Limnocnida indica

exploring the diversity of plants and animals. During one such excursion, he found a new species of fresh water jellyfish – *Limnocnida indica* (Annadale). The jellyfish was until then known to occur only in African rivers. His findings were published in *Nature* in 1912. The joy from this output hooked him to research. He was helped by Dr Annadale, Superintendent of the Indian Museum at Calcutta (now Kolkata) on his collection, preservation and microscopic examination of plant and animal specimens. Even at his ripe old age, he would often join younger colleagues for botanical collections in the hills.

Agharkar's name has been immortalised in the names of many species of plants and animals he discovered. These included amongst others, the net-veined midges *Philorus bioni* Agharkar, not previously reported from India; two flowering plants (*Dioscorea agharkarii* and *Musa agharkarii*); one fungus (*Mitrula agharkarii)*; and one centipede (*Cryptorbyptops agharkarii*). Agharkar also studied the flora of Nepal and the Western Ghats and was a scholar on Gymnosperms and Angiosperms.

He was determined not to let adverse social and cultural restrictions interfere with his education. In 1914, he travelled to Germany for a two – year training course by overcoming the cultural restriction about a Hindu crossing the seas. He made the most of the opportunity to pursue research further. However, his sojourn abroad was highly disrupted. The First World War broke out just as he landed in Germany. He was imprisoned for three years and could secure his Ph.D. from Berlin University only in 1919. However, despite the hurdles, Agharkar visited botanical gardens in Europe and England, including the famous Royal Botanical Gardens at Kew, London. He collected rare plants from the European mountains and gifted this rich collection of materials to Calcutta University.

Shibpur Botanical Garden, Kolkata

Agharkar Research Institute, Pune

Agharkar returned to Calcutta University in 1920. His distinguished work as a botanist landed him the Ghosh Professorship of botany at Calcutta University. His name had been suggested by none other than C.V. Raman to Asutosh Mookerjee then the Chairman of the Selection Committee. He took this opportunity to serve the country in return. He transformed the Botany Department of Calcutta University into one of the finest plant sciences research institutions. His students found him a mine of information and were inspired to imbibe the much needed scientific and critical attitude. Many top Indian botanists have had their initial training under Agharkar. Moving onwards, he extended the benefit of his exemplary administrative and organisational skills to many scientific organisations across the country. This was a reflection of his nationalist fervour to place India on the high pedestal of scientific research world over.

Agharkar served as the Secretary of the Indian Science Congress Association for many years and shaped its destiny. It was because of his efforts that the London Overseas scholarship is available to Indians. Till 1931, the scholarship was awarded only to British nationals though the funds for the same came from contributions by many members of Indian royalty. He fought to retain rare type-specimens from the Sibpur Herbarium, Kolkata, the British proposed to shift to the Royal Botanical Gardens at Kew, London. This valour prevented further erosion of invaluable herbaria now held by the Botanical Survey of India.

Agharkar retired from the Ghosh Professorship at Calcutta University in 1946. Typical of him, he did not rest and moved to Mumbai to teach at the Master's level at Bombay University. He was called by the Indian Law Society at Pune to head the institution they wished to launch to promote scientific research in the city. The Maharashtra Association for the Cultivation of Science (MACS) in Pune was then born with Agharkar as its Founder-Director. He was also the head of the Department of Botany. The MACS experienced several teething troubles including flow of funds. Agharkar's office did not have a fan, because he considered it a luxury. He would often spend his own money for the cause of the Institute. His dedication, simplicity and work ethic set him as an example for many to follow. He transformed MACS into a centre of research excellence. He worked with the Chief Palynologist of the Oil and Fuel Commission on the origin of the Bengal flora.

With advancing age his enthusiasm for work and the call of duty could not face up to the cancer that afflicted him. In 1956, he had to undergo surgery. He retired from

the Institute in 1960 because of his failing health. Eventually, Agharkar quietly prepared his will, donating to a trust in favour of the MACS all but bare necessities for his wife. Despite these challenges his love for the Institute would often draw him to the MACS. He continued to visit MACS laboratories till just a few days before his death; to enquire about progress of research projects. Shankar Purushottam Agharkar breathed his last on 2 September 1960. On 10 September 1992, in a befitting tribute to this great soul who nurtured the Institute till the last moment of his life, the MACS renamed the Institute as the 'Agharkar Research Institute'.

Hasan Jawaid Khan

Janaki Ammal

Edavaleth Ekkat Janaki Ammal (4 November 1897 –7 February 1984); popularly known as Janaki Ammal, made pioneering contributions in the fields of genetics, evolution, phytobiology, and ethnobotany. She was a founder member of the Indian Academy of Sciences, Bengaluru, and its first woman fellow. She blazed a trail by reforming large institutions and created knowledge resources that are treasured for decades.

Her active research career that spanned over five decades saw her first research paper published in 1931 and the last in 1985 (after her death). Her life is worth emulating with equal measure for excellence in her path-breaking scientific contributions and personal attributes. Thus C.V. Subramanian wrote about her in *Lilavati's Daughters: The Women Scientists of India* (2008): "She lived up to her definition of greatness which combined virtue in life and passion in the pursuit of science. There is thus much for us to emulate in her life and work." She was a truly Gandhian in her lifestyle. Her integrity and professional ethics were exemplary.

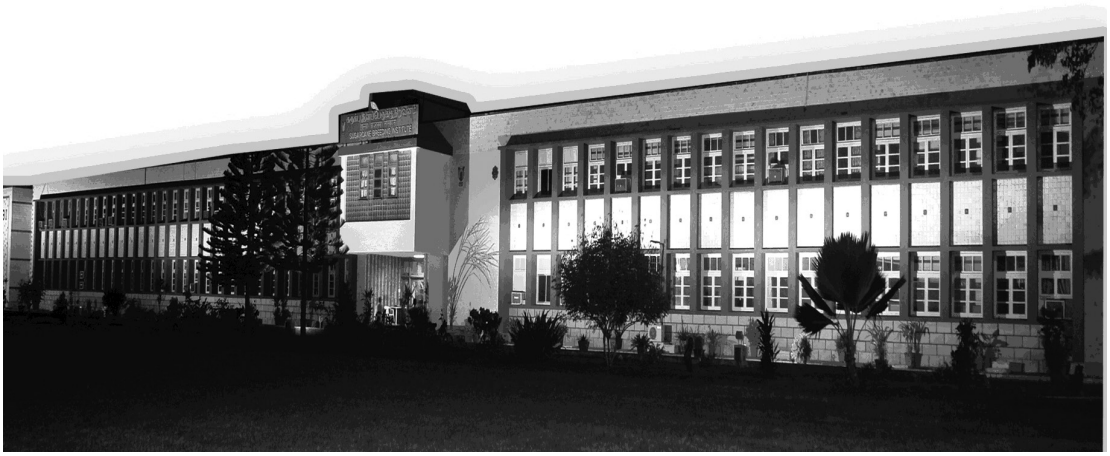
She focused on such ethnobotanical aspects as the use of plants by tribal communities of Kerala. Her other studies were on the genetic make-up of crop/garden/plantation/ medicinal/wild plants etc. These were when related lines of investigation were just emerging. These efforts enhanced our understanding of cross-breeding in plants in the wild. She implicated polyploidy in speciation of plants seen at particularly high rates in the humid cold northeast Himalayas; distinctly varied from occurrences in the dry and cold northwest Himalayas. Janaki Ammal and C.D. Darlington authored *The Chromosome Atlas of Cultivated Plants* (1945) which is quite popular among botanists and agriculture scientists world over.

Janaki Ammal was born on 4 November 1897 in Tellichery, Kerala (at the time of her birth it was part of the Madras Presidency). Her parents were Srimathi Devaki and E.K. Krishnan. Her father was in the judicial service of the Madras Presidency. She had six brothers and five sisters. She studied at the at the Sacred Heart Convent in Tellichery. Later she moved to the Queen Mary's College in Chennai and subsequently to the Presidency College. She obtained her Bachelor's degree with Honours in 1921 from the Madras University; followed by a Master's degree in 1923. She joined the Women's Christian College as Lecturer in Botany. She went to Michigan University in the USA as a Barbour Scholar in 1924 and obtained an MSc degree. The Barbour Scholarship Programme launched in 1914 supported women with highest academic caliber, especially from the Orient. Her special focus was on pursuits in modern science, medicine, mathematics and other academic disciplines and professions critical to the development of their native lands.

After returning to India in 1926, Janaki Ammal resumed her teaching assignment at the Women's Christian College, this time as Professor of Botany. She again went to

Women's Christian College, Chennai

Michigan University. This time, she went as the first Oriental Barbour Research Fellow and obtained DSc degree from there in 1931. After that she returned to India and joined the Maharaja's College of Science at Thiruvananthapuram (then Trivandrum) as Professor of Botany. However, on realising that she was not content with her teaching assignment she left Maharaja's College in 1934 and took up a full-time research assignment at the Sugarcane Breeding Station (later renamed as Sugarcane Breeding Institute) at Coimbatore, Tamil Nadu. The Breeding Station had acquired international fame long before Janaki Ammal joined it. This was due to the efforts of C.A. Barber and T.S. Venkataraman that



Sugarcane Breeding Institute, Coimbatore

embedded drought- and disease-resistant qualities. The Coimbatore varieties of sugarcane were cultivated throughout India and in other countries too. Janaki Ammal laid the foundation for cytological work on *Saccharum* and allied genera and generated several inter-specific and inter-generic hybrids involving sugarcane and related grass species and *Bambusa* (Bamboo).

In 1939, Janaki Ammal went to England and stayed there for the next eleven years. She first worked as an Assistant Cytologist at the John Innes Horticultural Institution, London. Subsequently, she worked as the Cytologist at the Royal Horticultural Society, Garden, Wisley. She investigated chromosomes of a wide variety of garden plants and helped understand the evolution of species and varieties.

Janaki Ammal returned to India in 1951. This was at the invitation of the Prime Minister Pandit Jawaharlal Nehru. She served the Government of India in different capacities. As part of her first assignment as the OSD, she revamped the Botanical Survey of India (BSI). She served as the Director of the Central Botanical Laboratory, for five years (1954-59). The laboratory was initially at the Chhatter Manzil, Lucknow and later moved to Allahabad. She later served as the OSD at the Regional Research Laboratory (now renamed as the Indian Institute of Integrative Medicine) of the CSIR for three years and subsequently as the Head of its Cytogenetics Division (1962-64). The next five years saw her at the Regional Research Laboratory, Jammu (1964-1969) as an Emeritus Scientist. She also served as Honorary Professor of Botany at the Jammu University.

It was in Jammu that Janaki Ammal developed her interest in mountain flora. She demonstrated the intermingling of plant strains that originated in China, Burma, and

Malaysia. She then moved to Mumbai and worked for about a year at the Bhabha Atomic Research Centre as Visiting Professor. In November 1970 she moved to Chennai; wherein she was associated with the Centre for Advanced Study in Botany of Madras University. She worked at its Field Station at Maduravoyal, on the outskirts of Chennai. Towards the end of her life, she focused on medicinal plants and ethnobotany. She developed a garden of medicinal plants at the Field Station of the Centre of Advanced Study in Botany, Madras University.

Her contributions to the field of botany and Cytogenetics fetched her an honorary LL.D of the University of Michigan, USA, in 1956. The citation stated that Janakiammal was, "blessed with the ability to make painstaking and accurate observations, she and her patient endeavors stand out as a model and dedicated scientific workers." She was elected President of the Botanical Society of India (1960) and the Indian Society of Genetics and Plant Breeding (1961).

Janaki Ammal passed away on 7th of February 1984 at the age of 86. The herbarium at the Indian Institute of Integrative Medicine, Jammu is named after her. It has over 25,000 collections from across India including species collected before 1935. This includes Nephradiummalle; collected by E.N. Trotter (1888) from Chamba Himachal Pradesh. The (then) Ministry of Environment and Forests, Government of India, instituted the E.K. Janaki Ammal Taxonomy Award in 1999.

Subodh Mahanti

Anna Mani

Anna Modayil Mani (23 August 1918 – 16 August 2001) was a visionary scientist with boundless energy. Popularly known as Anna Mani, she greatly contributed to India's self-sufficiency in meteorological instruments. She worked on stratospheric ozone long before its role in shielding all life forms on Earth was understood. It was because of her that India was among top five countries in the world to have their ozonesondes. (The ozonesonde is a lightweight, balloon-borne instrument for gathering information on ozone that is mated to a conventional meteorological radiosonde.) She was made a member of the International Ozone Commission; based on her extraordinary contributions to the field.

She realised the potential of solar energy as an alternative source of energy for India as a tropical country and generated data on its seasonal and geographical distribution. She also worked on harnessing wind energy.

Anna Mani was greatly influenced by the ideals of Mahatma Gandhi. She wore *khadi* throughout her life. She did not marry and devoted her life to the pursuit of science. She is regarded an early feminist. Describing her personal attributes, C.R. Sreedharan of the India Meteorological Department (IMD), Pune and a former student of Anna Mani says: "Her obsession with quality of meteorological data made her influence WMO to some extent. She was directly or indirectly associated with international instrument companies since 1956 and ensured that international and interregional comparisons of all types of instruments were regularly carried out. Although she belonged to an ancient Christian Church, she was an agnostic. She never distinguished between people of different faiths. Nature was her passion. She loved going to mountains, to the sea, enjoyed bird-watching, reading, and listening to music. She was emotional and sensitive to the sufferings to others. She loved dogs and always used to keep one or two with her. She had friends from

all walks of life all over the world. She was a good communicator and made a conscious effort to keep with her friends."

Anna Mani was born on 23 August 1918 in a prosperous family in Peermedu in the state of Travancore (now in Kerala). The family belonged to the ancient Syrian Christian Church. She was the seventh of eight children of her parents. Her father was a successful civil engineer, and he owned cardamom plantations. She was quite different from her sisters. They married early. Anna Mani on the other hand decided to pursue higher studies; much like her brothers. She would read diligently and extensively as a child. This prompted the science historian Abha Sur to write in *Resonance* (November 2008) that: "Her formative years were spent engrossed in books. By the age of eight, she had read almost all the books in Malayalam and, by the time she was twelve, all the books in English at the public library. On her eighth birthday, she declined to accept her family's customary gift of a set of diamond earrings, opting instead for a set of *Encyclopedia Britannica*. The world of books opened her mind to new ideas and imbibed in her a deep sense of social justice."

Anna Mani wanted to study medicine, but when that was not possible, she opted for physics. She obtained her BSc (Honours) degree in physics and chemistry from the Madras Presidency College in 1939. She also secured a scholarship for research at the Indian Institute of Science (IISc) and worked for her Ph.D. under the supervision of C.V. Raman. Her focus was on the spectroscopy of diamonds and rubies. She spent long hours at work and often slept in the laboratory. This is also because she had to expose photographic plates for 16-20 hours.

While working with C.V. Raman, she wrote five research papers on the luminescence of diamonds. She submitted her Ph.D. dissertation to the Madras University, as was the trend those days. She however never secured her Ph.D. degree; strangely due to the stand of the University that she did not possess an MSc degree.

After three years at Raman's laboratory, she won a scholarship in 1945 for higher studies in England, for work on the development of meteorological instruments. She took up the challenge, despite her abiding interests in physics. On reaching England, she worked at the Harrow Laboratories of the Instruments Division of the British Meteorological Office. She studied the evolution of weather instruments, their calibration and standardisation procedures. She visited field observatories and manufacturers of meteorological instruments and took the opportunity to work for some time at the National Physical Laboratory at Teddington on standards and standardisation for different weather parameters.

In 1948, Anna Mani returned to India and joined the Instruments Division of the IMD at Pune as a meteorologist. It was then headed by S.P. Venkiteshwaran, who had set up a workshop to produce simple meteorological instruments including rain gauges, evaporimeters, thermometers, anemometers, wind valves and others. Venkiteshwaran was a nationalist, and his aim was to develop meteorological instruments in the country. He did not want to import them from England. Anna Mani too was a staunch nationalist and was inspired by Venkiteshwaran. She resonated on the idea of making India self-reliant on weather instruments. She decided to use the expertise she gained in England to achieve this goal. The challenge was quite daunting because it was not easy to find people in typically large numbers to operate the machinery. Even such simple meteorological instruments as the barometers and thermometers were imported from England. Anna Mani decided first to train people in design, manufacture, calibration, installation and observation. She also standardised and prepared detailed drawings and technical manuals for more than a hundred varied instruments. She helped the Indian Standards Institution (ISI) publish Indian standards for various weather instruments.

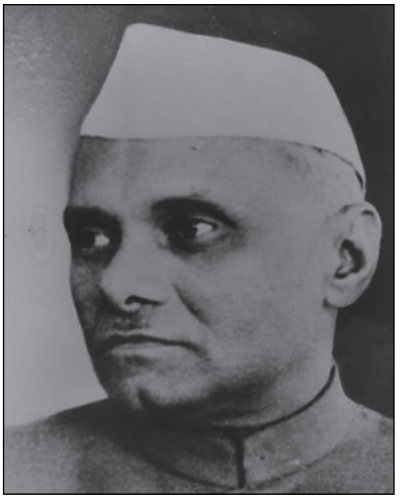
Once her dreams to make India self-reliant in weather instruments was realised in shortest possible time, Anna Mani shifted her attention to solar energy She also realised that proper harnessing of solar energy would be possible only after acquiring sufficient knowledge of seasonal and geographic distribution of solar energy, but there was no sufficient data on this. However, there was a network of stations in the country for measuring solar radiation. The network was the result of the growing interest in atmospheric physics brought about by the International Geophysical Year (1957-58), in which India played a significant role. The stations were initially equipped with solar radiation instruments produced outside India.

She designed and manufactured many solar radiation instruments and ensured calibration and standardisation meet the world standards. The Instruments Division of IMD, Pune she headed was designated as the regional centre for Asia. She rose to be the Chairperson of the CIMO (The Commission of Instruments and Methods of Observations) Working Group on radiation instruments due to her credibility. She was also elected Member of the International Radiation Commission.

Anna Mani had rightly anticipated the potential of wind energy in India and organised round-the-year measurement of the wind pattern at over 700 sites in the country by using the state-of-the-art equipment so that plausible assessment of India's wind energy could be made. She brought out important publications on solar and wind energy, namely *Handbook of Solar Radiation Data for India* (1980), *Solar Radiation over India* (1981) and *Wind Energy: Resource Survey in India-I* (1983).

Anna Mani began her investigation on atmospheric ozone in 1960. India's ozonesondes helped generate reliable data. This helped establish a clear picture of seasonal and geographical variation of upper atmospheric ozone over the tropics. She published her research findings on atmospheric ozone in reputed research journals. She set up a meteorological observatory and an instrumentation tower at the Thumba rocket launching facility on the behest of Dr. Vikram A Sarabhai. She established a factory in Bengaluru to manufacture instruments to measure wind speed and solar radiation.

Subodh Mahanti



Atma Ram

Atma Ram (12 October 1908 – 6 February 1983) played a prominent role in the development of science and technology in post-independence India. His contributions cover fundamental and applied sciences as well as the technology of production. He was largely responsible for indigenisation of Indian industry, especially about glass and ceramic products. He was instrumental in establishing the Central Glass and Ceramics Research Institute at Kolkata in 1945.

He succeeded in developing and producing optical glass; quite a commendable achievement especially when knowledge on its production was a closely guarded secret held by some countries. He defined the role of cuprous oxide colloid in the origin of colour in copper-red glasses. This was unlike the commonly held view that copper colloid was responsible. His comprehensive all-India survey of glass and ceramic raw materials established many unknown sources of high-grade raw materials. This helped access materials and produced many products indigenously; otherwise imported from Europe. These include glass electrodes used to measure pH, ceramic and vitreous enamel colours and stains, coloured glass, chemical-porcelain, sun-

Atma Ram (middle) S.S. Bhatnagar (left) and Zakir Hussain

Showing products developed at CGCRI to Pt. Jawaharlal Nehru

glare glasses and special refractories. He held 23 patents.

He was appointed Chairman of the National Committee on Science and Technology (NCST) in 1977. Through this niche, he also served as the Principal Adviser to the Prime Minister and the Union Cabinet on science and technology. He believed freedom and accountability must go hand in hand.

Atma Ram lived a simple, austere life. He had a subtle sense of humour; was always pragmatic and forthright in his views. He was born in Pilana, Bijnor District, Uttar Pradesh, on October 12, 1908, into a lower-middle-class family. He walked long distances to school. In 1931, he completed his MSc examinations, securing the first place of merit. He taught chemistry briefly at the Government College, Ajmer. Subsequently, he joined Professor Nil Ratan Dhar's group to pursue his doctoral work. He was awarded DSc in 1936 from the Allahabad University for his fundamental research on the physical chemistry of photochemical reactions.

While at Allahabad University, he was greatly influenced by the celebrated Indian physicist Meghnad Saha, who was then a Professor of Physics at Allahabad University. At Saha's instance Atma Ram did some background work for the National Planning Committee under Pandit Jawaharlal Nehru's Chairmanship. While doing this work Atma Ram came in contact with Pandit Nehru who exerted a considerable influence on him.

With his family members

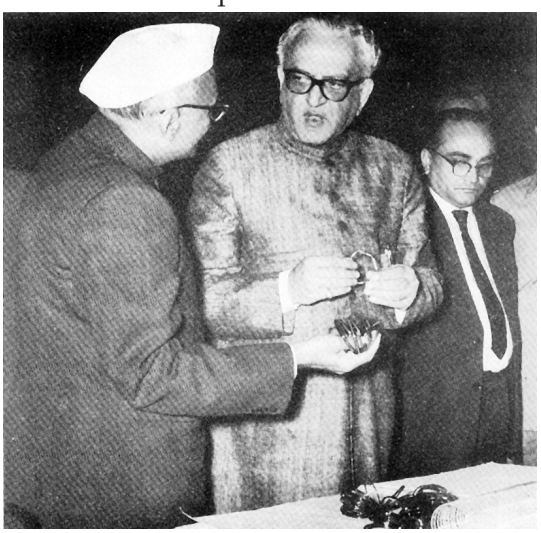
He started as Secretary of the Glass and Ceramic Institute Committee, detailing the plans for the Institute. Later he was appointed Officer-in-Charge of the proposed

institute. In 1952 he was made its Director. In August 1966, he took over as the Director General of the Council of Scientific and Industrial Research, New Delhi. He concurrently held the post of the Secretary to the Government of India. His interests were on high-priority war-related challenge of dousing petrol fires

In his office

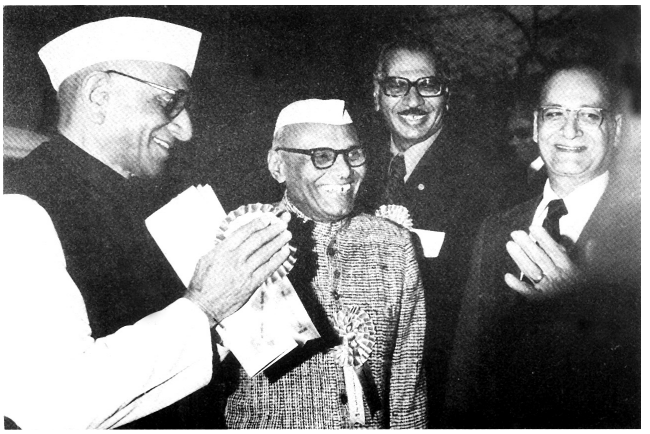
Atma Ram was an elected member of the International Commission on Glass, an Honorary Member of the International Academy of Ceramics and the Society of Glass Technology, Sheffield, UK, a rare honour bestowed by the Society upon a very few selected high ranking scientists of the world for outstanding contributions in the field of glass technology. He was a member of the Commission on the Chemistry of High Temperature at the International Union of Pure and Applied Chemistry (IUPAC). He was the President of the Indian National Science Academy, New Delhi (1969-1970) and the President of the Institution of Chemists, and Indian Chemical Society.

He encouraged, and himself taught science in Hindi, with an emphasis on communicating science in the mother tongue. He initiated publication of Bharat Ki Sampada and served as the President of Vigyan Parishad Prayag, Allahabad. He also authored "History of Chemistry" in Hindi. This prompted the Central Hindi Institute, Agra Institute prizes on his name to promote science writing in Hindi.



With M.C. Chagla, Education Minister

Dr. Shiv Gopal Mishra served as Dr. Atma Ram's colleague. He passionately narrated about his contribution in the first part of *Bharat Ki Sampada*, published by the Publication and Information Directorate (PID) of CSIR. Dr. Atma Ram was then the Director General of CSIR. He took Dr. Mishra along to the residence of Mrs. Indira



Seen with Morariji Desai

Gandhi and got the book launched by her. This occasion reflected deep rooted values of Dr. Ama Ram to acknowledge and honour contributors.

Mrs Uma Gupta, the niece of Dr Atma Ram, narrated an interesting incident about Dr Atma Ram's social views. She highlighted the fact that Dr Atma Ram was in favour of re-marriage of helpless widows, only to reduce drudgery they would otherwise face in all walks of life. This was adopted by his family at his initiative despite resistance from many. He was articulate about the links between technology, science, and benefits for society.

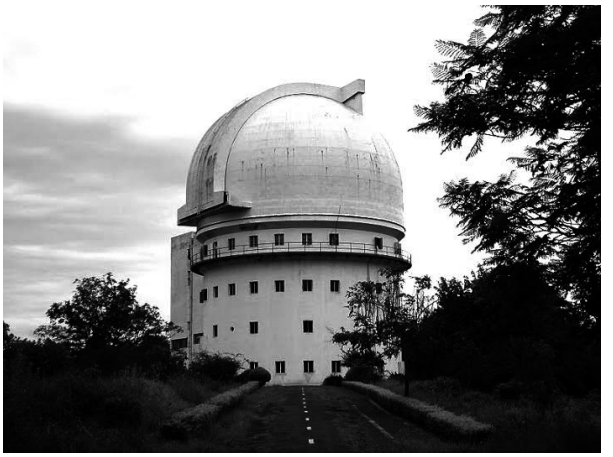
Subodh Mahanti

Manali Kakuzhi Vainu Bappu

Manali Kakuzhi Vainu Bappu (10 August 1927 − 19 August 1982) is considered the father of modern astronomy in India. He was President of the International Astronomical Union (IAU) from 1979 to 1982. Bappu's case was typical of the saying, "Fortune favours the prepared mind". Bappu's feat of discovering a new comet the very day he joined the Harvard University as a graduate student in 1949 surprised many. He rose as an internationally renowned astronomer and served as the President of the International Astronomical Union Executive Committee over 1979 to 1982.

The Associated Press of the United States of America ran a news story with the title "Harvard Tyro Finds Comet". It began: "Imagine taking up astronomy and then, on your first night as an observer, discovering a new comet! That's what happened to M K Vainu Bappu, a Harvard University graduate student from Hyderabad, India, when he came to Harvard University Observatory's Oak Ridge station in this little town – which carries the name of Harvard."

Though no year is mentioned in the press clipping available at archives of the Indian Institute of Astrophysics, Bengaluru, it might have been in the year of 1949 because as per records that it was the year when Bappu enrolled for his Ph.D. at Harvard. Born to Manali Kakuzhi Bappu, then an astronomer at Nizamiah Observatory in Hyderabad, and Sunanna, who hailed from an illustrious family in northern Malabar, on 10 August 1927, Bappu was fascinated by the mysteries of the sky right from a tender age. Even when at school, he accompanied his father to the observatory. "He developed a deep familiarity with the sky and the instruments, and this experience remained an important asset throughout his life. While still in college he built a spectrograph all by himself and obtained a spectrum of the night sky airglow," said J.C. Bhattacharya, a former colleague of Bappu and a renowned



Vainu Bappu Observatory at Kavalur

Indian astronomer, in a biography of Bappu.

Apparently, when Bappu joined Nizam's College in 1942, he was under-aged and required a special exemption for the admission. When he was young, most his idols were scientists. It is said that when he was barely 16, he cycled over 30 kilometres to and fro continuously for many days when Sir C.V. Raman was in Hyderabad to give a series of lectures. Later, when he became the President of the International Astronomical Union, he is said to have advised young astronomers to read biographies of great men and women of science. Talking about his experience, Bappu said, "I myself have read the biographies of great scientists like Kelvin, Rayleigh, Thomson, Maxwell, and Raman ever since my boyhood. I was curious to know what circumstances determined their lives, what they thought about the world, what their scientific work was. There is no doubt that these outstanding personalities created contemporary science. And what was their source of inspiration? It was, primarily beyond doubt, the examples set by and the work of their predecessors that made them set for themselves new goals and finally reached them. I believe that such reading is very stimulating, particularly for young people". Bappu published two scientific papers in *Current Science*, an academic journal brought out by the Indian Academy of Science, Bangalore (now Bengaluru), at the age of 19!

Even though astronomy was most close to his heart, Bappu had wide-ranging interests in literature, music, painting and architecture. He took an active part in debating and literary activities in school as well as in college. An eloquent speaker, Bappu could hold an audience spellbound. He loved to recite the poetry of Wordsworth, Shelley, and Keats. He was well versed in modern poetry too. He had a special liking for Urdu literature and Mirza Ghalib was his favourite poet. He was an avid sportsperson too. He used to be play both cricket and tennis reasonably well.

Bappu obtained his MSc degree in physics from Madras University in 1948. He wanted to pursue a career in astronomy; but India, which had just got freedom the British, had very limited opportunities to offer. He had a choice of research in telecommunication in a London institute which he wasn't very keen to pursue. But he had resigned to his fate and had made up his mind to pack up his bags and head for England. Destiny had

something else in store for him. Just as he was preparing to head for England, a news item in papers drew his attention. He learnt that two towering astronomers of the time – Sir Harold Spenser Jones, Astronomer Royal of the UK and Harlow Shapley of Harvard University – who were on a visit to India would visit Hyderabad. Bappu visited Shapley at his hotel room and conveyed his eagerness to pursue research in astronomy. Persuading Shapley to work on the then Government of Hyderabad wasn't difficult, as the Harvard professor was already aware of Bappu's exploits as an amateur astronomer. As a result, Bappu found himself in Harvard, USA, in early 1949 for pursuing graduate studies in astronomy.

At that point in time, Harvard had one of the best astronomy faculties in the world. Apart from Shapley, it had on its rolls accomplished astronomers like Donald Menzel, Bart J. Bok, Cecilia Payne-Gaposchkin, and Fred Whipple. So were his batch mates too. Among his classmates were Harlan Smith, Bill Buscombe, Frank Kerr, Ivan King, and William Liller who went on to make a mark in the field subsequently.

According to the news item mentioned in the beginning, Bappu began his stint as a research student at Harvard with a bang. The comet discovery happened when Bappu's keen eyes noticed an unusual object on a routine sky plate. He persisted with is efforts to unravel the path and its identity along with his colleague Gordon Newkirk and Prof Bok. A new comet emerged through this effort and was accordingly christened the Bappu-Bok-Newkirk after its discoverers. The continuous observation helped Bappu and others calculate the comet's orbit, which turned out to be so large that it would be visible only after 60,000 years! Bappu was awarded the Donhoe Comet Medal of the Astronomical Society of the Pacific for this discovery. However, the reaction that the news of the discovery elicited in India was somewhat different. A section of *babus* in the Hyderabad state government − which sponsored his studies at Harvard – wanted to know why Bappu was deviating and not undertaking research according to what was agreed upon. Harvard University, however, took it as an affront. Prof. Whipple, who spent nearly 70 years at the Harvard University, took up the matter with the officials of the Hyderabad state government. He wrote: "This is the first occasion in my experience in which a foreign government has taken on itself the criticism of our educational methods in the Astronomy Department of Harvard University." He further requested them to communicate the reasons for their criticism of the university authorities instead of reprimanding the student.

Bappu obtained his Ph.D. in 1952 and continued with his academic / research pursuits as a Carnegie post – doctoral fellow at Mt. Wilson and Palomar Observatories. This gave him the opportunity to work with Colin C. Wilson and discover an important phenomenon regarding luminosity of certain kind of stars. This is known as the 'Wilson-Bappu effect.'

Bappu returned to India in December 1952. In those days, India did not have institutional infrastructure to carry out research in modern astronomy. This prompted him to say: "I was returning to a country with facilities which were primitive compared to those in the United States; the largest telescope I could expect to use was a 15-inch refractor." Bappu, in fact, spurned many exciting offers from many universities and observatories abroad to come back to India. He was actually inspired by the efforts of prominent Indian scientists such as Homi J. Bhabha to create scientific research infrastructure in India.

His return was due also to the pre-condition of his scholarship; to serve the Hyderabad state for ten years. However, the Hyderabad government could not offer him a suitable job. He was, therefore, free to move ahead soon after. Bappu got a senior research fellowship at the National Institute of Sciences (later renamed as Indian National Science Academy) in 1954. Subsequently, he joined the Uttar Pradesh State Observatory, Varanasi, as its chief astronomer and later its head. He convinced the Uttar Pradesh government to relocate the observatory to Nainital as it was better suited for astronomical observation.

Dr. M.S.S. Murthy, author of Vainu Bappu's biography *The Man Who Knew the Stars*, recollected the following. "After completion of his Harvard fellowship, Bappu had several job offers from Europe and the USA, including one from Harvard itself. He was however determined to return to India. He was aware of India's glory in astronomy over periods covering Aryabhata in the 5th century to Sawai Jai Singh in the early 18th century. He also took note of the fact that institutions in the West made large strides with many facilities and wanted to create similar circumstances in India too. He denied himself all personal benefits from a job in the West and decided to return home without even the promise a job for his dream of putting India back on the astronomical map of the world."

After being with the UP Observatory for five years, Bappu moved to Kodaikanal in 1960 to take over as the Director of Kodaikanal Observatory, originally set up by the East India Company in 1899. Later, the Government of India also entrusted him with the task of setting up a modern observatory for stellar studies. Bappu chose Kavalur, in Vellore district of Tamil Nadu for the new station. The Kavalur observatory became functional with a modest 38-centimetre (15-inch) aperture telescope in 1968. Subsequently, he conceived and steered a project to build a 2.36-metre telescope, which is comparable to the best observatories of the time. This telescope, capable of resolving an object the size of Re.1 coin from a distance of 40 kilometres, was designed and fabricated indigenously as was the desire of Bappu. However, he was not alive to see its commissioning in 1986. The then Prime Minister Rajiv Gandhi named both the observatory and telescope after Vainu Bappu.

T.V. Jayan

Homi Jehangir Bhabha

Homi Jehangir Bhabha (30 October 1909 – 24 January 1966) is rightly known as the main architect of the nuclear energy programme of our country. His contribution to India's development encompasses several other spheres too. He can be deemed a builder of modern India. Bhabha attained international recognition as a physicist for his original contributions in the field of cosmic radiation, the theory of elementary particles, and quantum theory.

He calculated the cross-section of electron-positron scattering (Bhabha scattering). His Cascade Theory of Electron Shower developed with W. Heitler in 1937, has proved to be a fundamental contribution towards our understanding of the soft component of cosmic radiation and the behaviour of high-energy electrons and gamma rays. In his vector meson theory, Bhabha predicted that the measured lifetime of a meson in flight is affected by time dilation as stated by Einstein's special theory of relativity. This measurement is considered to be the most direct evidence of the correctness of Einstein's special theory relativity at extremely high velocities. Bhabha suggested the name 'meson' that today represents a group of fundamental particles.

Bhabha never accepted mediocrity, never compromised on excellence and met challenges head-on with confidence. He possessed artistic gifts of the highest order. His interest in art, literature and music began at an early age. He loved music and had considerable knowledge of Indian and western music. He loved to dance, painted and sketched. He designed the settings of dramas produced. His brother Jamshed Bhabha remarked: "For Bhabha, the arts were not just a form of recreation of pleasant relaxation; they were among the most serious pursuits of life, and he attached importance to them as to his work in mathematics and physics. For him, the arts were, in his own words 'what made life

worth living.'" He was also a profoundly talented architect; landscaping was not a luxury for him. He was a true friend of trees and did everything under his powers to protect them. Bhabha was a perfectionist, and no detail was too small for eyes.

Homi Jehangir Bhabha was born on 30 October 1909 in a wealthy Parsi family of Mumbai. Bhabha's family had a long tradition of learning and service in the field of education. His grandfather, also named Homi Jehangir Bhabha, was the Inspector General of Education in the State of Mysore. Bhabha's father Jehangir Hormusji Bhabha was educated at Oxford and later qualified as a lawyer. His mother Meheren was the granddaughter of Sir Dinshaw Maneckji Petit, widely respected in Mumbai for his philanthropy.

Bhabha attended the Cathedral and John Connon Schools in Mumbai. After completing the Senior Cambridge examination at the age of 15, he joined the Elphinstone College. Subsequently, he moved to the Royal Institute of Science, Mumbai. In 1927, he joined the Gonville and Caius College in Cambridge, UK. This was the place his uncle Sir Dorab J. Tata went to. He enrolled for Mechanical Tripos in 1930. This was according to the wishes of his father and his uncle Sir Dorab J Tata that he becomes an engineer. This was also with the view he would join the Tata Iron and Steel Company at Jamshedpur. However, Bhabha's interest gradually shifted to theoretical physics, and he conveyed the same to his father in a letter in 1928. He wrote: "I seriously say to you that business or job as an engineer is not the thing for me. It is totally foreign to my nature and radically opposed to my temperament and opinions. Physics is my line. I know I shall do great things here. For, each man can do best and excel in only that thing of which he is passionately fond, in which he believes, as I do, that he has the ability to do it, that he is in fact born and destined to do it…I am burning with a desire to do physics. I will and must do it sometime. It is my only ambition. I have no desire to be a 'successful' man or the head of a big firm. There are intelligent people who like that and let them do it…It is no use saying to Beethoven 'You must be a scientist for it is great thing' when he did not care two hoots for science,

Bhabha Atomic Research Centre

or to Socrates 'Be an engineer; it is the work of an intelligent man'. It is not like things. I therefore earnestly implore you to let me do physics." For doing physics, Bhabha wanted to pursue Mathematics Tripos. Bhabha's father yielded to his son's firm determination on the condition he completes the Mechanical Tripos successfully. Bhabha met this condition successfully and two years later passed the Mathematical Tripos again with a first class.

At Cambridge, Bhabha was taught by Paul Adrien Maurice Dirac, then the Lucasian Professor of Mathematics at Cambridge University. Bhabha joined the Cavendish Laboratory, from where he obtained his Ph.D. in mathematical physics. His research supervisor was R.H. Fowler, who was also the supervisor for Subrahmanyan Chandrasekhar. Over 1932-1934 he held the Rouse Ball Travelling Studentship in Mathematics. Earlier he held the Salomons Studentship in Engineering over 1931-1932. He travelled across Europe; worked with Wolfgang Pauli in Zurich and Enrico Fermi in Rome. His first research paper in 1933 won him the Isaac Newton Studentship in 1934. He held this for three years and worked mostly in Cambridge. He also worked with Niels Bohr at Copenhagen. In 1937, he was awarded the 1851 Exhibition Scholarship that enabled him to continue his research in Cambridge.

As mentioned earlier, Bhabha suggested the name 'meson,' presently used for a class of elementary particles. Carl David Anderson discovered a new particle in cosmic radiation

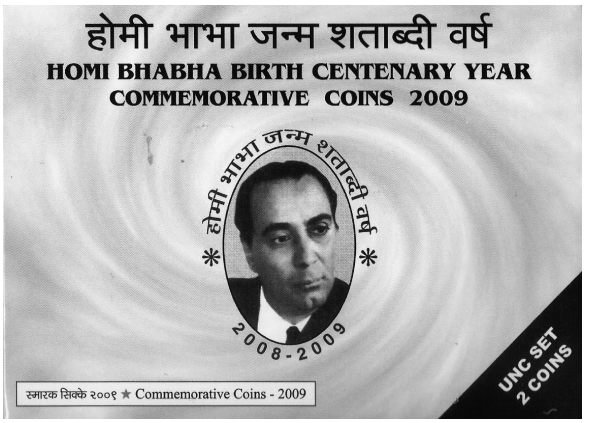
with a mass between that of electron and proton, calling it the 'mesotron'. Bhabha proposed the name 'meson' through a short note communicated to Nature (February 1939). In this note, he wrote: "The name 'mesotron' has been suggested by Anderson and Neddermeyer for the new particle found in cosmic radiation with a mass intermediate between that of the electron and the proton. It is felt that 'tr' in this word is redundant since it does not belong to the Greek root 'meso' for the middle; the 'tr' in neutron and electron belong of course, to the roots 'neutr' and 'electra'…It would, therefore, be more logical and also shorter to call the new particle a 'meson' instead of a 'mesotron.'" Bhabha's suggestion was finally accepted.

Bhabha was in India for a brief holiday in 1939. This was the time the Second World War broke out. Bhabha abandoned his plan of returning to England and therefore did not resume his research work in Cambridge. Most scientists in England had to take part in war activities; with no scope for working on basic research. In 1940, he joined the Indian Institute of Science in Bengaluru. A Readership in Theoretical Physics was specially created for him. Sir C.V. Raman was then the Director of the Institute.

At the Indian Institute of Science, Bhabha guided research on experimental and theoretical aspects of cosmic rays. He took note of the fact that facilities necessary were meagre for work on nuclear physics, cosmic rays, high-energy physics, and other frontier areas. He sent a proposal in March 1944 to the Sir Dorab J. Tata Trust to tackle this need by establishing 'a vigorous school of physics.' The trustees of Sir Dorab J. Tata Trust accepted the proposal to start the proposed Institute in April 1944. The Government of Bombay evinced interest to fund the proposed institute jointly. The Tata Institute of Fundamental Research was thus born in 1945 in 540 square metres of hired space. In 1948, the Institute moved into premises of the Royal Yacht Club. The present building of the Institute was inaugurated by Pandit Jawaharlal Nehru in January 1962. Bhabha was the first Director of the Institute besides being a Professor of Theoretical Physics. He picked the right kind of people and gave them opportunities to grow. The TIFR served as the cradle for India's atomic energy programme and evolved as one of the most famous scientific institutions in the country.

The Board of Research on Atomic Energy was constituted as part of the Council of Scientific and Industrial Research (CSIR) with Bhabha as its Chairman. The Atomic Energy Commission was established in August 1948, following the Indian Atomic Energy Act 1948. The first Atomic Energy Commission had three members including its Chairman,

Bhabha. The other two members were S.S. Bhatnagar and K.S. Krishnan. The Atomic Energy Establishment (later named the Bhabha Atomic Research Centre) was established in 1954 at Trombay near Mumbai with Bhabha as its Director. The same year the Department of Atomic Energy was also established with Bhabha as its Secretary. He shaped the atomic energy programme; created appropriate institutional frameworks and the mechanism to train people to carry the programme forward.



Bhabha was elected Fellow of the Royal Society in 1941. In 1943, he received the Adams Prize of the Cambridge University for his work on cosmic rays, and in 1948 the Hopkins Prize of the Cambridge Philosophical Society. He was the President of Indian Science Congress in 1951 and the National Institute of Science of India (now INSA) in 1963. He was the President also of the historic International Conference of the Peaceful Uses of Atomic Energy held under the auspices of the United Nations at Geneva in August 1955 and the International Union of Pure and Applied Physics over 1960-1963. Bhabha perished in an air-crash near the Mont Blanc peak, The Alps on January 24, 1966. He was on his way to Vienna to attend a meeting of the Scientific Advisory Committee of the International Atomic Energy Agency. Commenting on the sudden death of Bhabha, Smt. Indira Gandhi, the then Prime Minister of India, said: "India will long cherish Homi Bhabha's memory, for he was deeply involved in her destiny and in the process of changing the texture and the quality of her society."

Subodh Mahanti

Shanti Swarup Bhatnagar

Shanti Swarup Bhatnagar (21 February 1894 – 1 January 1955) was one of the builders of the scientific and industrial foundations of modern India. He played a significant part along with such stalwarts as Prasanta Chandra Mohalanobis, Meghnad Saha, Homi Jehangir Bhabha, and Vikram Ambalal Sarabhai in building India's post-independence S&T infrastructure. He was a multi-faceted personality; a highly accomplished scientist, an able science manager, and administrator, a great creator of institutions, an inspiring teacher, and a poet. He was the Founder-Director of the Council of Scientific and Industrial Research (CSIR) established in 1942, the first Chairman of the University Grants Commission (UGC). Bhatnagar and played an important role in the constitution and deliberations of the Scientific Manpower Committee Report, 1948. The two major areas in which Bhatnagar made significant contributions were the magneto-chemistry and physical chemistry of emulsions.

Bhatnagar lost his father when he was just eight months old. His mother had no inheritance or income of her own for the upbringing of her children. Bhatnagar lived in his maternal grandfather's house till he was 13. After that, he was on his own. He had an indomitable will for higher studies and pursued them either through scholarship or working outside school and college hours. He wanted to become a scientist and by the power of his sheer will and hard work attained such reputation, he was elected Fellow of Royal Society of London. People were touched by his simplicity that twinned his intellectual excellence and honesty.

Shanti Swarup Bhatnagar was born on 21 February 1894 at Bhera in the district of Shapur in Punjab of undivided India (now in Pakistan). His father Parameswari Sahai Bhatnagar was a distinguished graduate of the Panjab University. He refused to take up

judicial or executive service, and therefore deviated from the trend his family had set. He became the headmaster of a high school in Bhera. Unfortunately, his untimely death left his wife and young children in dire poverty.

Bhatnagar had his early schooling in a private elementary school; known as maktab. He then proceeded to the A. V. High School in Sikandrabad, Uttar Pradesh, where his maternal grandfather was. Rai Sahib Lala Ragunath Sahai, the Headmaster of Dyal Singh High School at Lahore and a friend of Bhatnagar's father, persuaded his mother to send him to Lahore for schooling. Bhatnagar passed the Matriculation examination in the first division and secured a university scholarship. At school, he earned a significant reputation as an actor through skills he displayed at events of the Saraswati Stage Society. He authored a one-act play Karamati (Wonder worker) in Urdu. The English translation earned him the prize and a medal for the best play of the year 1912 conferred by the Saraswati Stage Society. He published a collection of his poems in Urdu titled Lajwanti.

In 1911, he joined the then newly established Dyal Singh College. He passed the Intermediate examination of the Panjab University in 1913 in the first division. He completed his BSc studies from the Forman Christian College in 1916. He was then appointed a Demonstrator in the Physics and Chemistry Department of the same college. He later became a senior demonstrator at the Dyal Singh College. His job responsibilities did not hinder his higher studies. He joined the MSc course in chemistry at Forman Christian College and secured the degree in 1919. Bhatnagar was awarded a scholarship by the Dyal Singh College Trust for studies overseas. This was possible because of the initiative was undertaken by Ruchi Ram Sahni, an eminent Professor of Chemistry in the Government College, Lahore and a pioneer of science popularization in Punjab. Bhatnagar worked at the University College of London under the supervision of Professor F.G. Donnan and obtained the DSc degree of the London University in 1921. As a member of Professor Donnan's team Bhatnagar was engaged in the study of adhesion and emulsions.

On his return to India, Bhatnagar joined the Banaras Hindu University (BHU), Varanasi as Professor of Chemistry. He stayed for three years in BHU and during this short span of time created an active school of physical-chemical research. He also composed the *kulgeet* of the University. He also served as the University Professor of Physical Chemistry and Director of University Chemical Laboratories at the Panjab University, Lahore, where he spent 16 years. This was the most active period of his life as far as original scientific work is concerned.

He realized the importance of the application of magnetism to chemistry quite early in his research career. He accordingly decided to make use of magnetic susceptibility measurements to study the properties of compounds, solutions, films, and colloids.

However, there was no suitable instrument to measure small changes in magnetic susceptibilities. Bhatnagar responded to this challenge and jointly with one of his students K.N. Mathur (who later became the Director of the Central Scientific Instruments Organisation, Chandigarh) invented one of the most sensitive instruments for this purpose. This was called the 'Bhatnagar-Mathur Magnetic Interference Balance.' The invention was patented, and it was licensed to Messers Adam Hilger and Co., Camden Town, London, for production and marketing. The balance was first exhibited at the Royal Society soiree at London in 1931.

The first industrial production challenge he tackled was the development of a process to convert bagasse (peelings of sugarcane) into food cake for cattle. He addressed several problems of the Delhi Cloth Mills; J.K. Mills Ltd., Kanpur; Ganesh Flour Mills Ltd., Layallapur; Tata Oil Mills Ltd., Mumbai; Steel Brothers & Co. Ltd., London, and so on.

One of his remarkable achievements in applied and industrial chemistry was for Attock Oil Company at Rawalpindi (representative of Messers Steel Brothers & Company, London). The company confronted a peculiar problem in its drilling operations. The mud used for drilling operation came in contact with saline water and converted into a solid mass. This hardened further over time and rendered drilling operations impossible. Bhatnagar identified the colloidal chemistry aspect of the problem and solved it holistically. He added an Indian gum that lowered the viscosity of the mud suspension and increased stability against the flocculating action of electrolytes.

M/s Steel Brothers acknowledged his excellence and offered Rs. 1,50,000 to him as a token of their gratitude for research on subjects related to the problem. Bhatnagar requested that the sum is placed at University's disposal for research. This amount helped establish the Department of Petroleum Research under his guidance. Investigations were carried out on de-odourisation of waxes, increasing the flame height of kerosene and utilization of waste products in vegetable oil and mineral oil industries. The company realized the commercial importance of the outcomes and increased the quantum and period of-of support. Bhatnagar abided by his commitment to not receive any monetary benefit arising out of his applied/industrial chemical research for his personal ends. This was due his conviction that the benefits be used to strengthen research facilities at the University.

Bhatnagar became the Head of the Board of Scientific and Industrial Research (BSIR) established on 1 April 1940. He persuaded the Government to set up an Industrial Research Utilisation Committee (IURC; early 1941). This was to translate research outputs into applications. The Government agreed to confer funds from royalties received from industry on industrial research. The Council of Scientific and Industrial Research (CSIR), accordingly emerged as an autonomous body in September 1942, to administer

the research fund. Bhatnagar became its Founder Director, a post later re-designated as Director General.

In 1943, the Governing Body of the CSIR approved Bhatnagar's proposal to establish five national laboratories–the National Chemical Laboratory (Pune), the National Physical Laboratory (New Delhi), the National Metallurgical Laboratory (Jamshedpur), the Fuel Research Station (Dhanbad), and the Central Glass and Ceramics Research Institute (Kolkata). Many others followed over time. Bhatnagar was elected Fellow of the Royal Society, London in 1943. He was the President of the Indian Chemical Society, the Indian National Science Academy; as it is now known and the Indian National Science Congress.

Bhatnagar's contribution to the field of education is quite significant. He was an excellent teacher and an accomplished researcher. He taught for 20 years in universities. He inspired a large number of students; many of whom occupied important positions and spread the ideals of their teacher. Bhatnagar felt that it was the duty of the scientists to make common citizens aware of their work. He emphasized the need to instill the spirit of adventure in students. This was of paramount importance to him because of his patriotic fervor. He believed that because India was under foreign rule, natives of the country were dissuaded/discouraged from being adventurous. He desired students should explore and be ready to tread unconventional paths.

The Late Professor T.R. Seshadri, a colleague of Shanti Swarup Bhatnagar, recollected in his memoir, "Prof. Shanti Swarup Bhatnagar was not only an eminent scientist, but he held a record as an administrator and organiser. He exhibited high poetic talent, particularly in Urdu. The testimony of one of his teachers that he was good in all subjects of study and did well in anything that he undertook as a student is applicable fully to his life's work in its various aspects. In spite of heavy administrative duties he was able to devote sufficient time to research work and during this period several patents of great importance were developed by him and his staff."

The CSIR has instituted the "S.S. Bhatnagar Memorial Award" for scientific research in disciplines of physical, chemical, biological and medical sciences or engineering. These are given annually and are widely recognised as the most prestigious awards of the country. These are given to scientists 45 years or less in age who have worked in the country. The Indian National Science Academy, New Delhi awards the Shanti Swarup Bhatnagar Medal for outstanding contribution in any branch of science that comes within the purview of the Academy.

Subodh Mahanti

Jagadish Chandra Bhattacharyya

Jagadish Chandra Bhattacharyya (1 September 1930 – 4 June 2012) was an Indian astrophysicist well-known for his contributions in experimental astrophysics. Popularly known as J.C. Bhattacharyya, he was an eminent instrumentation scientist and observational astronomer. He discovered, among others, the thin atmosphere on Jupiter's satellite Ganymede and the detailed ring structure around Uranus by occultation techniques. He was the Director of the Indian Institute of Astrophysics, Bengaluru, from 1982 to 1990 and established graduate schools to guide students to take up astronomy and astrophysics for a career. He trained and encouraged a whole generation of scientists who made further discoveries including the outer rings of Saturn, and six main-belt asteroids, one of which bears his name.

Bhattacharyya was born on 1 September 1930 in Calcutta (now Kolkata) in a family of scholars and educationists. His father was Phatik Chandra Vidyabhusan– a Sanskrit scholar and science teacher, and his mother was Mrinalini. His grandfather, Mahamahopadhyaya Pramath Nath Tarkabhusan was an eminent Indologist and scholar of Vedantic Philosophy. Bhattacharyya obtained his MSc degree from the Institute of Radio Physics and Electronics, Calcutta University in 1951. After a couple of years at Calcutta University as Ghosh Research Scholar, he joined the India Meteorological Department (IMD) as Assistant Meteorologist in 1953. While at IMD he developed instruments for meteorology and undertook scientific studies in solar astronomy and ionospheric physics. In 1964, he was appointed Assistant Director of the Astrophysical Observatory at Kodaikanal when M.K. Vainu Bappu was its Director. In close association with Bappu, he designed and constructed several electronic instruments for the photometric recording of astronomical data, including the solar magnetograph at Kodaikanal. The design and fabrication of the

solar magnetograph earned him the DPhil degree from Calcutta University in 1971. He used this instrument to measure the small-scale velocity field in the solar chromosphere. At Kodaikanal, using ionospheric data during a solar flare, he developed a method to estimate spectral characteristics of ionising radiation.

Meanwhile, on the initiative of Bappu and Bhattacharyya, a new field observatory was started in 1968 at Kavalur in Javadu hills of North Arcot district in Tamil Nadu for stellar spectroscopy and photometry. The site, chosen after extensive tests over fifteen months for "seeing" now has the largest optical telescope in India, a 2.34-m reflector, and a 38-cm photometric light collector. Most research on galaxies, stars, and the solar system are now done from Kavalur. The Further expansion optics, electronics and data analysis centre at Bengaluru emerged as a result of expanding interests and expertise.

The Indian Institute of Astrophysics (IIA) was established in 1971 as an autonomous researchiInstitute wholly financed by the Government of India with Bappu as its Director. After the untimely demise of Bappu in 1982, Bhattacharyya took over and continued till his superannuation in 1990. The IIA, with its headquarters in Bengaluru, is a premier national Institute of India for the study of and research into topics pertaining to astronomy, astrophysics, and related subjects.

Astronomers use occultation of stars by planets to detect atmosphere or rings around them. Occultations occur when the Moon, a planet or other close-by bodies momentarily cover distant objects, mainly stars. In 1971, when Jupiter occulted the star β Scorpii, a 15-inch (38-cm) telescope fabricated at the Kodaikanal Observatory was in regular use with a photo electric photometer. As the chart recorder was too slow to record the occultation in detail, Bhattacharyya decided to record it by photographing an oscilloscope screen. This resulted in the discovery of stratification in Jupiter's atmosphere. In 1972, the occultation of the star SAO186800 by Jupiter's moon Ganymede was observed from Kavalur as part of another international collaboration. Bhattacharyya's technique helped detect the thin atmosphere around this Jovian satellite. Ganymede is now known to be the second small body in the solar system, after Saturn's moon Titan, to have an atmosphere and the information came mainly through the records obtained at Kavalur by Bhattacharyya and his team. They were also among the first to detect the presence of complex dark rings around Uranus in 1977 during an occultation of a faint star observed from Kavalur. The team observed repeated dimming of the star as Uranus passed in front of it. This was found later to be due to the presence of five dark rings around Uranus.

With Bhattacharyya's encouragement, R. Rajamohan of IIA initiated a project to identify near-Earth asteroids. This helped discover several main-belt asteroids over 1988-

1989, the first of which was named *Ramanujan.* This was the first asteroid discovered by Indian scientists. Two other discoveries were named *Bhattacharyya* and *Gokumenon* subsequently. Bhattacharyya also recruited engineers and set up a team for technology development. This encouragement helped develop hardware and software controls of telescopes, dome and such new generation detectors as charge-coupled devices. These facilities significantly enhanced capabilities within the country for research in astronomy and astrophysics.

The 2.34-m telescope project at Kavalur was conceived and initiated by Bappu in the1970s. Bhattacharyya took full charge of its electronic control systems apart from playing a supportive role in many other aspects. When Bappu passed away in1982, the indigenous telescope was still under fabrication. It was because of the untiring efforts and leadership of Bhattacharyya that it was completed and commissioned in 1985. The telescope was inaugurated on 5 January 1986 by the then Prime Minister Rajiv Gandhi. He along with his children had a glimpse of Comet Halley and several deep-sky objects using the telescope. Till date, the 2.3-m Vainu Bappu Telescope at Kavalur Observatory (now renamed as Vainu Bappu Observatory) is India's largest facility in optical astronomy and serves national astronomers and students in their research programmes.

Bhattacharyya also provided strong support through IIA to the DST project of astronomical site survey in Leh, Ladakh; initiated by Bappu for the next-generation telescope. Following encouraging results of the survey, he made a proposal for a high-altitude, remotely controlled infrared telescope of the 4-m aperture in Leh district. Though this idea did not come to fruition fully, his successor, R. Cowsik, could take the lead in identifying Hanleat as the site at an altitude of 4,500 metres. This was followed by the national observatory with a 2.01-m aperture remotely operated optical-infrared telescope. The telescope at the new observatory at Hanle, now known as the Indian Astronomical Observatory, was commissioned in September 2000.

In addition to guiding students working in the areas of astronomical techniques and observation of the Sun and the solar system, Bhattacharyya also took up the responsibility of guiding Bappu's students. The Joint Astronomy Programme of the Indian Institute of Science, involving several astronomy institutions, was initiated in his tenure, where he taught a course on astronomical techniques for several years. He went on to lay a firm foundation of IIA's graduate school and encouraged younger colleagues to teach and supervise projects. As the President of the Astronomical Society of India (1986–1988), Bhattacharyya catalyzed its programme on the popularization of astronomy, especially to train students and teachers in astrophysics. His popular articles in Bengali and English

magazines, written from 1977 onwards, inspired many students to take up astronomy as a career. The structure of IIA, as it exists today, owes itself fully to Bhattacharyya. He had initiated the new campus of IIA in Bengaluru, leading a small group and setting up an electronics laboratory in the space provided by the Raman Research Institute during the early 1970s. The Institute moved to its present Koramangala campus in Bengaluru in 1975. Further infrastructure development continued for nearly a decade.

Tushar Prabhu, a student of J.C. Bhattacharyya, recollected, "Opportunities for research in astronomy and astrophysics were extremely limited in the country before 1980. Jagadish Chandra Bhattacharyya devoted considerable efforts to establish graduate schools in addition to guiding students working in the areas of astronomical techniques, Sun, and solar system astronomy. As President of the Astronomical Society of India (1986–1988), he energized its programme on the popularization of astronomy, especially to train students and teachers in astrophysics. His popular articles in Bengali and English magazines, which were written from 1977 onwards, inspired many students to take up astronomy as a career."

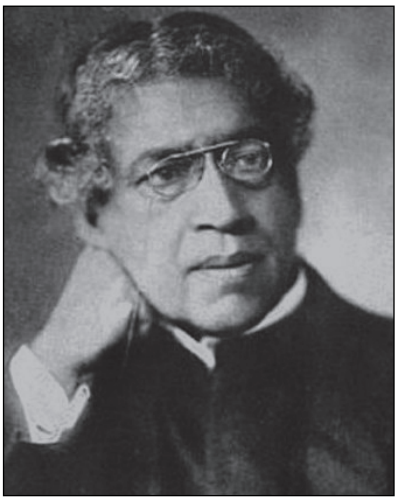
After Bhattacharyya took charge of IIA in 1982, he focused on institution building in right earnest – setting up the academic faculty, Group Committees, instrumentation division, and administrative structure and various benefits for the employees to foster an atmosphere of academic excellence. According to his IIA colleagues, Bhattacharyya set an example of personal integrity in public service, understood and followed rules and regulations of the government in the spirit of promoting discipline, transparency, and accountability.

After his superannuation from IIA in 1990, Bhattacharyya continued to be associated with IIA, as CSIR Emeritus Scientist (1990–1993), Emeritus Professor (1993-1995), Honorary Professor (1995–1997), and Member of Governing Council (1997–2007). He served on many advisory committees and working groups at both national and international level over the last two decades of his tenure. He was associated with the Jawaharlal Nehru Planetarium in Bengaluru for over two decades. He was Editor of the *Journal of Astrophysics and Astronomy*, published by the Indian Academy of Sciences, from 1988 to 1991. He was a Fellow of the Indian Academy of Sciences, Bengaluru, the Institution of Electronics & Telecommunication Engineers (IETE), and the National Academy of Sciences (India), Allahabad, and was President of the IAU Commission 9 on Instruments and Techniques (1992–1995). The honours and awards he received include the M.N. Saha 30th Memorial Lecture Award of SINP (1983), UGC–Hari Om Trust–Sir C.V. Raman Award for Research in Physical Sciences (1986), S.V.C. Aiya Lecture Award of the IETE (1986), ISOI Lifetime

Achievement Award (1993), and S. K. Mitra Birth Centenary Award of the Indian Science Congress Association (2005).

With his passing away in 2012, India lost one of her founding fathers of modern experimental optical astronomy and an exemplary head of a scientific organisation. The legacy he left behind will inspire generations to explore the skies to unravel mysteries of the universe.

Biman Basu

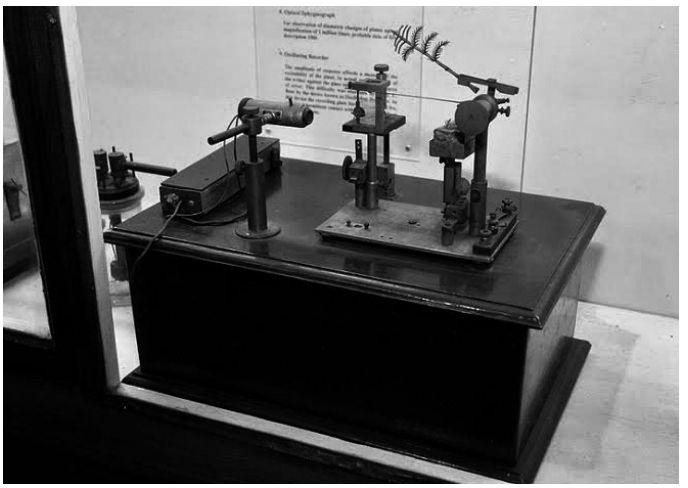


Jagadis Chandra Bose

Jagadis Chandra Bose (30 November 1858 – 23 November 1937) occupies a unique position in the history of Indian science. He was modern India's first physicist. As one of his biographers, Subrata Dasgupta writes: "Bose was the first Indian to be admitted in person to the *sanctum sanctorum* of English, thus Western science." In 1897, Bose was invited to deliver a lecture at the Royal Institution in London, then the most prestigious and visible platform that announced discoveries. It was Michael Faraday who started the Friday Evening Discourses in 1826.

One of his biographers Patrick Geddes wrote: "The life story of Jagadis Chandra Bose is worthy of close and ardent consideration by all young Indians whose purpose is shaping itself towards the service of science or another high course of the intelligence or social spirit. It is possible that looking upon the triumph of the end and knowing nothing of the long uphill road, the slow, costly attainment of ends, they may think that a fine laboratory or another material endowment the antecedent condition of achievement in intellectual creation. The truth indeed is far otherwise. The countless obstacles which had to be surmounted only called forth in Bose all the endurance…In contemplating the great career of his countryman, the young Indian will be stimulated to put brain and hand to fine tasks, nothing fearing."

Writing in *The Life and Work of Sir Jagadis C. Bose*, Geddes quotes Late Mrs. A.M. Bose, eldest sister of J.C. Bose, "At our country house, Fairy Hall at Dumdum, outside Calcutta (now Kolkata) I watched Jagadis's passion towards the peculiar movements of leaflets of Biophytum, which led to his discovery of multiple responses, and its continuity with the automatic response of the Telegraph-plant".



Optical sphygmograph

D.M. Bose, nephew of J.C. Bose, wrote in his memoir, "A more detailed study of his interests since his boyhood days, reveals Jagadis Chandra as endowed with great physical energy, imaginative, strong minded and impatient of control; he had the potentiality of becoming an artist, a biologist or an engineer."

Bose did pioneering research, first in physics and then in plant physiology. He was the first to produce and study the properties of millimetres-length radio waves and perfected the method of transmission and reception of electromagnetic waves. Additionally, he showed, semiconductor rectifiers could detect radio waves. His galena receiver of lead sulphide photo-conducting device was amongst the earliest. W.H. Brattain (1902-1987), the Nobel Laureate American physicist who co-invented the transistor, credits Bose with the first use of semi-conducting crystals to detect radio waves. According to Nevill Mott (1905-1996), the British physicist who won the Nobel Prize in Physics in 1977, "He (Bose) had anticipated the existence of p-type and n-type semiconductors."

Bose was a pioneer in experimental science in India; yet much against the philosophy of patenting. His American friend persuaded him to file a patent application for his galena receiver. The patent (US patent no. 755,840) was granted on 29 March 1904 after nearly two years from the date of application. Bose refused to accept his rights and the patent lapsed.

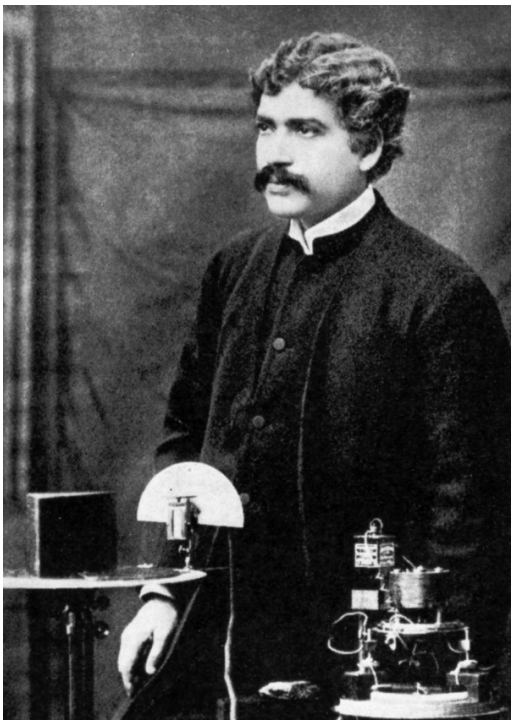
Jagadis Chandra Bose was born in Mymensingh (now in Bangladesh). His father Bhagwan Chandra Bose, a civil servant in the British Raj, was deeply interested in the welfare of his fellow citizens. He was particularly interested in improving the living conditions of rural people and always thought of new schemes for their benefit. Bose had his early education in a local vernacular or a Bengali-medium school, a *pathshala,* founded by his father in Faridpur. His father had the option of sending him to a local English school. He, however, wanted his son to learn his mother tongue well, know his culture before he learned English and imbibed foreign culture. In this *pathshala*, children of peasants, fishermen and workers were his classmates.

In fact, one of the students studying with him was the son of his domestic servant! In their midst, Bose imbibed an abiding love for animals, birds, and plants, as many of his later writings bear testimony to this. He also developed a love of equality and brotherhood, and he was free from caste, class, and religious prejudices. His father used to take his young son for evening strolls in the neighbouring areas and make him familiar with the natural objects around them. He used to encourage young Bose to ask questions. There used to be occasions when he could not answer the question and in such situations, he prompted him to look for answers by himself and even as he would grow up. This developed a spirit of asking questions in young Bose. In his childhood, Bose was inspired through folk plays to read the Ramayana and Mahabharata. He was deeply influenced particularly by Karna from Mahabharata.

J . C. Bose Institute in Darjeeling

In 1869, Bose proceeded to Calcutta. After three months at the Hare School, he joined St. Xavier's College, that included a secondary school; founded by Belgian Jesuits in 1860. Bose came in contact with Father Eugene Lafont (1837-1908), who helped established the tradition of modern science in Kolkata. Father Lafont's laid a lot of emphasis on experimentation. Bose was highly influenced by this approach of Father Lafont. In 1879, Bose passed the degree (BA) examination in Physical Science of the Calcutta University. At that Bose was not clear about his career path. He had the option of following his father's example to join the Indian Civil Service. However, his father did not want his son to become a civil servant and in fact serve common people.

It was finally decided that Bose would study medicine in an English university. So finally Bose went to England in 1880. His mother had to sell off her jewellery to send him to England. But Bose had to abandon his plan to study medicine as he fell ill, due to odours in the dissecting rooms. In January 1882, Bose left London for Cambridge to join the Christ College and study natural science. Among his teachers at Cambridge was the famous



J. C. Bose demonstrating radio receiver at Royal Society of London

scientist Lord Rayleigh (1842-1919) with whom Bose struck a life-long friendship. In 1884, Bose passed the Natural Sciences Tripos; the same year he obtained the Bachelor of Science degree from the University of London. On returning to India in 1885, he joined the Presidency College in Kolkata and served as the first Indian Professor of Physics. His appointment was initially strongly opposed by Sir Alfred Croft, Director of Public Instruction of Bengal and Charles R. Tawney, the Principal of the Presidency College. Despite these, Bose finally secured appointment through the intervention of Lord Ripon, then Viceroy of British India.

British officials of that period were biased against Indians, that the latter cannot handle high posts in educational service. The Imperial Educational Service was therefore beyond their reach despite high qualifications. Against this back drop Bose was taken only on a temporary basis at half the pay. Bose protested and asked for salary; an Englishman was entitled for. He refused to accept the half salary when his plea was not heard. He continued teaching without pay for three years. This was even at a time when his father was deep in debts. Finally, the Director of Public Instruction and the Principal of the Presidency College took note of Bose's skill in teaching and his tenacity. This helped Bose secure a permanent appointment with retrospective effect. He used the money he received to pay his father's debts off.

In 1894, Bose decided to pursue scientific research in real earnest, and not be confined to teaching alone. He conducted research in a small room at the Presidency College. He received help from an untrained tinsmith to devise and construct new apparatuses for his researches on electric waves. He studied properties of electric waves; inspired by Oliver Lodge's book Heinrich Hertz and His Successors. Bose devised and fabricated a new type of radiator to generate radio waves and highly sensitive 'coherer' or detector to receive radio waves. This coherer was more compact, efficient and effective than the ones used in Europe at that time. Using his improved equipment he demonstrated such properties of radio waves as reflection, absorption, interference, double reflection and polarisation. He also demonstrated micro waves of 5 to 10 millimetres. These waves are used in radars, ground telecommunication, remote sensing, and microwave ovens.

At a public demonstration in the Town Hall, Kolkata in 1895 he transmitted electric waves through three walls and activated a receiver that caused a bell to ring; a pistol fire; and a small heap of gunpowder explode. Among those present to witness this great event was Sir Alexander Mackenzie, the then Lieutenant Governor of Bengal.

His first research paper before the Asiatic Society of Bengal in May 1895 was titled, "On the Polarisation of Electric Rays by Double Refracting Crystals". His other paper that year was "On the Determination of the Index of Refraction of Sulphur for the Electric Ray". This was communicated by Lord Rayleigh to the Royal Society of London. The paper was read before the Royal Society in December 1895 and accepted for publication in the Society's proceedings in January 1896. Bose's three articles were published in the Electrician, Friday 27 December 1895. In those days *Electrician* was amongst the most prominent periodicals devoted to electrical matters. The University of London awarded Bose the Doctor of Science (DSc) degree without any examination. Lord Kelvin congratulated Bose stating he was "literally filled with wonder and admiration…for his success in the difficult and novel experimental problem."

Bose's success in his researches and appreciation by leading scientists in England and other European countries prompted the Education Department to send him to England on deputation. On reaching England, Bose first presented a lecture-cum-demonstration on his new findings at the meeting of the British Association for the Advancement of Science. This was at Liverpool. Scientists at the meeting were highly impressed by his presentation. J.J. Thomson, Oliver Lodge, and Lord Kelvin were amongst them. Bose was invited by the Royal Institution to deliver a Friday Evening Discourse on 29 January 1897; a matter of great honour. The lecture was not only praised but was considered for publication in the *Transactions of the Royal Society*. The Government of India extended his deputation. Bose's fame spread to France and Germany. He was invited by the Physical Society of Paris and leading physicists of Berlin to deliberate on his results.

After pioneering work in physics, Bose focussed on plant physiology. He demonstrated electric responses produced by plants in response to mechanical stimuli, application of heat, electric shock, chemicals, and poisons. He tried to demonstrate a similar electric response to simulation in certain inorganic systems and the physical basis of memory. Bose invented several novel and highly sensitive instruments for his investigations. Among these, the most important one was the crescograph–an instrument for measuring the growth of a plant. It could record growth as minute as 1/100,000th of an inch (0.00003 cm) per second. In all his investigations, Bose offered original interpretations. His findings subsequently influenced knowledge systems in biophysics, chronobiology, cybernetics, medicine and agriculture.

Bose retired from educational service in 1915. After his retirement, he established a research institute–the Bose Institute in Kolkata. The foundation ceremony of the Institute took place on 23 November 1917. Bose collected nearly Rs.11 lakh for its endowment; with help from Rabindranath Tagore. Bose became the Lifetime Director of the Institute. In his inaugural speech, he said: "I dedicate to-day this institute–not merely a laboratory but a temple…The advance of science is the principal object of this Institute and also the diffusion of knowledge…I have sought permanently to associate the advancement of knowledge with the widest possible civic and public diffusion of it; and this without any academic limitations, henceforth to all races and languages, to both men and women alike, and for all time coming."

Bose was a close friend of Rabindranath Tagore. He received significant emotional support from him in times of difficulty. Before seriously launching into scientific investigations in 1894, Bose visited and photographed historic places of scenic beauty. He documented some of his experiences in vivid Bengali prose.; published later as Abyakta (The Inexpressible). Bose was conferred Knighthood by the British Government in 1917. He was elected a Fellow of the Royal Society of London in 1920.

Subodh Mahanti

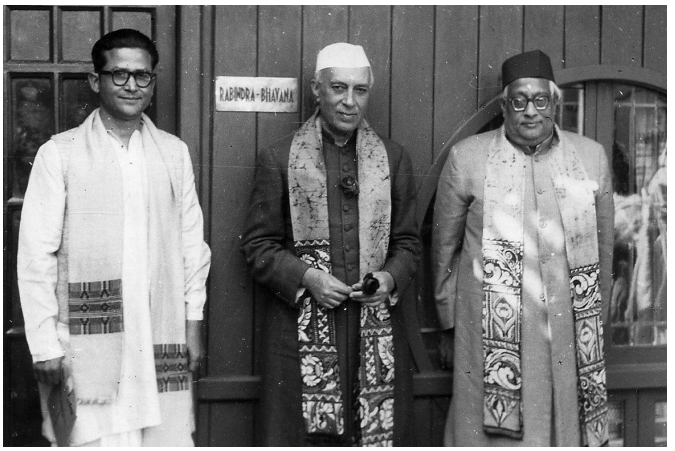
Satyendra Nath Bose

Satyendra Nath Bose (1 January 1894 – 4 February 1974), popularly known as S.N Bose, belonged to a rare breed of Indian scientists who made fundamental contributions to the world of science. Bose was a mathematician and physicist of the highest calibre. His pioneering efforts, appreciated and further developed by the great Albert Einstein, led to the system of statistical quantum mechanics, now known as Bose-Einstein Statistics. His contribution to the Unified Field Theory, which he studied three decades later, could have been equally spectacular. But Bose, saddened by his "Master" Einstein's demise in 1955, whom he was planning to meet during a scheduled European trip, tore up the only available manuscript.

His profound contribution to modern physics might not have won him a Nobel Prize. But, it is impossible to erase his name from the history of science. Bose is remembered by students of science, particularly those who study physics, because of Bose-Einstein Statistics and also because of the word Bosons, particles named after him. "You do not know who he was. Half the molecules in the universe obey him," so quipped a professor of physics, when a student shocked him once by asking who Satyendra Nath Bose was.

Even otherwise, Bose was not one who went after laurels and publicity. Despite being so easily achievable for him and being important for a career in research, Bose never bothered to complete his Ph.D. In fact, there were occasions in which lack of a doctorate actually came in his way, especially during the early years of his career.

Bose was born in Calcutta (now Kolkata) on 1 January 1894. He was the eldest and the only male of seven children born to his parents. His father Surendranath Bose worked in the engineering department of East India Railway Company. The young Bose went to



Satyendra Nath Bose (Right) with Prime Minister of India Jawaharlal Nehru (Middle) and Professor Khitish Roy (Curator, Rabindra Bhavan, Santiniketan, Kolkata) (Photo credit : http://www.oldindianphotos.in/)

several schools and finally passed matriculation with flying colours from the Hindu School in Kolkata, considered to be one of the oldest schools in India. A trivia from his school days is that his math teacher once gave him 110 marks out of 100! The teacher's logic for giving him more marks than the specified maximum limit was that Bose got answers right for all problems, including for the alternative questions, within the stipulated time.

As a boy, Satyendra Nath was influenced by the protests going all around against the British Rule. About those days, he wrote in his memoirs: "We must do something for our country just to show the British that we are no way inferior." When he subsequently joined at the Presidency College for his Intermediate studies, among his teachers were renowned scientists like Jagadis Chandra Bose (not related) and Prafulla Chandra Ray, who inspired him to do well in life. For his Bachelor's degree, Bose opted for a course in mixed (applied) mathematics. Interestingly, Meghanad Saha, who later became a legendary Indian scientist, was Bose's classmate for both BSc and MSc. Both Bose and Saha, who were credited with paving the foundation for modern theoretical physics in India, remained friends forever.

From 1916 to 1921, both Bose and Saha were lecturers in the physics department of Calcutta University. During this period, they collaborated closely and authored two joint papers, besides doing an English translation of papers by Einstein and H. Minkowski from German. Subsequently, in 1921, Bose joined the Department of Physics of the then newly-founded Dacca University (now the University of Dhaka in Bangladesh), whereas Saha moved to the University of Allahabad a couple of years later.

Even as Bose was involved in teaching postgraduate students at Dacca, he was not happy with Max Planck's radiation law. A discussion with Saha prompted him to try out a new derivation, which he thought was more logical. Bose sent a paper detailing his findings to the *Philosophical Magazine*, which had published his earlier works. However, this time, his paper was turned down.

What he did next was very daring, and became legendary. He sent the paper to Albert Einstein requesting him to arrange for its publication in Zeitschrift für Physic. Einstein not only acknowledged the receipt of the letter and intimated Bose of his decision to publish it as it was an important contribution, but he also translated the paper into German, himself. The paper was published in August 1924, a couple of months before Bose embarked on his maiden European journey, which was to last two years. As a translator's note, Einstein wrote: "Bose's derivative of Planck's formula appears to me to be an important step forward. The method used here also gives the quantum theory of an ideal gas, as I shall show elsewhere." Scientists regard Bose's work as a bridge between "the old quantum theory" propounded by Planck, Einstein and Neils Bohr and "the new quantum mechanics" of Erwin Schrodinger, Werner Heisenberg, Max Born and Paul A.M. Dirac. This signified the birth of quantum statistics.

The Bose-Einstein condensate is another classic proof of the excellence he stood for. Scientists had to strive for almost seven decades before they could prove the existence of such an extreme state of matter. Three American physicists won the Nobel Prize in Physics for this achievement in 2001.

Interestingly, in a biography, they wrote of Satyendra Nath Bose, Santimay Chatterjee, and Enakshi Chatterjee narrate an incident Bose's joke on Bose-Einstein Statistics: "Professor P.A.M. Dirac had come to Kolkata along with his wife in the mid-fifties. They were sharing the same car with Bose. Bose let them have a back seat. The front seat, which Bose occupied along with the driver, did not have much room. Nevertheless, Bose asked some of his students to get in. Dirac, a little surprised, asked if it wasn't too crowded. Bose looked back and said in his disarming fashion, "We believe in Bose Statistics." Dirac explained to his wife, "In Bose Statistics things crowd together."

His association with Einstein has been personally beneficial to Bose. It was Einstein's postcard acknowledging the paper mentioned above that helped him get permission for a two-year study trip to Europe. During this visit, Bose spent nearly a year at Einstein's lab and had the chance to interact with several giants in science, namely Marie Curie, Paul Langevin, Max Born, and Maurice de Broglie, from whom he learned X-ray crystallography, which he used extensively for teaching as well as research on minerals later on. A recommendation from Einstein ensured that Bose was made a professor of physics at Dacca University upon his return and subsequently the head of the department.

Bose spent the next two decades mostly teaching and carrying out research outside his core areas. For instance, he even fabricated X-ray diffraction cameras and dabbled in powder photography. During this period, he studied crystal structures and carried out

studies on organic compounds. Also, at Saha's behest, he investigated the problem of total reflection of radio waves in the ionosphere.

Bose returned to Kolkata in 1945 to become a professor of physics at Calcutta University. Almost three decades after his work on the Bose-Einstein Statistics, Bose published five papers on the Unified Field Theory. Though these were significant, they failed to have a similar impact as those published in 1924. Bose sent them to Einstein and wanted to discuss the work with him during a trip planned to Germany later. Before it materialised, Einstein passed away in 1955. It is said that the grief-stricken Bose tore up the paper, which is believed to have answered some of the scientific concerns raised by Einstein. The paper never saw the light of the day.

Bose was a great connoisseur of folk, Indian and / or western classical music. He played the instrument *Esraj*. One of his friends, who wrote on Indian music and benefitted from his interactions once said if Bose had not become a scientist, he might have become a master musicologist. Bose argued for teaching science to children in their mother tongue. To popularise science, he wrote books in Bengali and even set up an organisation for science popularisation called Bangiya Bijnan Parishad in 1948.

In 1952, he became a nominated member of Rajya Sabha for a period of six years. In 1956, he was made vice-chancellor of the Visva Bharati University at Shantiniketan, a position he relinquished in 1958. The same year, he was elected Fellow of the Royal Society of London. In 1959, Bose was appointed National Professor, a post he held until his death on 4 February 1974. On his death, his biographers Santimay Chatterjee and Enakshi Chatterjee say, "the public expression of sorrow was spontaneous and overwhelming." "Clearly the common people had no idea of the scientific miracle which had made Bose a name; still less did they care about the complications of modern physics. But they were proud of him, proud of the legend that was Satyen Bose and fond of the man behind the legend."

T.V. Jayan

Upendranath Brahmachari

Rai Bahadur Sir Upendranath Brahmachari (7 June 1875 – 6 February 1946) was a scientist and medical practitioner. He dedicated his life to science; in particular to chemistry, biochemistry and medicine. His abiding contribution to healthcare was the discovery of the chemical urea stibamine to treat kala-azar – an almost always fatal form of leishmaniasis. Leishmaniases are diseases caused by the protozoan parasite *Leishmania* sp. The infection is transmitted to humans by the bites of bloodsucking flies known as sandflies. There are three main forms of the disease– one of which is visceral leishmaniasis or kala-azar. Even today, untreated kala-azar is the second largest parasitic killer in the world. In the early twentieth century, it infested and decimated entire villages. With urea stibamine, doctors had a chance to fight back; it was also a powerful prophylactic. In the words of the British doctor H.E. Shortt, "*...overnight, a death rate of 90% was transformed into a cure rate of 90%.*"

Upendranath Brahmachari was born in Jamalpur, Monghyr (Munger) district, Bihar, to Dr. Nilmony Brahmachari and Saurabh Sundari Devi. The family had its ancestral roots in Sardanga village in West Bengal. He received his early education at the Eastern Railways Boys' High School, Jamalpur. After passing his entrance examination, he joined the Hooghly Mohsin College, from where he secured his BA degree in 1893. He graduated with honours in mathematics and chemistry standing first in the order of merit in mathematics. He was awarded the Thwaytes Medal for Mathematics.

A glimpse of his intellect can be gleaned from the fact that he took up the simultaneous study of chemistry at Presidency College, Calcutta (now Kolkata) with the study of medicine at the Medical College. He received his master's degree in chemistry in 1894. Subsequently, in 1900 he obtained top rank in the MB examination, standing first in Medicine and Surgery. He received the McLeod and Goodeve Medal for this feat. He earned his MD in 1902 and PhD in 1904, from the University of Calcutta. His thesis titled

Studies in Haemolysis is still considered an important piece of research on the physiological and physiochemical properties of red blood cells.

While pursuing higher education, he joined service in 1899 with the Provincial Medical Services, Dhaka. In 1901 he joined Dacca (Dhaka) Medical School as 'Teacher of Physiology and Materia Medica and Physician' – a post he graced for four years. A year after securing his doctoral degree, he joined the Campbell Medical School, Calcutta (now Nil Ratan Sircar Medical College, Kolkata) as 'Teacher and First Physician'. In 1923 he joined the Medical College Hospital, Kolkata, as Additional Physician– a post from which he retired in 1927. Subsequently, he joined the Carmichael Medical College as Professor of Tropical Diseases. He also served the National Medical Institute as In-charge, Tropical Disease Ward and was Head of the Department of Biochemistry, and Honorary Professor of Biochemistry at the University College of Science, Kolkata. He was also the Chairman of the Blood Transfusion Service of Bengal and played an important role in establishing the world's second blood bank in Kolkata in 1939.

Between 1915 and 1921, Brahmachari carried out many experiments in a small laboratory attached to the Campbell Medical School. His laboratory was a small, ill-equipped room lacking even such basic facilities as a gas burner, water tap or an electric bulb. Undeterred, he carried out his research by the light of a lantern. In 1919 he prepared an arsenic-containing unstable acid called stibanilic acid and various salts. The next year he made urea stibamine by heating stibanilic acid with urea. It was the world's first pentavalent antimonial drug designed to treat kala-azar. Looking back on the miserable conditions of his laboratory, he later said, "*To me, it will ever remain a place of pilgrimage where the first light of urea stibamine dawned upon my mind*." This attitude can only be attained by a mind so truly immersed in the subject of study so as to transcend all material limitations.

Urea stibamine was the first organic antimonial compound to achieve wide acceptance as a treatment for human leishmaniasis. Brahmachari tested it on the patients at Campbell Medical School with "gratifying results." In October 1922 he published his results in the *Indian Journal of Medical Research,* and the world began to take notice. A much larger number of patients now began to receive this new medicine in different wards of the Calcutta Medical College and Hospital. By 1923 it was evident that this once-fatal infection was fully cured, three weeks after an injection of 1.5 gm of urea stibamine. Brahmachari shared this medicine with doctors at the Pasteur Institute, Shillong and there too, the results were successfully replicated. Subsequently, there was hardly any hospital in India that did not receive urea stibamine free of charge. By 1925, the mortality rate from kala-azar had plunged to 10 per cent from 95 per cent, and it dipped to 7 per cent by 1936. The effect was particularly dramatic in the Gangetic plains and Brahmaputra Valley, the epicentre of kala-azar in those days. Greece, France and China too reported success.

Brahmachari was a scientist with far-ranging interests, but it was the generous spirit and empathy that characterised the person he was. Few know that he took note of the fact that urea in combination with certain drugs reduces the pain on injection. The process of making urea stibamine was never patented. This shows the magnanimity of Brahmachari, for urea stibamine was a brand new weapon in a medicinal quiver that held few specific medicines apart from quinine for malaria, arsenic for syphilis and digitalis for heart conditions and patenting it could have earned large amounts of money for him.

Brahmachari married Nani Bala Devi in 1898. They had two sons Phanindra Nath and Nirmal Kumar. Around 1924, Brahmachari established a research institute at his residence which was later converted into a Partnership concern with his sons. Unfortunately, this institute has not stood the test of time. Brahmachari is celebrated for his work on kala-azar. He also worked on malaria, blackwater fever, cerebrospinal meningitis, diabetes, filariasis, old Burdwan fever, influenza, leprosy, and syphilis. He was the first to identify the rare quartan fever (a type of malaria fever that recurs every 72 hours) in Kolkata and Dacca. He also identified a cutaneous leishmaniasis that occurs in patients who have recovered from kala-azar. This is christened Brahmacharileishmanoid.

He published about 150 research papers. Much of his research work has been collected in two volumes under the title, *Gleanings from my research*. The University of Calcutta published these in 1940 and 1941. He was a Fellow/Member of Asiatic Society (President, 1928-29), Indian Institute of Science, and Indian Association for the Cultivation of Science; Fellow/Patron of Indian Chemical Society, Society of Biological Chemists (India), Physiological Society of India, Royal Society of Medicine (London), and Royal Society of Tropical Medicine and Hygiene (London), and Honorary Fellow of State Medical Faculty of Bengal and the International Faculty of Science (London). He was elected Fellow of the Indian National Science Academy in 1930.

Brahmachari was showered with many awards and honours including the title of Rai Bahadur in 1911. He was the recipient of the Coates Medal and Griffth Memorial Prize of Calcutta University, Minto Medal of the School of Tropical Medicine & Hygiene, Kolkata (1921); Kaisar-e-Hind Gold Medal (1924); and Sir William Jones Medal of the Asiatic Society of Bengal. He was knighted in 1934. Sir Upendranath Brahmachari was the first Indian to be nominated for the Nobel Prize in Physiology or Medicine.

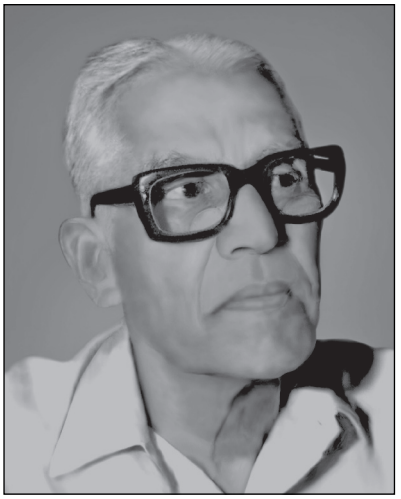
He was charitable by nature and donated generously to various organisations and made provisions for several awards, scholarships and medals at the University of Calcutta. The journal *Science and Culture* owes much to his generous donation. He contributed generously when the Council of Scientific and Industrial Research was setting up the Central Glass and Ceramic Research Institute in Kolkata.

Dr. P.N. Brahmachari, a relative of Upendra Nath Brahmachari, wrote in his memoir, "From the early days of his education, Upendra Nath began to show his proficiency and began to lead in his class. A quality that was apparent from his very early days was his faculty of remarkable memory. He acquired a good and thorough knowledge of English and could speak like an educated Englishman.

"His keen power of observation, critically analysing mind with the vast background of knowledge he had already acquired and the vast experience he was gaining day after day, made him an excellent clinician and his name and fame as a reputed physician of high calibre spread out far and wide in no time."

Perhaps Sir Upendranath should have reached greater heights, even in colonial India. Although associated with almost all the scientific and literary organisations in Kolkata such as Asiatic Society of Bengal, Indian Association for the Cultivation of Sciences, University of Calcutta, and Indian Museum Kolkata, he did not engage through networks or leverage his connections. He never left the shores of India. On the other hand, he focused on the city he called home and the regions adjoining it. It is marvellous to see his multi-faceted interests and achievements. No wonder he was considered the "Living dictionary of medicine" of his time. He was a pioneer of modern drug research in India through his work on urea stibamine the first of the modern drugs originating in India. The Dr. U.N. Brahmachari Street in Kolkata is the great person he was.

Sukanya Datta



Brahm Prakash

Brahm Prakash (21 August 1912 – 3 January 1984) was an eminent metallurgist of India, and one of those who helped turn Homi Jehangir Bhabha's vision of India's nuclear programme into reality. He also laid foundations for India's space programme. Thus C.V. Sundaram, former Director, Indira Gandhi Centre for Atomic Research in Kalpakkam near Chennai wrote: "In post-independence India, Dr Brahm Prakash, the eminent metallurgist and administrator, played a major role in formulating and implementing research and development activities of far-reaching consequences in the Department(s) of Atomic Energy and Space. He was also vitally instrumental in establishing a firm base for self-reliance in many areas of advanced materials technology. Also, his sphere of influence extended to several educational institutions, CSIR and Defence Laboratories…The achievements of Dr Brahm Prakash made an indelible impact on the character and growth of science and technology in India for well over three decades."

Brahm Prakash is regarded as the father of nuclear materials technology in India. The separation of zirconium and hafnium achieved by Brahm Prakash was a path-breaking contribution, which made feasible the development of Zircaloy cladding for nuclear fuel. He was the prime architect of the Nuclear Fuel Complex at Hyderabad. He became the first Chairman of the Uranium Corporation of India Ltd., which was established in 1967 as a Public Sector Undertaking under the Department of Atomic Energy for uranium mining and processing. He shaped India's space programme too on the steps of Vikram Sarabhai. He was the first Director of Vikram Sarabhai Space Centre, Thiruvananthapuram. He shaped the metallurgical education and research in India to a great extent. He was the first Indian to be appointed as Head of the Department of Metallurgy of the Indian Institute of Science, Bengaluru.

Government College, Lahore

Describing Brahm Prakash's personal qualities his wife wrote: "In the midst of raising a family under constraints, doing a demanding job, he never succumbed to any impure impulses or less dignified ways, never entertained unkind thoughts or words. Every moment of his life, he guarded his actions carefully in the light of his ultimate values–truthfulness, devotion to work and kind thoughts for all. This came spontaneously to him. He did not have to fight with himself to pour out such uniform goodness." Such qualities are indeed extremely rare to be found in a person. The qualities 'truthfulness', 'devotion to work', and 'kind thoughts for all' should be considered as essential qualities of every human being.

Brahm Prakash was born on 21 August 1912 in Lahore (now in Pakistan) of undivided India. His parents were Khem Kaur and Jodha Ram Sekhri. His father worked for the Indian Railways. He first studied at the Central Model School, Lahore from where he passed the Intermediate examination, standing first. After completing his Master's degree in chemistry from the Government College, Lahore he worked as a demonstrator in the same college. He began his first research work under the guidance of H.B. Dunnicliffe. Brahm Prakash was deeply influenced by Dunnicliffe. Later he worked with Shanti Swarup Bhatnagar. He studied magnetic characteristics of compounds of transition metals. Some chromium compounds were synthesised by him, and he also derived the valence states of chromium in these compounds. His studies on chromium compounds cleared some of the existing controversies related to these compounds. He investigated crystallographic phase transformations in systems like MnS by using the technique of magnetic susceptibility measurement. As a part of his PhD work he also investigated the role of particle size in chemical reactions, for example, reactions between H_2S and chromates of lead and silver. In 1942, Brahm Prakash obtained his PhD in physical chemistry from the Panjab University.

After his PhD, he proceeded to the USA on a Government of India scholarship for higher studies. He first went to the Columbia University, but he was told that the field of investigation in which he was interested could not be pursued there. He then went to Massachusetts Institute of Technology (MIT) and started working there in metallurgy. At MIT, he got the opportunity of interacting and working with some of the most accomplished

metallurgists. He obtained a Doctor of Science degree from the MIT specialising in mineral dressing.

Vikram Sarabhai Space Centre, Thiruvananthapuram

On his return to India in 1949, Bhatnagar recommended his name to Homi Jehangir Bhabha for a suitable position in the Atomic Energy Programme. Brahm Prakash got the appointment. At the time of his appointment, India's atomic energy programme was just being launched. He was deputed to the Indian Institute of Science (IISc), Bengaluru as Professor and Head of the Department of Metallurgy. As mentioned earlier he was the first Indian to head the Department of Metallurgy at IISc. While at IISc he was also supposed to plan and organise the metallurgy programme for atomic energy development. He spent six years (1951-57) at IISc and played an instrumental role in transforming the department into an excellent centre for teaching and research in metallurgy.

In 1957, Brahm Prakash went to Mumbai to take up his original assignment in the Atomic Energy Programme. His first task was to commission the Fuel Fabrication Facility for producing aluminium-clad uranium fuel for the CIRUS (Canadian-Indian Reactor, United States). The CIRUS, the second reactor to be established in India, was supplied by Canada in 1954 but used heavy water (deuterium oxide) supplied by the United States. It was decided that India would supply half the fuel. The development of the fuel required that uranium metal should have a fine-grained structure so that radiation growth in the reactor could be prevented. The uranium fuel developed by Brahm Prakash and his team was found to be even better than the Canadian fuel. It was indeed a great achievement. Brahm Prakash and his team also achieved the production of Zircaloy clad UO_2 fuel for the first atomic power station at Kota, Rajasthan constructed with Canadian collaboration.

Under the leadership of Brahm Prakash, the metallurgy group of the Atomic Energy Establishment successfully achieved the establishment of a facility for the fabrication and assembly of fuel components for research and power reactors, a method for producing nuclear-grade zirconium, and the establishment of facilities needed for plutonium extraction and fabrication of plutonium fuels. They also developed a detailed plan for the Nuclear Fuel Complex at Hyderabad.

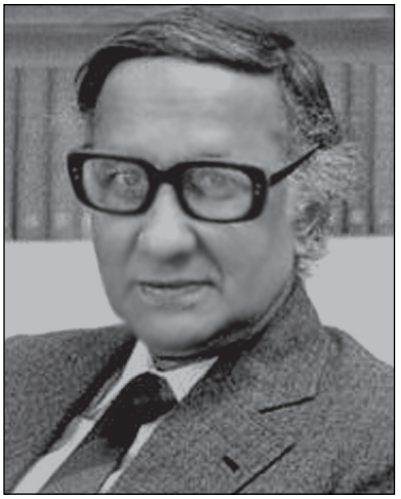
Brahm Prakash was the first Director of the Vikram Sarabhai Space Centre (VSSC) at Thiruvananthapuram. It was Satish Dhawan, then Chairman of the Indian Space Research

Organisation (ISRO), who brought Brahm Prakash to shape this lead organisation of ISRO. The VSSC comprised the Thumba Equatorial Rocket Launching Station, Space Science and Technology Centre, Rocket Propellant Plant, Rocket Fabrication Facility, and Propellant Fuel Complex. Brahm Prakash nurtured the VSSC in its formative stage by providing able and inspiring leadership. MGK Menon, a noted Indian physicist and who have played a major role in developing science and technology infrastructure in post-independence India wrote: "It was Dr Brahm Prakash who brought success to welding all the amorphous entities, out of which it was composed and nurturing it to make it the dynamic structure it is today."

In 1955, in recognition of his professional competence Brahm Prakash was elected as one of the scientific secretaries for the First UN Conference on the "Peaceful Use of Atomic Energy" held in Geneva. The paper, "Separation of hafnium and zirconium by vapour phase de-chlorination" presented by him at the Conference was regarded as the first original pyro-chemical approach of separation of hafnium and zirconium–two elements very similar to each other.

Brahm Prakash passed away on 3 January 1984 in Mumbai. A laboratory named after Brahm Prakash, the Professor Brahm Prakash Laboratory for Advanced Materials, has been established in the Department of Materials Science, Indian Institute of Science, Bengaluru. A Brahm Prakash Chair for a Visiting Professorship has also been established in the Department of Materials Science at IISc with the financial support of the Departments of Atomic Energy, Space and Science and Technology and the Defence Research and Development Organisation. The Indian Space Research Organisation has also established a Distinguished Professorship in the name of Brahm Prakash. Prof. Brahm Prakash Memorial Materials Quiz is being organised by the Indian Institute of Metals, Kalpakkam Chapter. The idea behind the programme is to create awareness among students about the excitement of materials science and importance of materials in industrial and technological development. The quiz was originally started in 1990, but it was named after Brahm Prakash in 1993. A prize in the name of Brahm Prakash has been instituted by the Indian National Science Academy, New Delhi.

Subodh Mahanti



Sivaramakrishna Chandrasekhar

Sivaramakrishna Chandrasekhar (6 August 1930 – 8 March 2004) is best known for his discovery of the class of discotic liquid crystal. Ths discovery led to a number of important applications ranging from legibility films for giant liquid crystal devices (LCDs) to hybrid nano chips. His book *Liquid Crystals* became a universally acclaimed classic. The book was first published in 1977 by Cambridge University Press and a second revised edition was brought out in 1992 by the same publisher. The book is popular amongst workers in the field and has been translated into Russian and Japanese. It is accepted that the worldwide revival of interest in liquid crystals was largely due to the pioneering work of Chandrasekhar and his group. He was a great supporter of liquid crystal science and technology in India. Chandrasekhar was a great educator too. He had a deep interest in classical Indian as well as western music. He was a good singer. Among his other interests were theatre, painting, and sculpture.

Chandrasekhar belonged to a large family distinguished in both science and public service. His mother Sitalakshmi was the younger sister of the Nobel Laureate Chandrasekhara Venkata Raman. He father served as the Accountant General in Kolkata. Sivaramakrishnan was the fourth among five brothers. S. Ramaseshan, a well-known materials scientist of India, was one of them. His younger brother S. Pancharatnam discovered the geometric phase in optics; thus named after him. Subrahmanian Chandrasekhar, who was awarded Nobel Prize in Physics in 1983, was his first cousin.

Chandrasekhar studied in schools in Kolkata, Delhi, Nagpur, Madras (now Chennai) and Coimbatore, as his father had a transferable job. He did his Intermediate Course in Loyola College, Chennai, and obtained his BSc (Hons) and MSc degrees from the College

of Science of Nagpur University. After completing his MSc examination, in which he stood first, he went to the Raman Research Institute in Bengaluru to work under the supervision of C.V. Raman for his doctoral thesis. He obtained a DSc degree of the Nagpur University in 1954 and the same year he went to Pembroke College of Cambridge University in the UK as an 1851 Exhibition Scholar. He worked at the Cavendish Laboratory on X-ray scattering from solid crystals for his second Ph.D. degree. He worked under the joint supervision by H.D. Megaw and W.H. Taylor. He received a Ph.D. degree in 1957 for his work on the connection between extinction in neutron and X-ray scattering from crystals. After his Ph.D. he worked with Dame Kathleen Lonsdale at the University College of London (1957-1959) and then with Sir Lawrence Bragg and David Phillips at the Royal Institution (1959-61).

On his return to India from the UK in 1961, he joined the then newly created Mysore University as Professor and Head of the Department of Physics. He had to build the department virtually from scratch. Two other students of C.V. Raman namely, D. Krishnamurti and S. Panchanan (who was his younger brother) joined the department as Readers. Describing the beginning of the department C.W. Grey, C.R. Luckhurst and E.P. Raynes, while writing about Chandrasekhar in *Biographical Memoirs of Fellows of the Royal Society* (2007) wrote: "Return to India saw Chandra (Sivaramakrishna Chandrasekhar) setting up the new Department of Physics at the University of Mysore, where the campus was wild land attached to the estates belonging to Princess Leelavathi of the Mysore Royal Family. Even after clearance, the land was still frequented by jackals, huge owls, and even leopards. The Physics Department started in unoccupied parts of the Palace, which were taken over at night by myriads of bats. Chandra's brother Dr. Pancharatnam was with him at the time, and scientific discussions were often held by candlelight when the electric power failed. Chandra remained at Mysore University as head of the Department of Physics until 1971…"

At Mysore, Chandrasekhar decided to work on liquid crystals. This was at a time when most were not even aware of the existence of such materials. He wrote: "When I was setting up the new department at Mysore, I made up my mind to change my field of solid crystals. My knowledge of these intermediate phases was, at the time, limited to brief accounts I had come across as a student more than ten years earlier in books published in the 1930s, but I was determined to make the change. With some trepidation, I mentioned this to Bragg (Lawrence Bragg), hoping that he would not be too disappointed that I was wandering off into an unfashionable and long-forgotten field. His response was, in fact, just the opposite, for which I was truly grateful. He started a serious discussion on the subject, and I felt jubilant." His initial contributions were theoretical in nature as his laboratories were not equipped to take up practical work. However, gradually he gathered necessary facilities to take up practical work.

Chandrasekhar and his group at Mysore University did pioneering work in liquid crystal physics, especially on pressure effects on liquid crystal phase transition. They discovered the optical analogue of the Bormann effect–the anomalous increase in transparency to X-ray beam observed when X-rays satisfying Bragg's law diffract through a perfect crystal. Chandrasekhar and his colleagues discovered a type of liquid crystals known as discotic crystals in 1977. The molecules that made up these crystals were disc-shaped; unlike the well-studied rods. This discovery was published in Pramana an Indian physics journal, and set itself as one of the most highly cited papers in this field. Chandrasekhar's discovery attracted increasing interest from scientists from all over the world and since then thousands of discotic molecules have been synthesised in laboratories worldwide.

After C.V. Raman's deaths in November 1970, the Raman Research Institute was made an autonomous institution under the Department of Science and Technology, Government of India. Sivaramakrishna Chandrasekhar was invited to start a liquid crystal laboratory. Chandrasekhar took up the challenge and in 1971 and left the Physics Department of Mysore University to join Raman Research Institute. The laboratory built by him at the Raman Research Institute became world-class research centre in the area of liquid crystal research.

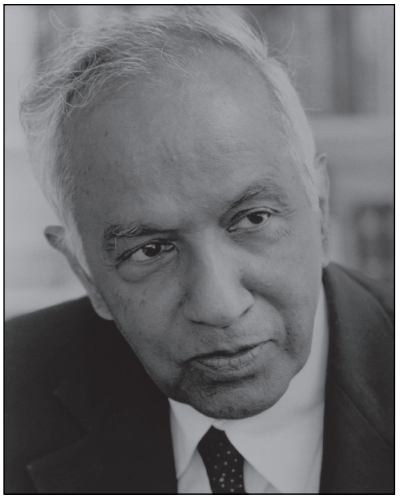
After his retirement from Raman Research Institute in 1990, Chandrasekhar started a Centre for Liquid Crystal Research in Bengaluru. It had a very humble beginning. It started with ad-hoc grants from the Department of Science and Technology, Government of India and a small grant given by the Raman Research Institute Trust. In 1995, it got the support of Planning Commission and it was brought under the administrative control of the then Department of Electronics. It also moved to its present location in Bengaluru with the land and building provided by Bharat Electronics Ltd. (BEL).

Chandrasekhar was a member of International Union of Pure and Applied Physics (IUAP) Commission on Physics for Development and Executive Council of the Association of Asia Pacific Physics Societies. He was the founder President of the International Liquid Crystal Society (1990-1992) and the Indian Liquid Crystal Society; a Fellow of all three science academies in India, an elected Fellow of the Royal Society of London, the Institute of Physics of London, and the Third World Academy of Sciences, Trieste. He also received the Shanti Swarup Bhatnagar Award of the Council of Scientific and Industrial Research (1972), Homi Bhabha (1987) and Meghnad Saha (1992) medals of the Indian National Science Academy, C.V. Raman Centenary Medal of the Indian Association for the Cultivation of Science (1988), and the Freedericksz Medal of the Russian Liquid Crystal Society (1986). He received the Royal Medal of the Royal Society of London in 1994. The only other scientist of Indian origin to receive this award before him was the Nobel Laureate astrophysicist

Subrahmanian Chandrasekhar, who happened to be his first cousin. In 1998, he was awarded the Niels Bohr UNESCO Gold Medal for his contributions on liquid crystals, advancement of science in developing countries and teaching physics. He was a Nehru Visiting Professor, University of Cambridge, UK (1986-1987).

Chandrasekhar was the editor of the Journal, Molecular Crystals, and Liquid Crystals for two decades. He organised several international conferences in Bengaluru including the Ninth International Liquid Crystals Conference in 1982, and the Second Asia Pacific Physics Conference in 1986. Soon after his 60th birthday, a two-day symposium was held in 1991 at the Massachusetts Institute of Technology in the USA to mark the occasion. An international conference was held at the Abdus Salam International Centre for Theoretical Physics in Trieste, Italy, in November 2002 to celebrate the 25th anniversary of Chandrasekhar's seminal paper on discotic liquid crystals. Sivaramakrishna Chandrasekhar died on 8 March 2004 in Bengaluru.

Subodh Mahanti



Subrahmanyan Chandrasekhar

Subrahmanyan Chandrasekhar (19 October 1910 – 21 August 1995) an Indian-born astrophysicist, shared the 1983 Nobel Prize in Physics for his theoretical studies on the structure and evolution of stars. A scientist par excellence, Chandrasekhar was known for his exploits in the field of astrophysics, and living his life as close to science as possible. He discovered the Chandrasekhar limit and showed that there is a maximum mass that can be supported against gravity by the pressure of a degenerate gas of electrons. The value of this limit is about 1.44 times the solar mass. This was derived by Chandrasekhar in 1930, as a student. His hypothesis that was proved almost two decades later put forward a revolutionary idea regarding the evolution of starts. It only argued that white dwarfs are not the only terminal stage of dying stars; they could also become black holes or neutron stars depending on their mass.

Chandrasekhar was born in Lahore (now in Pakistan) on 19 October 1910 to Chandrasekhara Subrahmanya Ayyar, an officer in the Indian Audits and Accounts Services, and Sitalakshmi, a woman of high intellectual attainments (she translated into Tamil, for example, Henrik Ibsen's *A Doll House*). He was the third of six daughters and four sons born to his Tamil Brahmin parents. His father was the elder brother of legendary Sir C.V. Raman, the first Indian scientist to win the Nobel Prize. Home-schooled till the age of 12, Chandrasekhar subsequently attended the Hindu High School in a suburb of Madras (now Chennai) during the 1922-25. Initially, Chandrasekhar was keen to enrol for a degree in mathematics. However, his father wanted him to go for physics as it promised a better employment opportunity. Chandrasekhar responded to his father's wish and joined the BSc course in physics at the Presidency College in Chennai.

A chance meeting with German theoretical physicist Arnold Sommerfeld – who was the Ph.D. supervisor to many Nobel Prize winners including Werner Heisenberg and Wolfgang Pauli – in Chennai was to change the course of young Chandra's life. It is said that Chandrasekhar went to the hotel where Sommerfeld was staying during his Chennai trip, apparently to impress the German teacher about his thorough knowledge of former's book, *Atomic Structure and Spectral Lines*. But what Sommerfeld had for Chandrasekhar was somewhat discouraging. Sommerfeld told him that the entire field of physics had changed since the book was written. Probably sensing that the young student was crestfallen, Sommerfeld asked if he knew anything else too. In response, he indicated he knew a little bit of statistical mechanics. Sommerfeld advised him to concentrate on this field, even though it too was undergoing changes. The German professor also showed him galley proofs of a paper he was then writing on electronic theory of metals but was yet to be published.

Chandrasekhar was quick to grasp the meaning and importance of this new and emerging stream of statistics. Without any advice or assistance from his teachers, he applied it to a problem in astrophysics and used it to develop a new statistical model to show what happens to the aged stars called "white dwarfs" when they run out of nuclear fuel and collapse to about the size of the Earth. The paper Chandrasekhar wrote on this topic was sent to Ralph Fowler, a theoretical physicist at the Cavendish Laboratory in Cambridge and son-in-law of Ernest Rutherford. Fowler and his colleague Nevill Mott suggested some changes after reading the manuscript. Chandrasekhar carried out those changes and subsequently it was published in the *Proceedings of the Royal Society*. The publication by an unassisted undergraduate student who was just 18 then was a great feat, to say the least. Many stalwarts in the field of astrophysics took notice of Chandrasekhar's paper. The paper readily won him a special scholarship which would allow him to do study and research in Britain. So, very next month, after completing his BSc (Hons) in Physics in June 1930, he left for Cambridge, UK, for his graduate studies.

It was while in Cambridge that Chandrasekhar made the celebrated discovery of the 'Chandrasekhar limit' on the mass of a white dwarf. He was just 19 years old then. In those days the white dwarf stage was considered to be the only terminal stage for stars. So the discovery raised many fundamental questions. A prominent one among them was whether there are other terminal stages for stars. While at Cambridge, Chandrasekhar put in years of hard work to prove and establish his 1930 findings. He was finally ready to present his exciting findings at a meeting of the Royal Astronomical Society in January 1935. To his horror, the objection to his findings came mainly from his senior and mentor at Cambridge, Sir Arthur Stanley Eddington, who made it look like Chandrasekhar had gotten it all wrong.

"The manner in which Eddington cavalierly dismissed the whole idea of a limiting mass amounted to public humiliation. Eddington's prestige and authority prevailed, and it took over two decades before the Chandrasekhar limit entered the standard lexicon of astronomy and astrophysics," commented Kameshwar C. Wali, the Distinguished Research Professor at Syracuse University, who wrote his biography *Chandra: A Biography of S. Chandrasekhar*, in an article after Chandrasekhar's death in 1995. When it did, it pioneered the way to the discovery of other terminal stages, namely, neutron stars and black holes.

As we know now, the Chandrasekhar limit played a crucial role in our understanding of stellar evolution. If the star is so massive that the mass of the white dwarf produced by its demise exceeded this limit (that is 1.44 times the solar mass), the star will not become a white dwarf. It would rather continue to collapse under the extreme pressure of gravitational forces, eventually becoming a neutron star or a black hole.

What was remarkable about the controversy, according to Wali, was the manner Chandrasekhar handled the situation. Instead of confronting Eddington and others, Chandrasekhar withdrew himself and focused on another area of research. This is what Chandrasekhar told Wali during one of their conversations decades later: "After all, I was in my middle twenties at that time. I foresaw for myself some thirty to forty years of scientific work, and I simply did not think it was productive to harp constantly on something which was done. It was much better for me to change the field of interest and go into something else. If I were right, then it would be known as right. For myself, I was positive that a fact of such clear significance for the evolution of stars would in time be established or disproved. I didn't see that I had the need to stay there, so I just left it."

Interestingly, this had later become a pattern in Chandrasekhar scientific career. As he said in his Nobel Prize acceptance speech: "After the early preparatory years, my scientific work has followed a certain pattern motivated, principally, by a quest after perspectives. In practise, this quest has consisted in my choosing (after some trials and tribulations) a certain area which appears amenable to cultivation and compatible with my taste, abilities, and temperament. And when after some years of study, I feel that I have accumulated a sufficient body of knowledge and achieved a view of my own, I have the urge to present my point of view, *ab initio*, in a coherent account with order, form, and structure."

There were seven such distinct periods in Chandrasekhar's life. The fields he chose to work on during these periods include areas relating to stellar structure, stellar dynamics, the general theory of relativity and relativistic astrophysics and the mathematical theory of black holes. "In one of his cycles of study on a topic, he could assimilate the fundamentals in a field, assess their importance, build his perspective and express in a comprehensive

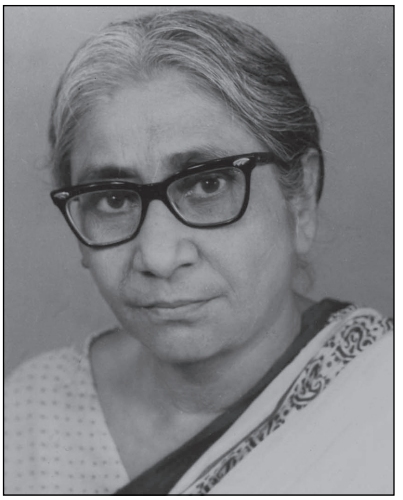
monograph," said scientist-cum-writer William H. Cropper in his 2001 book *Great Physicists: The Life and Times of Leading Physicists from Galileo to Hawking*.

Except for the first six years at Cambridge, Chandrasekhar spent his entire scientific career at the University of Chicago in the USA, where he remained for nearly six decades until his death in 1995. Just before moving to the US in 1936, he married Lalitha Doraiswamy, who was one year junior to him during his undergraduate days at Presidency College in Chennai. Chandrasekhar became naturalised US citizen in 1953.

Even when he was deeply involved in a fruitful research career, Chandrasekhar sustained his interests in other things as well. Like his mother, he too was very much interested in literature. During initial years at Cambridge, he found time between semesters to read translated works by Russian masters such as Fyodor Dostoevsky, Ivan Turgenev, Anton Chekov, and Leo Tolstoy. Among his favourite English writers were Virginia Woolf, T.S. Eliot, Thomas Hardy, John Galsworthy, and Bernard Shaw. He also enjoyed reading the works of Henrik Ibsen, noted playwright and was extremely fond of music – both Indian and Western classical genres.

Chandrasekhar built an unparalleled reputation as a theoretical physicist, mathematician, teacher, and research adviser. He did important work on energy transfer by radiation in stellar atmospheres and convection on the solar surface. He also attempted to develop the mathematical theory of black holes, describing his work in The Mathematical Theory of Black Holes (1983). His other books include An Introduction to the Study of Stellar Structure (1939), Principles of Stellar Dynamics (1942), Radiative Transfer (1950), Hydrodynamic and Hydromagnetic Stability (1961), and Truth and Beauty: Aesthetics and Motivations in Science (1987).

T.V. Jayan



Asima Chatterjee

Asima Chatterjee (23 September 1917 – 23 November 2006) was a pioneer woman scientist of India. She is best known for her significant work in the field of natural products, especially alkaloids, coumarins and terpenoids derived from Indian medicinal and other plants. Her pioneering work on indole alkaloids made a considerable impact on subsequent research in this field in India and abroad. She was the first woman to receive the Doctor of Science (DSc) degree (which she received in 1944 from the Calcutta University) from an Indian University. She is also the first woman on two other counts; occupy a Chair in an Indian university; serve as the General President of the Indian Science Congress (1975). Her research career spanned more than five decades. She published over 350 research papers in Indian and foreign journals and guided over 50 Ph.D. students. Her works are widely quoted, and some elements are embedded in textbooks related to her fields of work. She established a school of natural products chemists in India.

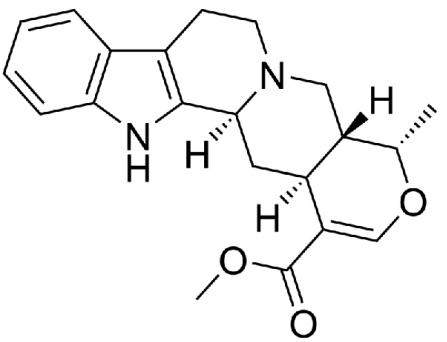
Chatterjee started her research career in 1938 when she initiated her chemical investigations on the indole alkaloids of *Rauwolfiacanescens*. She studied almost all the principal types of indole alkaloids and for instance, helped elucidate the structure and stereochemistry of ajmalicine and sarpagine. In fact, it was Chatterjee who first suggested the correct stereo-configuration of sarpagine.

Some of her most important achievements included the isolation and characterisation of geissosehizine, a key product in the biogenesis of indole alkaloids from *Rhazyastricta;* stereo-specific synthesis of rauwolscine, the major alkaloid of *Rauwolfiacanescens* and studies on the transformation of terpenoids. Her work on coumarins started with the elucidation of the structure of luvanget in isolated from *Luvungascande*ns followed by isolation of

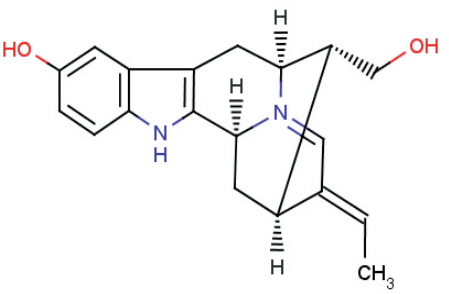
Rauwolfia canescens, *the first medicinal plants to be studied by Chatterjee*

a large number of coumarins bearing interesting substitution patterns from Indian medicinal plants belonging to the families *Rutaceae, Umbelliferae*, *Compositae, Euphorbiaceae*, and *Thymelaeaceae*. She made extensive studies on the action of various Lewis acids on phenylated coumarins and devised simple routes to some complex coumarin systems.

Chatterjee worked on mechanistic organic chemistry; investigated the mechanism of the acid-catalysed hydramine fission of phenyl ethanol and developed a method to detect and locate double bonds in organic compounds using periodic acid (H_5IO_3). This method is a good alternative to ozonolysis. Chatterjee had to establish herself as an accomplished researcher against heavy odds. She had to work like other scientists of those days in the most ill-equipped university laboratories with inadequate chemicals and meager financial assistance. Scholarships for research students were few and barely enough. The Department of Science and Technology (DST) and the Department of Biotechnology (DBT) were not around. The Council of Scientific and Industrial Research (CSIR) was in its formative stage.



Molecular structure of ajmalicine



Molecular structure of sarpagine

Asima Chatterjee was born on 23 September 1917 in Kolkata. After completing her school education, she entered the Scottish Church College of Calcutta University from where she graduated with Honours in Chemistry in 1936. She obtained her MSc degree from Calcutta University in 1938, majoring in organic chemistry and her DSc from Calcutta University in 1944. Her research guide was P.K. Bose, a pioneer in natural products chemistry in India. Her thesis was on the chemistry of plant products and synthetic organic chemistry. Her thesis was examined and highly spoken of by A.R. Todd, a Nobel Laureate in chemistry. She imbibed

her interest in medicinal plants from her father Indra Narayan Mukherjee, a medical man-cum-amateur botanist.

In 1940, Chatterjee joined the Lady Brabourne College as the Founder Head of Chemistry Department. She was appointed Honorary Lecturer, Chemistry, of Calcutta University in 1944.She worked in USA and Switzerland during 1947-1950. In the USA she first worked with L.M. Parks at the University of Wisconsin on naturally occurring glycosides and then with L. Zechmeister at the California Institute of Technology. In Switzerland, she worked with the Nobel Laureate Paul Karrer at the University of Zurich on biologically active alkaloids.

Chatterjee left the Lady Brabourne College in 1954 to join the Department of Chemistry at the University College of Science, Calcutta University. She worked here until the end of her active academic career. She was appointed the Khaira Professor, a position she occupied till 1982. Besides being a Professor of Chemistry, Chatterjee served Calcutta University in many ways. She served as a member of the University Senate and the Syndicate and the Academic Council and Board of Studies in Chemistry. Chatterjee revised the Bharatiya Banashoudhi, a six-volume treatise on Indian medicinal plants, published by the Calcutta University over 1973-1977; a treatise was originally edited by K.P. Biswas. Chatterjee was the Chief Editor of the six-volume Treatise on Medicinal Plants published by the Council of Scientific and Industrial Research, that described seven hundred medicinal plants.

Writing in *Current Science* (10 May 2007), S.C. Pakrashi, a Ph.D. student of Prof. Chatterjee, recalled, "Asima Chatterjee achieved success against heavy odds due to her exemplary indomitable spirit, total commitment, strong will, hard work and an insatiable urge for the pursuit of knowledge. She attended her laboratory even during the last year of her life despite her frail health, an example hard to emulate.

"In the 1950s, it was not easy to carry out research in an ill-equipped university laboratory with meagre funds and hardly any prospect of research as a profession. Still, she could motivate, inspire and instil in her students the sense of commitment, integrity, sincerity, tenacity and all the essentials of a good research worker by her example. As a teacher, she was a hard taskmaster, never satisfied with the performance so far as work was concerned. As a human being, she was kind-hearted and understanding. She would go out of her way to help not only her associates but anybody who would approach her."

Asima Chatterjee helped establish the Regional Research Institute for investigations on Indian medicinal plants for the development of Ayurvedic drugs. The institute was established under the aegis of the Central Council for Research in Ayurveda and Siddha in Salt Lake, Kolkata through a unique Centre-State collaboration. An Ayurvedic Hospital

was also established as part of the Institute for systematic clinical trials. Chatterjee was made the Honorary Principal Coordinator. In this capacity, she nurtured the institute till she breathed her last.

Chatterjee was closely associated with the Indian Science Congress; as its General Secretary and Treasurer and as its General President in 1975. She believed that the Indian Science Congress Association could and should play an effective role to foster scientific thinking. In her Presidential Address to the Indian Science Congress held in New Delhi in 1975, she said: "…scientific way of thinking if properly cultivated, would help secure for the people of the country all the benefits of progress in science and technology. But dissemination of scientific knowledge must not be limited to urban areas. It should also be extended to people in villages in an effective manner. In this field, the Indian Science Congress could play an effective role as well. More widespread and systematic dissemination of scientific information is sure to educate public opinion."

Chatterjee was the recipient of the Nagarjuna Prize and Medal, Premchand Roychand Studentship, Mouat Gold Medal, Sir P.C. Ray Research Scholarship and other university medals and prizes. She was awarded the S.S. Bhatnagar Prize for Chemical Sciences for the year 1961. She acted as Chairperson in the symposium on phyto chemistry held under the joint auspices of UNESCO and Federation of Malaya at Kuala Lumpur (1957), presided over the Natural Products Section of the IUPAC International Congress, Paris (1957), and acted as Co-Chairperson at the IUPAC Symposium, New Delhi (1972). She served as the President of Bangiya Bijnan Parishad. Asima Chatterjee died in Kolkata on 23 November 2006 at the age of 89.

Subodh Mahanti

Sambhu Nath De

Sambhu Nath De (1 February 1915 – 15 April 1985) was a pathologist whose path-breaking research revolutionised our understanding of the killer disease cholera. It was his extraordinary experimental skill and keen observation that helped him successfully elucidate the mechanism of action of the cholera toxin. In less than a decade (1952 – 1959) of investigations he discovered the cholera toxin. This was however after almost three-quarters of a century following Robert Koch's first culture of *Vibrio cholerae* (known as comma bacillus at that time) and 105 years after the epidemiologic studies of John Snow, a British physician describing the water-borne nature of the disease.

Koch was not able to work out the process behind the typical symptoms of the disease – the uncontrolled 'rice-water' diarrhoea. Mistaking the cause for effect, Koch reported that systemic toxinosis (a disease caused by the bacterial toxin alone, not necessarily involving bacterial infection) and multi-organ failure led to severe dehydrating diarrhoea. As a result, while vaccines and drugs were developed for other microbial pathogens, the only measures put forward to prevent the spread of cholera were better sanitation and other public health measures. Sambhu Nath De used a novel technique to produce the symptoms of cholera artificially in rabbit intestine. He was able to demonstrate that cholera was caused by a toxin produced by *Vibrio cholerae* and not the bacteria itself. This finding opened up a dynamic new era of cholera research leading to oral vaccines against the disease. It is De's work that transformed cholera from being a dreaded killer to a disease that could be tamed. His findings were published in the British science journal *Nature* in 1959. Eugene Garfield concluded that De's 1959 paper in *Nature*, "while initially unrecognised, today is considered a milestone in the history of cholera research".

His scientific eminence can be clearly gauged from the comments of his PhD guide Professor Roy Cameron, Head of the Department of Morbid Anatomy in the teaching

hospital of University College, London. Cameron, one of the world's leading pathologists, said: "There is no doubt about it – he is one of the most outstanding of young men I have had through my hands and am prepared to believe that he is probably the best of the experimental pathologists in India… I am confirmed in my belief by other people's opinion."

Sambhu Nath De had humble beginnings. He was born on 1 February 1915 in a small village, called Garibati, on the west bank of river Hooghly, about 40 km north of Calcutta (now Kolkata). After his initial schooling at the local high school, followed by a stint in the Hooghly Mohsin College, De received a scholarship in his inter-science examination and was admitted to the Calcutta Medical College. Here, in 1942, he also took up the job of a demonstrator in pathology and while working under Prof. B.P. Trivedi and published a few papers jointly with him. In 1947, Sambhu Nath went to England and joined the University College Hospital Medical School in London to work under Prof. G.R. Cameron, FRS (later Sir Roy Cameron) as a PhD student. He was awarded the PhD degree from the London University in 1949.

De returned to Calcutta soon after and joined the Calcutta Medical College, before taking up the Chair of Pathology at the Nilratan Sircar Medical College. High-calibre research in the UK had transformed him, and he became truly and completely focussed on his research work on the pathogenesis of cholera. At the Nilratan Sircar Medical College, Sambhu Nath began studying the damaging effects of cholera on kidneys. The Medical College provided him easy access to numerous cholera cases admitted to the attached hospital for treatment. He published several research papers on this topic between 1950 and 1955.

De had his moments of frustration, though. He could not purify the toxin or stabilise his collection of the strain. He wrote about this frustration to W.E. van Heyningen, who too worked on bacterial toxins that "workers in developed countries cannot imagine how difficult it is to carry out and continue research work without willing personnel and without equipment in an undergraduate teaching department in a country like ours". However, these challenges did not deter his progress.

His novel technique for discovering cholera enterotoxin with the rabbit ileal loop has been widely recognised. (Ileal loop involves use of a segment of the ileum (part of the small intestine) for the diversion of urinary flow from the ureters. Ileal loop urinary diversion creates an opening on the abdominal wall that drains urine into a bag.) John P. Craig, a Professor at the State University of New York Health Center, New York, USA says about De's model: "Many of us who have worked in this area took for granted the discovery of this seemingly simple model system. But, looking back, it seems the world needed

the fertile mind of an investigator whose natural scientific instincts forced him to shun the conventional approaches...No matter how simple it may seem, his truly creative and novel piece of work started a chain of events which, in turn, forever altered our concepts surrounding the pathogenesis of secretory diarrhoea."

De and his co-workers also carried out extensive studies on diarrhoea produced by the common gut bacteria *Escherichia coli*, especially in infants. Using the rabbit loop experiment they were able to show that in both cholera and *E. coli* diarrhoea, the symptoms were produced by similar mechanisms.

Sambhu Nath De did not enjoy large gatherings, seminars and conferences. He maintained a distance from centres of power. No wonder, De retired from Calcutta Medical College in 1973, almost unknown despite his path-breaking contribution in cholera research. He did not receive any recognition; either a fellowship of an Academy, awards or honours. The Coates Medal awarded by Calcutta University in 1956 for outstanding research was the only one he secured. Prof. Padmanabhan Balaram of the Indian Institute of Science, Bengaluru pointed out in an editorial in *Current Science*, "De died in 1985, unhonoured and unsung in India's scientific circles. That De received no major award in India during his lifetime and our Academies did not see it fit to elect him to their Fellowships must rank as one of the most glaring omissions of our time."

De retired in 1973 from the Calcutta Medical College at the age of 58 and showed no interest in higher positions. A sort of recognition came in 1978 when he was invited to the 43rd Nobel Symposium on Cholera and Related Diarrhoeas held in Stockholm. At the end of his presentation to the Nobel Symposium, S.N. De said: "Chairman and Friends, before I conclude I wish to make a few personal remarks. I have been dead since the early 1960s, I have been exhumed by the Nobel Symposium Committee and these two days with you make me feel that I am coming to life again."

De died in Calcutta on 15 April 1985. Paying tribute to him in a commemorative issue of *Current Science*, Nobel laureate Joshua Lederberg wrote, "Our appreciation for De must extend beyond the humanitarian consequences of his discovery….he is also an exemplar and inspiration for a boldness of challenge to the established wisdom, a style of thought that should be more aggressively taught by example as well as precept." There can be no better tribute for De, a modest scientist who spent his life grappling with a problem that had been tormenting humanity for long. He died largely unsung and did not receive his due honours.

Hasan Jawaid Khan

Nil Ratan Dhar

Nil Ratan Dhar (2 January 1892 – 5 December 1986) pioneered the field of physicochemical research in India. He was a chemist par excellence about whom Acharya P.C. Ray once said, "*I look upon it as a manifestation of Divine Grace that ... a Nilratan Dhar has at last been produced in the soil of Bengal*." Nil Ratan Dhar was born in Jessore (now in Bangladesh)on 2 January 1892. He was admitted to the Government Zilla School, Jessore in 1897 and studied English, Sanskrit, Bangla, Mathematics, History, and Geography. In 1907, he passed the entrance examination with distinction and was awarded a Merit Divisional Scholarship of Rs.15 per month for two years. He then joined the Ripon College, which had then introduced the ISc course and studied physics, chemistry, mathematics and English. His excellent results earned him a Government scholarship of Rs. 20 per month.

Ripon College was instrumental in setting Nil Ratan's feet firmly on the path of science. He was allowed to set up a small laboratory for experimental work at Ripon College. It was here; he came across the popular science writings of Ramendrasunder Trivedi, the Principal of Ripon College. He also attended the lectures delivered by Chuni Lal Bose, a chemical engineer and A.N. Palit, Professor of Physics, Metropolitan College at the Indian Association for the Cultivation of Science; a scientific organisation established by Mahendra Lal Sircar in 1876.

Nil Ratan Dhar received his BSc degree in chemistry (1911) from Presidency College. His academic excellence was evident: he was ranked First in Calcutta University and awarded a Gold Medal plus a scholarship of Rs.32 per month. His MSc (1913) results were spectacular. He stood first in chemistry and topped the list of all students across MA and MSc examinations that year under the University of Calcutta. He was showered with

medals – 20 gold medals from the Calcutta University and one from the Asiatic Society of Bengal. His feat also earned him the Griffith Memorial Prize of Rs.900 and the Merit Scholarship of Rs.100 per month of the University of Calcutta. Acharya Prafulla Chandra Ray, one of his teachers, recognised his capabilities and encouraged him to take up research on nitrate chemistry. Together they studied the physical evidence of the structure of mercury nitrite.

Subsequently, Nil Ratan Dhar took up research in the field of physical chemistry. He determined the mobility of ions at zero degree Celsius temperature working with DN Bhattacharya. He also determined the transport number of nitrite ions in a solution of silver nitrite. Along with A.K. Dutta, he determined the second dissociation constant of dibasic acids. The results were published in prominent science journals in Germany. From 1912 he began a steady and copious stream of research publications; over 150 on varied topics in physical and electrochemistry.

In 1915, the Government of India granted him a scholarship meant only for the exceptionally brilliant students to enable them to pursue higher studies in Europe. Specializing in soil science, Nil Ratan Dhar took his DSc (1917) from University of London and the degree of State Doctor of Science from France two years later. He was appointed to the Indian Education Service while he was still in London. He returned to join the Muir Central College, Allahabad University. When the chemical laboratories of Muir College formed the nucleus of University Department of Chemistry, he became the first University Professor. Here, he devoted himself to work on photochemistry, colloidal chemistry, and biochemistry. Dhar examined the influence of light on nitrogen fixation and nitrogen loss. He further looked at the relationship between nitrogen and phosphate in soils and the low recovery of nitrogen from fertilisers. The Royal College of Agriculture, Uppsala, Sweden, verified his theory of nitrogen fixation.

Few know that Nil Ratan Dhar's interests on the biochemistry of nutrition. He wrote a book titled *New Conception in Biochemistry* dealing with chemical aspects of biochemistry pertaining to metabolism. Dhar and his associates carried out experiments to uncover the causes of certain diseases. They opined that exaggerated oxidation of one of the three classes of food materials in preference to the others might be triggering the metabolic problems. After his retirement from the department, Dhar devoted himself to the Shila Dhar Institute of Soil Science, found in his wife's name, thanks to his generous donation to Allahabad University. Dhar wrote more than 450 original research papers, books, and monographs. He also wrote some popular books in Bengali. His autobiography, *Reflections on Chemical Education* makes interesting reading.

Looking back, it is clear that exhilarating developments were taking place in India in the 1920s. Physical science as a subject of study had emerged in the West in the 1910s

and within just a decade, colonial India had caught up with the rest of the world in this field; thanks to stalwarts such as Nil Ratan Dhar. The Indian School of Chemistry headed by Acharya P.C. Ray, (also known as the father of Indian Chemistry) was approaching its peak in the 1920s. A galaxy of bright students congregated around the Acharya and then fanned across India to serve different Universities. This included Nil Ratan Dhar, Jnan Chandra Ghosh (Director of IISc Bengaluru and the founding Director of IIT Kharagpur), Panchanan Niyogi (founding Principal of the Raja Manindra Chandra College in Calcutta), Priyada Ranjan Ray (famous researcher and Professor of Chemistry, Calcutta University), and Biresh Chandra Guha (pioneer of research in biochemistry in India).

While Nil Ratan Dhar benefited from the grace of having great gurus and peers, he too was no less when it was his turn to inspire the next generation. He remained a great mentor even in his old age. His experienced eyes could spot talent in the most unassuming of students. Dr. Atma Ram, who went on to be the Founding Director of CSIR's Central Glass and Ceramic Research Institute, Calcutta and the fourth Director General of the Council of Scientific and Industrial Research, was one such student he spotted and facilitated admission, albeit late. Among the juniors in his peer group of the period were such luminaries as Meghnad Saha, J.N. Mukerji, Shanti Swarup Bhatnagar, and Pulin Bihari Sarkar.

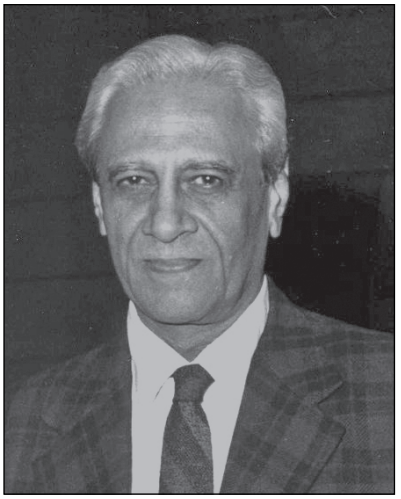
He was committed to science and once said, "*…I sincerely believe that sound progress of our nation depends essentially on science and its applications, and I have preached this gospel for over 40 years, I am extremely keen on seeing Indian scientists taking up this matter of national regeneration through science with hard labour, great fortitude, devotion, and sacrifice.*" He believed scientists would willingly sacrifice for the uplift of the society. "*I am convinced that this ancient land of Gautam Buddha, Asoka, Vivekananda, Rabindranath, and Gandhiji cannot fail to produce sacrificing and devoted men of science for the uplift of the starving millions.*"

Narrating the unique qualities of his teacher, Dr. Shiv Gopal Mishra, a student of Nil Ratan Dhar, says, "Dr. Dhar would reach in our class in Allahabad University before time and start his lecture. The students reaching late were rebuffed. He had gravity in his voice. He was indeed an ideal teacher and very popular amongst the students. He would continue explaining a principle till it did not completely imbibe by the students.

"Dr. Dhar had a life-long practice of morning walk. He wore a very simple dress and used to teach his student also to lead a simple life. He would eat one chapatti less in his meals and never slept during the day and used to advise us, his students, also to do the same."

In every aspect of his life, he walked the talk. Like his guru, Acharya Prafulla Chandra Ray, Nil Ratan Dhar too donated most of his earnings to further the cause of science. He never protected his intellectual property with patents. According to one estimate, he donated about Rs. 27 lakh to facilitate the study of science and to charity. He gifted land that houses the National Academy of Sciences (Allahabad). His generous donation created a Professorship in Agricultural Chemistry and Soil Science at the University of Calcutta in 1945. This Chair was created to commemorate the legacy of Acharya P.C. Ray. He also endowed Visva-Bharati, an institution established by Rabindranath Tagore for fellowships in soil science. He donated Rs.1 lakh to the Chittaranjan Seva Sadan to help build the nurses' quarters. He gave up his Barlowganj (Mussourie) House to the Ram Krishna Mission Ashram. Nil Ratan Dhar was Fellow of the Chemical Society (London) and Royal Institute of Chemistry; Corresponding Member of the Academy of Sciences, France; Foreign Member, French Academy of Agriculture and Founder Member of the National Academy of Sciences (India); Indian Chemical Society, the Society of Biological Chemist (India), Agricultural Society of India and the Indian Society of Soil Sciences (President).

Sukanya Datta



Satish Dhawan

Satish Dhawan (25 September 1920 – 3 January 2002) was an extraordinary scientist with a deep sense of social commitment who shaped India's space programme by translating Vikram Sarabhai's dreams into reality. It can be said without any doubt that his role in shaping the country's space programme made him one of the most influential personalities in post-independence India. However, his involvement in the development of science and technology went much beyond the confines of India's space programme. He was the longest serving Director (1962-1981) of the Indian Institute of Science (IISc), Bangalore (now Bengaluru), the Chairman of the Indian Space Research Organisation (1972-1995) and Chairman of the Indian Space Commission (1972-2002). Dhawan's pioneering research on 'shock reflection' and 'shock boundary interaction' significantly influenced later investigations in the field. He invented an ingenious method of directly measuring friction drag on a surface.

Dhawan carried out high-value pioneering experiments in rural education, remote sensing, and satellite communications. These helped develop such operational systems as the Indian National Satellite System (INSAT). This included a series of multi-purpose geostationary satellites launched by ISRO for telecommunication, broadcasts, meteorology and search and rescue operations. Others included the Indian Remote Sensing Satellites (IRS) and Polar Satellite Launch Vehicles (PSLV). Dhawan took great pains to connect with multiple users and established the Indian space programme at the core of India's development. He advocated the need for accurate weather prediction and is regarded as India's first champion of numerical weather forecasts.

Dhawan was an inspiring leader. He readily took responsibility for failures of people working under him and allowed them to take the credit for successes. It was not that

he was not disappointed at failures. He did not exhibit or reveal his disappointment to others. He would analyse the causes for failure to great depths only to make sure they are not repeated. He placed the institution on a higher pedestal than the individual and strived for collective decision-making structures. His most important contribution was as a teacher, and this role was not confined to his classrooms. He was widely regarded as the conscience of the scientific community. As Roddam Narasimha, an eminent scientist and one of his most successful students wrote: "He (Dhawan) was, most of all, the undeclared but widely accepted moral and social conscience of the scientific community." He was an original thinker and a deeply compassionate human being. He avoided publicity.

Satish Dhawan's father was a civil servant in undivided India. He retired as Resettlement Commissioner of the Government of India. Dhawan obtained his BA degree in mathematics and physics and MA in English literature – a rare combination – from Punjab University, Lahore. At the University of Minnesota, Minneapolis, USA, he secured a Bachelor of Engineering degree in mechanical engineering in 1945. In 1947, he obtained a Master of Science in aerospace engineering from the California Institute of Technology (Caltech); followed by a double Ph.D. in mathematics and aerospace engineering. This was under the supervision of Hans W. Liepmann, an engineer known for his numerous contributions in fluid mechanics. In 1951, Dhawan joined the Department of Aeronautical Engineering of the Indian Institute of Science, Bengaluru. His initial appointment was as Senior Scientific Officer. However within four years he rose as Professor and Head of the Department and in 1962, at the age of 42, he became the youngest Director of the Institute. He transformed the Institute and brought in young faculty from within and outside India. He launched new departments and encouraged them to work in newer areas including atmospheric sciences.

On the sudden demise of Vikram Sarabhai in December 1971, Smt. Indira Gandhi, the then Prime Minister of India, invited Dhawan to take over the reins of India's space programme. He was then teaching at the Caltech. He conveyed to the Indian Embassy official who met him with the invitation that he would not be able to return to India without completing the course. Importantly he would also have to consult his employer the IISc about the way ahead. On his return to

Indian Institute of Science, Bengaluru

India, he was informed by R. Choski, Chairman of IISc Council and JRD Tata - President of the Institute that the IISc had no objection to his taking up the assignment offered by the Prime Minister.

Dhawan met Smt. Indira Gandhi and expressed his willingness to take up the assignment; with two conditions. He wished to be allowed to continue as Director of IISc, and that the headquarters of Indian Space Programme should be located in Bengaluru. The Prime Minister accepted both the conditions and Dhawan took charge of India's space programme in September 1972. He became the Chairman of the Space Commission, Secretary of the Department of Space and Chairman of ISRO. K. Kasturirangan, former Chairman and a close associate of Dhawan pointed out that Dhawan selected Bengaluru as the headquarters of India's space programme for strategic reasons that the city could accelerate satellite building activities, using such institutions as the National Aeronautical Laboratories (now called National Aerospace Laboratories) and industries as the Hindustan Aeronautics and Bharat Electronics. These were in addition to the city's salubrious climate that facilitated fabrication of satellite systems.

Dhawan saw to it that he was not all by himself in charge of major projects. He, however, chaired the Aryabhata Project Management Board and ensured that work and responsibilities are properly delegated. Former President of India Late Dr. APJ Abdul Kalam wrote: "I learned an important lesson from Prof. Dhawan when I was appointed Project Director SLV-3 in 1972 to design, develop and launch the first satellite launch vehicle to inject Rohini into a near-Earth orbit. This was that when a Project Director is appointed, the whole organisation–including the Chairman ISRO–works for his success. It is the lesson that has been of abiding value all through the other projects I have worked on." Even after taking charge of ISRO, Dhawan continued with research in his laboratory and interacted with fellow scientists. Roddam Narasimha wrote: "While doing all the high technology and big science at ISRO, he (Dhawan) never forgot how crucially important 'little' science was, and ceaselessly promoted it, especially with young people. Indeed, he indulged in it himself whenever he could; the only book he wrote (to my mind) is a little gem on bird flight, which grew out of a lecture he gave first at the Academy, and then at many other places across the country (especially, by his insistence, at those off the beaten track, like Jammu and Guwahati). I still remember how he took a busy break from running his space empire to work on the Academy lecture, drawing his diagrams and doing his sums."

Dhawan had a deep sense of social commitment; emphasizing the need to go beyond mere economic benefits accruing from science and technology. His comments on ISRO's effort in identifying 13 types of wasteland in the country, as pointed out by Dr. Kasturirangan, are worth quoting. When Kasturirangan showed him the maps prepared

for reclaiming the lands for agricultural and other uses, Dhawan said: "…this is all very good, and these maps are very useful to develop this country. But do you know that wastelands in our country are not a waste? There are tribals and others who depend on the produce of these so-called wastelands. If you start water recharging and improve the vegetative cover, the whole place may look very promising to prospective developers. Then these tribals will be disturbed, and there will be no system to protect them." He looked at integrated benefits that serve the common person. This was the belief that the main objective of science and technology should serve the country and its people.

Dhawan's fascination for Nature was remarkable. Natural phenomena around him always made him curious. Like a true scientist and in the tradition of many great scientists, he had an inner urge to unravel the mysteries of Nature. He was fascinated with birds and their flight. He once wrote: "Whenever my work related to the country's space programme became a little taxing, I went to see the birds of SHAR–and came back feeling happy and invigorated." He was not simply contented by observing birds' flight. His consistent and painstaking observations evolved into a serious research problem that led to outstanding contributions in the field of aeronautics.

Writing in *Current Science* (25 January 2002), Amulya K.N. Reddy, a colleague of Satish Dhawan, recollected, "His genuine concern for people led him to be an unwavering friend of the poor, the underprivileged and the deprived. No wonder, he sympathized with movements such as the Narmada Bachao Andolan that championed the downtrodden. He took special care to protect the interest of tribals when the Sriharikota Launch Facility was established. He wanted science and technology to benefit the poor. And since the poor never benefit from war, he stood for the peaceful application of science and technology. He steadfastly guided the space programme along peaceful lines."

The launch centre of the Indian Space Research Organisation in Sriharikota has been named as Satish Dhawan Space Centre in his honour. Today it is one of the best-known names among the Spaceports of the world.

Subodh Mahanti

Jnan Chandra Ghosh

Jnan Chandra Ghosh (4 September 1893 –21 January 1959) was a pioneer of physical chemistry in India. He is best known for his research on the theory of strong electrolytes. His theory, which was designed to account for the abnormality of strong electrolytes, was proposed in 1918. His work led to the universal acceptance of the hypothesis of complete dissociation of strong electrolytes. This work brought appreciation from all across the world. This included a commendation from such scientists as Walther Hermann Nernst, Max Planck, William Lawrence Bragg, and Gilbert Newton Lewis. Nernst cited this in his famous book Theoretical Chemistry. Ghosh's work was written about in Lewis and Randall's book, Thermodynamics. Peter Debye and Enrich Huckel developed a suitable theory of strong electrolytes only on incorporating Ghosh's observations. Debye's concept of ion atmosphere is essentially an extension of the postulates of Ghosh. The other areas in which he made significant contributions were kinetics, fluorescence, catalysis, auto-oxidation, and other allied branches.

Ghosh is regarded as the architect of technical education in India. He was the founder of director of the Indian Institute of Technology Kharagpur, the first institute of its kind to be established in the country. He played a major role in developing the country's industrial base. He was a great institution builder.

Jnan Chandra Ghosh was born in Purulia, West Bengal (then in undivided Bengal). His father Ram Chandra Ghosh owned a mica mine. However, the family suffered difficult times because of heavy financial losses in this endeavor. Jan Chandra studied at the Giridih High School. He received a Divisional Scholarship (Chotanagpur) and on passing the Entrance Examination, he joined Presidency College, Kolkata (then Calcutta). In 1911, he passed ISc examination of Calcutta University. He passed the BSc (1913) and

MSc (1915) examinations of Calcutta University from Presidency College. He stood first in both the examinations and won some medals. At Presidency College he was greatly influenced by his illustrious teacher Acharya Prafulla Chandra Ray.

In 1917, Ghosh was appointed a lecturer in chemistry at the University College of Science of Calcutta University. He was awarded the DSc degree of Calcutta University for his work on the theory of strong electrolytes. In 1919, he was awarded the Sir Tarak Nath Palit Scholarship. This Scholarship took him to work under the supervision of F.G. Donnan in the University College of Science, London. He also met Nernst and Fritz Haber in Germany. Both of whom evinced keen interest in his work. On his return to India from England in 1921, he joined the newly established Dacca University at Dhaka (then Dacca), now in Bangladesh, as Professor and Head of the Department of Chemistry. In joining the newly established University, he was persuaded by its Vice Chancellor-designate Sir Philip Joseph Hartog. His contribution to the development of the newly established university was very significant. At Dhaka, Ghosh established a robust school devoted to photochemistry and the study of gas reactions. These studies attracted research students from all across India.

In 1939, Ghosh joined the Indian Institute of Science, Bengaluru as its Director following Dr C.V. Raman. He introduced aeronautical engineering, internal combustion engineering, fermentation technology and high-pressure technology. In spite of heavy administrative responsibilities, Ghosh actively pursued his research activities. He switched to fields of research pertaining to problems faced by the industry. Ghosh and his group pioneered investigations on the Fischer-Tropsch synthesis for obtaining liquid fuel from carbon monoxide and hydrogen and step-wise mechanism of ammonia synthesis from its elements, nitrogen, and hydrogen.

In 1947, Ghosh was appointed as Director General, Industries, and Supplies, Government of India and so he moved from Bengaluru to New Delhi. One of his tasks was to process several industrial schemes in collaboration with European and American experts. Under the leadership of Ghosh, several industrial schemes were formulated. These laid the basis for petroleum, petroleum-refining, machine tool, cable, wireless equipment, and radar industries in the country. He served as a member of the All India Council of Technical Education and as the President of the Principals of Technical Institutions in India and helped in the organisation of training programmes in these institutions.

He took note of the paucity of trained personnel for taking up large-scale industrial development projects in the country. This realization led Ghosh to create technological institutions in India. Ghosh himself became the founder Director of the Indian Institute

of Technology Kharagpur, the first institute of its kind in the country. The Institute was inaugurated in August 1951 wherein Ghosh established most of its departments.

In 1954, Ghosh left Kharagpur to become the Vice Chancellor of Calcutta University. He was not very willing to leave Kharagpur, but he was persuaded by Bidhan Chandra Roy, the then Chief Minister of West Bengal and an eminent physician. Ghosh did not stay long in this post as he was made a member of the Planning Commission in 1955. However, during his short tenure as Vice Chancellor, he undertook a very painstaking survey of the living conditions and educational facilities of students and colleges and the university. He initiated the establishment of "Day Students' Homes" for providing facilities for study, rest, and recreation to a large number of floating students when they had no classes.

Ghosh joined the Planning Commission in 1955 at the invitation of Pandit Jawaharlal Nehru. In Planning Commission, he was in charge of Education, Scientific Research, and Health. He persuaded the Government of India to grant a crore of rupees to the universities of Mumbai, Kolkata, and Chennai to help projects during their centenary celebrations. He made it possible to allocate large amounts of money for medical research and organizing medical relief in rural areas.

Ghosh believed it was essential to be conscious of social justice and that development of science and technology by itself cannot advance the goals of civilisation. In his Presidential address to the Indian Science Congress in 1939 at Lahore, he said: "Every intelligent man and woman have got to ponder deeply over the problem that scientific research for truth has not assured the advance of civilisation. Inventions intended to relieve toil, and to control the forces of nature which should have given to all a fuller and more satisfying life, have been perverted into forging instruments of destruction. The paradox of poverty amidst plenty mocks us in the face. In one part of the world wheat and cotton is being burnt and milk thrown into streams, while in another part half-naked people are starving. It is not difficult to get at the root of this evil…The chaos of modern world is calling out to every man of good will and understanding to join in a great educative effort, with a view to removing those narrow prejudices which are chocking the paths of progress. These prejudices did not matter much in olden days, when communications were difficult–in fact they were born because of such inaccessibility. But today when increasing rapidity of communications is causing the world shrink with a disconcerting rapidity, these prejudices spell disaster for mankind."

Ghosh with J.N. Mukherjee and S.S. Bhatnagar was largely responsible for establishing the Indian Chemical Society. The first President of the Society was Prafulla Chandra Ray. Ghosh also served as its President. He was the President of the National Institute of Sciences of India (later renamed as Indian National Science Academy and its headquarters

shifted to New Delhi) in Kolkata. He was also the President of the Indian Association for the Cultivation of Science (1951-55). He was the General President of 26thSession of the Indian Science Congress in Lahore (now in Pakistan).

J.N. Mukherjee, a fellow-student of J.C. Ghosh in Presidency College, Kolkata, writes in his memoir, "During his student life in the Presidency College he had friendly association with many fellow-students of whom mention should be made of such distinguished names in science as S.N. Bose, M.N. Saha, N.R. Sen, P. Parija and P.B. Sarker. I was also his fellow-student in the Presidency College. Five members of this batch of students later became General Presidents of the Indian Science Congress Association; Bose, Saha, Ghosh, Mukherjee, and Parija.

"Apart from initiation and development of research in India in the subjects mentioned earlier, his main contribution to the progress of science and technology is that he stimulated and provided opportunities to a team of brilliant young scientists to develop their talents. They now occupy positions of importance in several universities and other important research establishments as also in some industries."

He was a member of Indian Scientific Mission to England (1944-45). He attended the Royal Society Empire Scientific Conference (Great Britain) in 1946 as an Indian delegate. He represented India at the 4th General Assembly of the UNESCO held in Paris in 1946 and at the United Nations Conference on the Conservation and Utilisation of Resources held at Lake Success, New York in 1949, which was sponsored by the US President Harry Truman. At the time of his death in 1959, he was still a member of the Indian Planning Commission.

Subodh Mahanti

Biresh Chandra Guha

Biresh Chandra Guha (8 June 1904 – 20 March 1962) was active in India's struggle for freedom even as he was engaged in pioneering work on the biochemistry of vitamin C, ascorbic acid biosynthesis the B-vitamins, food and nutrition. He established biochemistry as a separate discipline in India and gave rise to the Central Food Technological Research Institute (CFTRI) of the Council of Scientific and Industrial Research (CSIR), Mysore.

B.C. Guha is often remembered as the 'stormy petrel of science'. He was a public speaker; known for his boldness and leadership qualities. His aggression and yearning to break shackles and obtain freedom for his country was profound and was accordingly at the age of 11 inducted into the revolutionary Jugantar Party. Later in life, he would have landed behind prison bars if not for his wife's counsel. Guha could recite freely passages from the works of Kalidas, Tagore, and Shakespeare. He entered the world of science not because he loved science – he was more inclined towards the arts. His brothers, both professors in English, prevailed upon him to take up science. Born on 8 June 1904, Guha was the youngest child born into the Guha Thakurtha family of Banaripara, in the district Barisal (now in Bangladesh).

Guha took up science courses in the City College, Calcutta (now Kolkata). Since botany was not taught at City College, he studied botany in the evening at the Indian Association for the Cultivation of Science. After passing the ISc examination in 1921, standing second in order of merit, he took admission to the BSc course with Chemistry Honours in the Presidency College. However, soon the young and passionate Guha was drawn into the Swadeshi movement. He was imprisoned for attending a banned political party meeting and subsequently asked to quit Presidency College. Guha had to secure admission in St Xavier's College then, to complete his graduation with flying colours.

His passion for science grew due to his close association with Acharya Prafulla Chandra Ray while studying MSc at Calcutta University. Acharya Ray's devotion to science, selfless idealism and patriotism left a great mark on Guha. No wonder he became one of the favourite students of P.C. Ray. B.C. Guha spent five years in England pioneering biochemical investigations with particular reference to B-vitamins. This was in the laboratories of Prof. Jack Drummond at the University College, London and Prof. Gowland Hopkins, a Nobel Laureate, at the Biochemical Laboratory, Cambridge University. Another Nobel laureate that Guha worked with was Szent-Györgyi, who won the Nobel Prize in 1937 for his discoveries concerning biological oxidation processes with reference to vitamin C. With his expertise in bioassay, Guha helped Szent-Györgyi understand the nature of the antiscorbutic property of hexuronic acid.

Returning to India in 1932 with Ph.D. and DSc degrees, Guha joined the Bengal Chemical and Pharmaceutical Works and initiated many lines of work on preparation of vitamin concentrates and other biologically active compounds. In 1936, he was appointed Professor of Applied Chemistry at the University College of Science, Calcutta, and got the opportunity to work on several aspects of carbohydrate metabolism, particularly on the biosynthesis of ascorbic acid for which he is most well known. The significance of Guha's work on ascorbic acid biosynthesis lies in its evolutionary implications. Guha's work showed the importance of biochemistry as the connecting link between molecular genetics and species evolution.

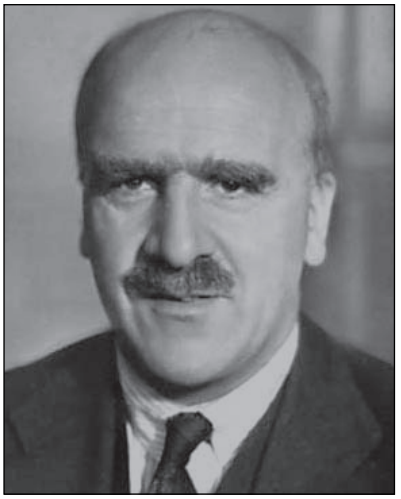
The next major change in his life came during the Bengal famine of 1943. The wanton suffering of millions of people shook him up completely. He became one of the most uncompromising advocates of science for rapid implementation of policies. He was deeply moved by the calamity and applied all his knowledge of biochemistry and food technology to prepare cheap protein foods and digests for the treatment of extreme cases of starvation and emaciation. He prepared vegetable milk for infants, and for adults, he prepared protein substitutes. Since there was an acute shortage of animal proteins he became a strong advocate of leaf proteins, even developing some processes for the preparation of edible proteins from grasses and weeds such as water hyacinth that was considered otherwise useless.

In 1944 he joined the Ministry of Food, Government of India as the Chief Technical Adviser, and initiated plans for nutrition surveys for the whole country. He also organised a Technical Wing for inspection, analysis and standardisation of foods. It was in the Food Department that he got the idea for a Food Technological Research Institute. Subsequently, when CSIR decided to establish such an Institute at Mysore, Dr. S.S. Bhatnagar asked Guha to serve in its Executive Council for many sessions during its formative stages.

Having spent much of his youth and even a part of his middle ages focusing on his passion for science and his yearning to serve fellow citizens, Biresh Chandra Guha married in 1944 at the rather late age of 41. Dr. Phul Renu Guha, a talented lady who later became a Member of Parliament, was a Ph.D. in languages from a French university. Guha was deputed to serve the UNESCO in Paris as India's representative and counsellor in Agricultural Sciences. Later he also joined the Damodar Valley Corporation as a member from West Bengal. However, the routine work, the general apathy and administrative delays were not to his liking. After almost ten years of administration related assignments, Guha once again came closer to his roots when he returned to University Professorship in 1953. He vigorously championed the cause of biochemistry in India pushing the University Grants Commission to form a Biochemistry Review Committee. As a member of the Committee, he visited all university laboratories where biochemical research was in progress. There were very few biochemistry departments in the country. It was due to his efforts and the recommendations of the Committee that the Departments of Biochemistry at Calcutta, Lucknow and Nagpur Universities were upgraded. He had led the delegation of Indian biochemists to the International Congress of Biochemistry held successively at Cambridge, Paris, Brussels, Vienna, and Moscow. Guha had an idea of holding a Summer School in Biochemistry at Srinagar. He had gone to Lucknow to discuss the modalities with scientists of the Central Drug Research Institute. But destiny had planned otherwise. He died abruptly on 20 March 1962, in Lucknow, at only 58 years of age.

B. Mukherji, a colleague of B.C. Guha, writes about his wide-ranging interests in his memoir: "Guha's interests were broad and ranged far beyond the sciences. He was deeply read in 'Sanskrit', 'Bengali' and 'English' literature and could recite freely passages from Kalidasa, Tagore or Shakespeare. Guha's unusual combination of gifts included an ability to deliver a good lecture and write in a clear and attractive style."

Hasan Jawaid Khan

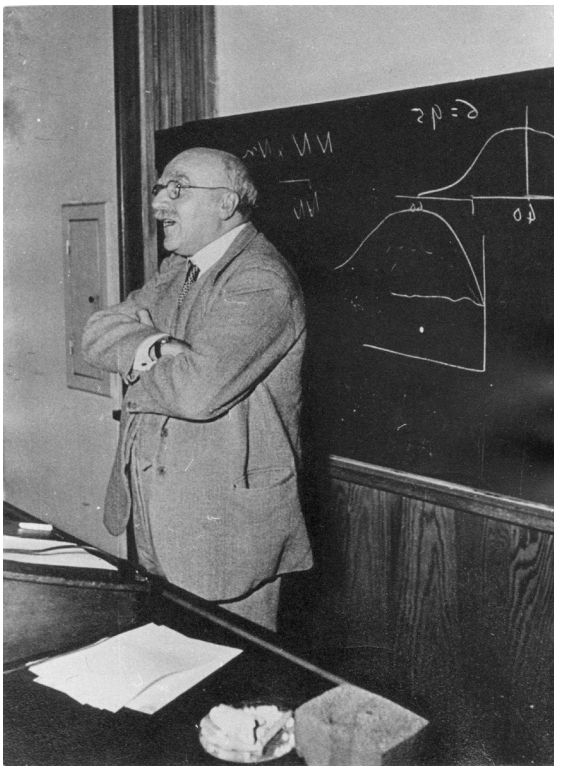


J.B.S. Haldane

John Burdon Sanderson Haldane, is commonly known as JBS Haldane and is amongst the greatest scientists of the 20th century. He is best-known for his contributions to the mathematical theory of evolution and as one of the three major founders of population genetics. The other two were Ronald Fisher and Sewell Wright. They forged a new synthesis between Mendelian genetics and Darwinian evolution, the concept more popularly known as Neo-Darwinism.

Haldane was outstanding at science popularization. He presented abstract concepts of science in a simple way without distorting their meaning. His popular science articles, lectures and broadcasts made him one of the best-known scientists in the world. He considered it an important duty of a scientist to render science intelligible to ordinary people. He believed that non-scientific audience has a right to know what goes on inside the laboratories for some of which it pays.

In 1957, Haldane migrated to India. His decision to move to India was also influenced by the fact he had better prospects for doing research in genetics and biometry in India. On moving to India he joined the Indian Statistical Institute (ISI) at Kolkata as Research Professor at the invitation of its founder, P.C. Mahalanobis. At ISI he gave great impetus to theoretical and applied research by initiating several research projects on quantitative biology. Haldane with Mahalanobis formulated academic programmes for Bachelor of Statistics (Honours) course at ISI. However, his association with ISI did not last long. He resigned from the Institute in 1961 and set up a research unit at his residence with the financial assistance from the Council of Scientific and Industrial Research (CSIR) and co-operation extended by several colleagues. In 1962, he moved to Bhubaneswar to set up a Genetics and Biometry Laboratory.



J.B.S. Haldane

He was elected a Fellow of the Royal Society of London in 1932 and President of the Genetics Society, London (1932-36). He received the Darwin-Wallace Medal of the Linnean Society of London, Legion of Honour (Legion d'honneur) of the Government of the Republic of France, the Feltrinelli Prize of the Academia Nazionaledei Lincei, Weldon Memorial Prize of the Oxford University, the Huxley Memorial Medal of the Royal Anthropological Institute of Great Britain and Ireland and Kimbler Genetics Award of the US National Academy of Sciences.

Haldane contributed to the development of the theory of enzyme action and the first map of specific genes on the human X-chromosome. He introduced the modern concept of chemical origin of life and as a polymath made significant contributions to other areas of biology, chemistry and mathematics. He was able to bring to the new field the equipment and concepts he had acquired in other disciplines and played a significant role in improving biology education in India. Haldane once wrote: "My scientific work has been varied. In the field of human physiology I am best known for my work on the effects of taking large amounts of ammonium chloride and ether salts. This has had some application in treating lead and radium poisoning. In the field of genetics I was the first to discover linkage in mammals, to map a human chromosome, and (with Penrose) to measure the mutation rate and make some minor discoveries in mathematics." Besides sciences, he was interested in western classics, philosophy, linguistics, Marxism, economics, and so on. He wrote extensively on history and politics.

Haldane edited the *Journal of Genetics*, the oldest in this field. It was found in 1910 by W. Bateson, who coined the term "genetics' and R.C. Punett, who held the first Chair in Genetics in Britain. Haldane brought the *Journal* with him to India. His wife Helen Spurway too edited the J*ournal*. After Haldane's death in 1964 Mrs. Haldane continued publishing the *Journal* with Madhav Gadgil, H. Sarat Chandra and Suresh Jaykar until she died in 1977. In 1985, the Indian Academy of Sciences resumed publication of the *Journal* and it still continues to this day.

We can have an idea about Haldane's personal outlook from his following: "As a child I was not brought up in tenets of any religion, but in a household where science and philosophy took the place of faith. As a boy I had very free access to contemporary thought, so that I do not today find Einstein unintelligible, or Freud shocking. As a youth I fought through the war and learned to appreciate sides of human character with which the ordinary intellectual is not brought into contact. As a man I am a biologist, and I see the world from an angle which gives me unaccustomed perspective, but not, I think, a wholly misleading one."

Haldane's brilliance was legendary from an early age. He was greatly influenced by his father. In fact he grew up in his father's laboratory. Haldane's father, John Scott Haldane, is regarded as the founder of modern decompression theory and whose pioneering work in the field resulted in the dive tables that determine the rate at which a deep-sea diver can safely ascend without getting the "bends". He studied first at the Eton College and then at the New College, part of the University of Oxford. During the First World War (1914-19) he served as a Military Officer fighting in France and then at Mesopotamia (now Iraq). After the First World War, he served as Fellow of New College and taught at the University of Cambridge (1922-32), the University of California (1932), and the University of London (1933-57). He also served as the first Weldon Professor of Biometry at the University College, London.

Haldane wrote extensively. Some of his major works are: *Daedalus, or, Science and the Future* (1924), *Enzymes* (1930), *Animal Biology* (with the British evolutionist Julian Huxley, 1930), *The Causes of Evolution* (1932), *New Paths in Genetics* (1941), *Science Advances* (1947), *What is Life* (1947), and *The Biochemistry of Genetics* (1954). His book *Daedalus*, a remarkable work of fiction, was the first to discuss the scientific feasibility of test-tube babies. In 1937, he also wrote *My Friend Mr. Leaky.* It was perhaps the only book he wrote for children. He explained his self professed stand as an atheist in his work *Fact & Faith* (1934): "My practice as a scientist is atheistic. That is to say, when I set up an experiment I assume that no god, angel or devil is going to interfere with its course; and its assumption has been justified by such success as I achieved in my professional career. I should therefore be intellectually dishonest if I were not also atheistic in my affairs of the world."

Haldane's comments on the education system of his time are still very relevant. He observed: "Our present education system is unjust to children because the majority of them don't get a fair chance and practically none are taught the truth of science from a human point of view. Science teaching should begin, not with a mythical body in rest or uniform motion, but with the human body. Mine did so begin at the age of three." He further wrote: "Between different men and women there are immense inborn differences which no amount of education can overcome. I do not believe that any training could have

made Ramsay MacDonald into Jack Hobbs, or vice versa. The ideal society would enable every man and woman to make best of their inborn possibilities. Hence it must have two characteristics. First, liberty, which would allow people to develop along their individual lines, and not attempt to force all into one mould, as far as is humanly possible, every man and woman would be able to obtain the position in society for which they are best suited by nature. The waste of human beings under our present system is a far worse evil than any merely economic waste."

He was very much concerned with human welfare. In his student days at Oxford he was a liberal. However, in the 1930s Haldane was drawn towards communist ideology and he eventually joined the British Communist Party in 1942. He became the editor of the Party's paper the *Daily Worker* published from London. However, later he became disillusioned with the Party's official line and left it. Perhaps there were many reasons for his moving to India, but it was projected that he moved out of England in protest against the Anglo-French invasion of Suez.

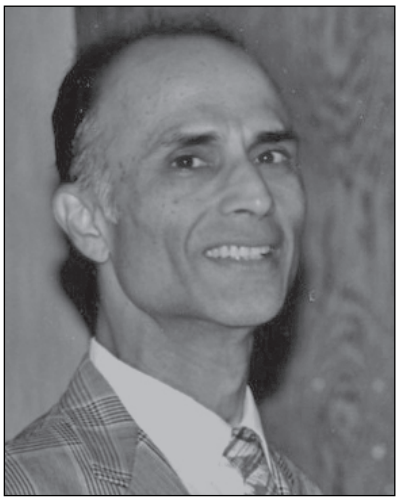
Writing in *Current Science* (25 June 1996), Krishna R. Dronamraju, a student and colleague of J.B.S. Haldane narrates the other qualities of Haldane. He says, "In addition to his brilliant scientific contributions, Haldane became famous for his outstanding popularisation of science in the lay press.

"It was during that period, from 1957 until his death in 1964, that I came to know him intimately as a pupil and a colleague in Calcutta (now Kolkata) and Bhubaneswar. He adopted an Indian lifestyle – wearing Indian style clothes, eating only vegetarian food etc. All these distinguishing qualities – intellectual, political, philosophical, and personal combined with his highly interesting family background, made Haldane a most interesting character for biographies."

Haldane died of cancer on 1 December 1964 in Bhubaneswar. He was by then an Indian citizen. Cancer was not able to dampen his indomitable spirit. In fact he made fun of the dreaded disease in a poem "*Cancer is a Funny Thing*" he wrote before his death. We quote here a few lines from the poem: "*Cancer's a Funny Thing: I wish I had the voice of Homer, To sing of rectal carcinoma, This kills a lot more chaps, in fact, Than were bumped off when Troy was sacked…*" As per will his body was sent to the Rangaraya Medical College, Kakinada. His last will states: My body has been used for both purposes during my lifetime and after my death, whether I continue to exist or not, I shall have no further use for it, and desire that it shall be used by others. Its refrigeration, if this is possible, should be a first charge on my estate." Haldane was not worried over the prospect of death. He once wrote: "I am a part of Nature, and, like other natural objects, from a lightning flash to a mountain range, I shall last out my time and then finish. This prospect does not worry me, because

some of my work will not die when I do so." In one of his works, *Possible Worlds* he wrote: "I have no doubt that in reality the future will be vastly more surprising than anything I can imagine. Now my own suspicion is that the Universe is not only queerer than we can suppose, but queerer than we can imagine."

Subodh Mahanti



Harish-Chandra

Harish-Chandra (11 October 1923 – 16 October 1983) is regarded as the greatest Indian mathematician since Srinivasa Ramanujan. He rose to become a mathematician of world stature. It should be noted at the beginning that Harish-Chandra's contribution are in the realm of higher mathematics and to appreciate the true signification of his work one should have an appropriate background in mathematics. But then, even those including the author of this article, not in a position to understand the actual work, will certainly be by inspired Harish-Chandra's life and work.

One may wonder about the hyphen in the name of Harish-Chandra because normally one does not come across hyphenated names. His original name was Harishchandra and the hyphen was bestowed on him by the copy editor of his first scientific papers. Harishchandra decided to adopt the hyphen. In this context it is pertinent to quote N. Mukunda from his editorial in *Resonance* on Harish-Chandra: "To very few of us is it given to be able to even appreciate the work of such gifted individuals, leave alone to reach such heights ourselves. And yet all we need heroes — verily the salt of the earth — from whom to derive the inspiration to reach beyond ourselves."

Harish-Chandra is best known for his general theory of semi-simple Lie groups. He formulated a fundamental theory of representations of Lie groups and Lie algebra. He started his work on Lie groups in 1949 and went on to erect his monumental theory over the course of three decades or so. The depth and beauty of his work is one of the most profound of twentieth century mathematics. And what is important is that he did it single-handedly. He published only one joint paper with A. Borel.

Harish-Chandra also extended the concept of a characteristic representation of finite-dimensional of semi-simple Lie groups to infinite-dimensional representations of a case and formulated a Weyl's character formula analogue. His other major contributions included: the construction of the Plancherel measure of semi-simple Lie groups; the evaluation of the representations of discrete series; his results on Eisenstein series; the theory of automorphic forms; and his philosophy of cusp forms as a guiding principle to have a common view of certain phenomena in the representation theory of reductive groups in a rather broad sense.

The Swiss mathematician Armand Borel mentioned: "Harish-Chandra was a highly principled man, for whom one's life had to have purpose. In his view, the main one of his own life was no doubt to prove the hardest and the most fundamental theorems accessible to him…Underlying this tremendous productivity were very strict, almost ascetic, disciplined and routine… The sense of purpose Harish gave to his life had some spiritual, even religious underpinning.

Harish-Chandra was born on 11 October 1923 in an educated family Uttar Pradesh (then United Provinces). His parents were Chandrakishore and Chandrarani (original name Satyagati Seth). Harish-Chandra had two brothers and one sister. His father, Chandrakishore, was an ardent follower of Mahatma Gandhi and had dropped his surname because of his opposition to the caste system. His maternal grandfather Ram Sanethi Seth was a successful lawyer. Harish-Chandra's early education was at home by private tutors. At the age of nine he was sent to a school, Christ Church High School, where he was directly admitted to the class seven. After completing his high school education at the age of fourteen, he joined the BNSD Inter College at Kanpur and from where he went to the Allahabad University. He obtained his BSc (1941) and MSc (1945) degrees from Allahabad University. His initial desire was to devote his life to the study of theoretical physics. Harish-Chandra later recalled that his reading of Paul A.M. Dirac's *Principle of Quantum Mechanics* was mainly responsible for getting him attracted to theoretical physics. Harish-Chandra was particularly influenced by its lucid style and powerful ideas. At Allahabad University he came in contact with K.S. Krishnan, the distinguished Indian physicist. C.V. Raman, the celebrated physicist of India was Harish-Chandra's MSc examiner.

It may be noted that Raman was Krishnan's research supervisor in the Indian Association for the Cultivation of Science in Kolkata (then Calcutta). It was Krishnan who persuaded Harish-Chandra to go to the Indian Institute of Science, Bangalore (now Bengaluru) to work with H.J. Bhabha in theoretical physics. Harish-Chandra worked with Bhabha for about two years and published research papers on classical point-particles, their equations of motion and the fields associated with them. Because of these papers Harish-Chandra came in contact with P.A.M. Dirac, one of the founders of quantum

mechanics, as they dealt with one of Dirac's research interests. He was recommended to Dirac for his doctoral work by Bhabha and Krishnan. In 1945, Harish-Chandra went to the Gonville and Caius College of the Cambridge University, Cambridge, United Kingdom, where he worked for his PhD degree under the supervision of Dirac. He was awarded his PhD degree in 1947 for his thesis entitled "Infinite irreducible representations of the Lorentz group."

Harish-Chandra found Dirac 'very gentle and kind and yet rather aloof and distant'. He did not have much personal interaction with Dirac because he had decided not to 'bother him too much'. Harish-Chandra later recalled that he went to see Dirac 'about once each term'. It has been reported that Harish-Chandra stopped attending Dirac's classes after realising that Dirac was actually reading from one of his books. In spite of all this Harish-Chandra was greatly influenced by Dirac. When Dirac visited the Institute of Advanced Study at Princeton, USA for a year (1947-48), Harish-Chandra accompanied him as his assistant. In Princeton, Harish-Chandra could meet leading mathematicians like Hermann Weyl (1885-1955), who gave the first rigorous account of the Riemann surfaces. Emil Artin (1898-1962), who solved David Hilbert's problem concerning the existence of a general reciprocity law and in this way he completed a line of inquiry begun by Carl Friedrich Gauss which was central to the theory of numbers, and Claude Chevalley (1909-1984), who made important contributions to number theory, algebraic geometry, finite group theory, and theory of algebraic groups. He was greatly influenced by these outstanding mathematicians.

It was at Princeton that he decided that he should pursue mathematics and not physics. Harish-Chandra wrote: "Soon after coming to Princeton I became aware that my work on the Lorentz group was based on somewhat shaky arguments. I had naively manipulated unbounded operators without paying any attention to their domains of definition. I once complained to Dirac about the fact that my proofs were not rigorous and he replied, 'I am not interested in proofs but only in what nature does.' This remark confirmed my growing conviction that I did not have the mysterious sixth sense which one needs in order to succeed in physics and I soon decided to move over to mathematics."

It is to be noted that there was no lengthy gap in his scientific output while making a transition from physics to mathematics. In fact his last physics papers were published in 1948 and his papers on mathematics started appearing in 1949. Canadian mathematician R.P. Langlands has described how Harish-Chandra, being both a theoretical physicist and mathematician, viewed the relationship between physicist and mathematician in the following words: "Although he (Harish-Chandra) was convinced that the mathematician's very mode of thought prevented him from comprehending the essence of theoretical physics, where, he felt, deep intuition and not logic prevailed and skeptical of any

mathematician who presumed to attempt to understand it, he was even more impatient with those mathematicians in whom a sympathy for theoretical physics was lacking, a failing he attributed in particular to the French school of the 1950s."

Dirac went back to Cambridge, UK, but Harish-Chandra remained in USA. After staying one more year at the Institute of Advanced Study, he moved to Harvard University for a year (1949-50). At Harvard he came in contact with the Russian-born American mathematician Oscar Zariski. From Harvard he moved to Columbia University, where he stayed from 1950 to 1963. While staying on the faculty of the Columbia University, Harish-Chandra spent considerable periods in other institutions — Tata Institute of Fundamental Research, Bombay (now Mumbai, 1952-53); Institute of Advanced Study, Princeton (1955-56 and then again during 1961-1963 as Sloan Fellow); and Paris (1957-58) as Guggenheim Fellow. In 1963, he was made a permanent faculty of the Institute of Advanced Study, where remained till his death. Harish-Chandra was elected a Fellow of the Royal Society of London in 1973.

He was also a Fellow of the National Academy of Sciences of the United States of America (1981), and Indian National Science Academy (1975). He was awarded honorary doctorate degrees by Delhi University (1973) and Yale University (1981). Among the awards received by Harish-Chandra were the Cole Prize of the American Mathematical Society (1954) and the Ramanujan Medal of the Indian National Science Academy (1974). The Harish-Chandra Research Institute of Mathematical Sciences is named after Harish-Chandra. The institute is funded by the Department of Atomic Energy, Government of India and it is located in Jhusi, Allahabad. Harish-Chandra died of heart attack on 16 October 1983, while on an evening walk during a conference in Princeton held in honour of Armand Borel's 60th birthday.

Prof. Satya Deo, one of Harish Chandra associates and presently a NASI Senior Scientist at Harish-Chandra Research Institute, Allahabad, recollects, "Harish-Chandra did his M.Sc. in Physics from the University of Allahabad when the well known physicist K.S. Krishnan was the Head of the Department of Physics there. He and Rajju Bhaiyya (Rajendra Singh) were class fellows. In the final exam of MSc. Rajju Bhaiyya was the topper and Harish Chandra was the second position holder. The Physics practical examination of Harish-Chandra was conducted by Sir C.V. Raman who had given him the full marks with the remark that the candidate is really outstanding.

"During the time he was in Cambridge, Harish Chandra met a mathematician who told him that he was leaving mathematics and going to physics because everything in mathematics was in a mess. At this, Harish-Chandra also expressed his opinion and said

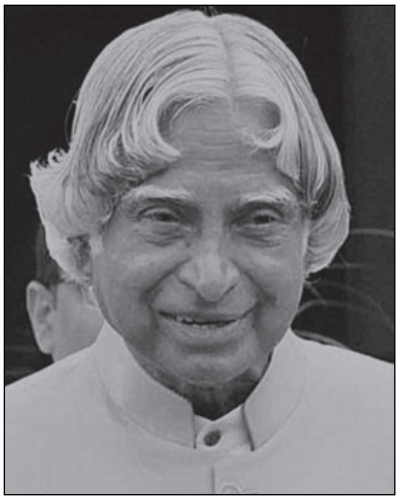
he is 'leaving physics and switching to mathematics exactly for the same reasons.' After that incident, he really changed his field of research and became a mathematician.

"Harish-Chandra was on visit to Paris during early years of his mathematical career. He did not understand Lie groups at that time and asked someone to explain a few things about these groups. He was bluntly told to go through a book on the subject by Chevalley to understand it. Hearing this, he bought the book on Lie groups by Chevalley and finished the entire book in two weeks. After reading the book he understood Lie groups during so well that his main area of research later became the famous topic called 'Representations of semi-simple Lie groups'. He created this beautiful field of mathematics alone and was recognised worldwide for his fundamental contributions in this area."

Harish-Chandra spent most part of his professional career abroad, but he remained an Indian by heart till the end of his life. His daughter Premala Chandra says: "Though he spent almost all of his professional life abroad, culturally my father was always very deeply rooted in India."

In his tribute to Harish-Chandra, V.S. Vardarajan of UCLA said: "In the austere simplicity and uncompromising nature of his approach to life, in his preference for solitary and profound reflection, and in his awesome capacity to discern and preserve after distant goals, he resembled the legendary figures from his country's ancient past. And like them, he came to be quite detached about his achievements as well as his failures. The detachment was not a false modesty; like many great men Harish-Chandra was fully conscious of his gifts and what he could do with them. It was rather a deeper humility, whose origin lay in a conviction that science was a collective endeavour and that any life is but a fragment in a larger fabric."

Subodh Mahanti



Avul Pakir Jainulabdeen Abdul Kalam

Avul Pakir Jainulabdeen Abdul Kalam (15 October 1931 – 27 July 2015) was the brain behind India's Integrated Guided Missiles Development Programme and one of the chief architects of now flourishing Indian space programme. Popularly known as A.P.J. Abdul Kalam, he took a leadership role in development and launching of India's first indigenous Satellite Launch Vehicle (SLV-3), which placed *Rohini* RS-1 satellite into Earth orbit in July 1980.

SLV-3 was a historical achievement for India, as the country entered the elite space club. He played a pivotal role as a nuclear scientist in the planning and conducting of the Pokhran-II nuclear tests in May 1998. He was conferred with Bharat Ratna, India's highest civilian honour, in 1997 for his immense and valuable contribution to country's scientific research and modernisation of defence technology. He was earlier awarded two other coveted civilian honours the Padma Bhushan in 1981 and the Padma Vibhushan in 1990. In 2002 he was elected as the 11th President of India.

Kalam was born on 15 October 1931 in a Tamil Muslim family at Rameswaram in the erstwhile Madras Presidency (now Tamil Nadu). His father, Jainulabdeen, was a humble boat owner; a devout Muslim and a close friend of the Rameswaram temple priest. He owned a ferry that took Hindu pilgrims back and forth between Rameswaram and the now uninhabited Dhanushkodi. It is said Jainulabdeen had a good rapport with local Hindu and Christian priests that helped Kalam imbibe spiritual values and principles. As a result, Kalam was brought up in a multi-religious, tolerant society; one with a progressive outlook. Speaking of his father, Kalam used to say: "My father Jainulabudeen was not formally educated but was a man of great wisdom and kindness".

A.P.J. Abdul Kalam with schoolmates

Kalam's ancestors had been wealthy traders and landowners, with numerous properties and large tracts of land. Their business had involved trading groceries between the mainland and the Pamban Island, to and from Sri Lanka and ferrying pilgrims between the mainland and the island. However, after the opening of the Pamban Bridge to the mainland in 1914, the ferry businesses failed and the family fortune and properties were lost over time, apart from the ancestral home. By his early childhood, Kalam's family had become poor; at an early age, he had to sell newspapers to supplement his family's income.

Despite hardship, Kalam completed his school education from Ramanathapuram Schwartz High School, where he revealed the excellence of a hardworking student with special interest in mathematics. His day would start at four in the morning and end at 11 pm. He studied physics at the Saint Joseph's College at Tiruchirappalli in Tamil Nadu, then affiliated to the University of Madras, and graduated from there in 1954. He moved to Chennai in 1955 to study aerospace engineering in the Madras Institute of Technology. He then wanted to join the air force. But he narrowly missed achieving his dream of

becoming a fighter pilot, as he was placed ninth in the qualifiers, and only eight positions were available in the IAF. Undeterred, Kalam joined the Aeronautical Development Establishment of the Defence Research and Development Organisation (DRDO) as a junior scientist.

He started his career by designing a small hovercraft, but he was not satisfied with his choice of a job at DRDO.

In 1963, Kalam was selected to join the Indian Committee for Space Research (INCOSPAR) as a rocket engineer. INCOSPAR was the predecessor to Indian Space Research Organisation (ISRO) headed by Vikram Sarabhai. Soon after joining INCOSPAR, Kalam attended a six-month training programme on sounding rocket launching techniques at NASA in USA in 1963. Later he served as one of the chief architects of now flourishing Indian space programme.

Over the 1970s and 1990s, Kalam successfully developed the SLV-3and Polar Satellite Launch Vehicle (PSLV) projects. He led the development and launching of India's first indigenous Satellite Launch Vehicle (SLV-3), which placed *Rohini* RS-1 satellite into Earth orbit in July 1980. SLV-3 was a historical achievement for India, as the country entered the elite space club. Before moving into ISRO, Kalam had started work on an expandable rocket project independently at DRDO in 1965. In 1969, Kalam received the government's approval and expanded the programme to include more engineers. After his stint at the ISRO for about two decades, Kalam moved back to DRDO in 1983 as its Chief Executive, to lead the Integrated Guided Missiles Development Programme (IGMDP). Under his leadership, the IGMDP developed and operationalised the *Agni* and *Prithvi* missiles during the 1980s for building indigenous capability in critical technologies. Later he was appointed the Chief Scientific Adviser to the Prime Minister and the Secretary of the DRDO and served the country between July 1992 and December 1999. Subsequently he also served as one of the Chief Project Coordinators in the Operation Shakti (Pokhran-II) nuclear tests in 1998, which received global attention as

A.P.J. Abdul Kalam with children

India became a full-fledged nuclear state in order to strike a balance to achieve regional stability and peace.

Kalam served as Chairman of the Technology Information Forecasting and Assessment Council (TIFAC), an autonomous organisation under Ministry of Science and Technology. Over 1990s, TIFAC was engaged in 'Technology Vision 2020' exercise for India with an objective of "Transforming the nation into a developed country, with five areas in combination having been identified based on India's core competence, natural resources and talented manpower for integrated action to double the growth rate of GDP and realise the Vision of Developed India". The book titled *India 2020: A Vision for the New Millennium*, authored jointly by Kalam and Rajan, was a refinement of the series of "Technology Vision 2020" documents published by TIFAC. They wrote a touching dedication to the book: "After one of the talks delivered by Dr. Kalam, a ten-year-old girl came up to him for his autograph. 'What is your ambition,' he asked her. 'I want to live in a developed India,' she replied without hesitation. This book is dedicated to her and the millions of Indians who share her aspiration." In this book, Kalam strongly advocated an action plan to develop India into a "knowledge superpower" and a developed nation by the year 2020. He used to say that India should become a nation where agriculture, industry and service sector work together in harmony. He regarded his work on India's nuclear weapons programme as a way to assert India's place as a future superpower.

Books by A.P.J. Abdul Kalam

Kalam was elected President of India in July 2002. He soon was known as the "People's President" because he welcomed the public into the Rashtrapati Bhawan in New Delhi and made himself accessible whenever he travelled. During his presidency (2002-2007), Kalam evolved many innovative ideas for sustainable development and peoples' empowerment, to be implemented by the national and local governments, including the Providing Urban Amenities in Rural Areas (PURA). PURA became a central scheme

titled 'Provision of Urban Amenities in Rural Areas' in 2010 led by Ministry of Rural Development and implemented on a pilot basis under a public-private partnership (PPP) framework during the 11th Five Year Plan.

After leaving office of the President in July 2007, Kalam continued his service to the nation in the field of education. He became a visiting professor at the Indian Institute of Management in Shillong, Ahmedabad, and Indore; a honorary fellow of Indian Institute of Science, Bengaluru; Chancellor of the Indian Institute of Space Science and Technology Thiruvananthapuram; Professor of Aerospace Engineering at Anna University; and an adjunct faculty at many other academic and research institutions across India. He taught information technology at the International Institute of Information Technology, Hyderabad, and technology at Banaras Hindu University and Anna University.

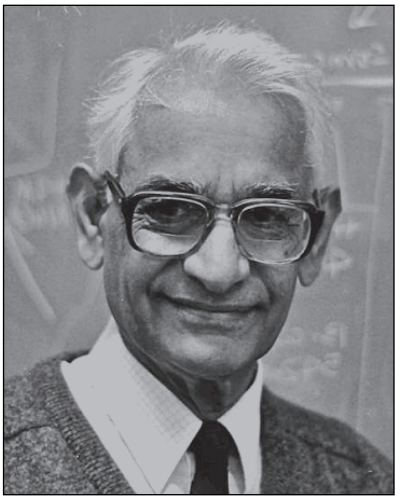
Kalam's inspirational speeches had ignited minds of millions of young students. He interacted with more than 19.5 million youth of the nation over two decades following his stint as the Scientific Adviser. He explained, "I feel comfortable in the company of young people, particularly high school students. Henceforth, I intend to share with them experiences, helping them to ignite their imagination and preparing them to work for a developed India for which the road map is already available." In May 2012, he launched the "What Can I Give" mission with a central theme to defeat corruption, infuse youth with ethics and family value system. He urged the youth to be givers of a robust environment, care, smile and/or rural reforms. Addressing students, he once said, "Never stop fighting until you arrive at your destined place, that is, the unique you. Have an aim in life, continuously acquire knowledge, work hard and have perseverance to realise the great life. These are four essential criteria." It is not rhetoric, but words of wisdom coming from a person who strongly believed in and practised them. He believed that "Ignited mind of youth is the most powerful resource on Earth, above Earth and under the Earth".

Lakshman Prasad, a friend of Dr. Kalam spoke about the latter's sense of time. "Dr. Kalam was very economical about his own time and expenses and he had some consideration about even the most common person coming in his contact. In this context, I would like to tell that whenever I asked time from his assistant to meet Dr. Kalam, he would invariable asked me whether I was coming to Delhi to see Dr. Kalam only or had some other engagement also? Once out of curiosity I sought from his PA the reason of this query and he told me that he had a standing instruction from Dr. Kalam that appointment be given even to a friend only when he is coming to Delhi with some other work also in addition to the purpose of meeting him, because this saves both time and money."

The end of this illustrious multi-faceted personality, who was one of the most versatile technologists, educationists and statesmen of modern time was abrupt. On 27

July 2015, Kalam travelled to Shillong in Meghalaya to deliver a lecture on "Creating a Livable Planet Earth" at the Indian Institute of Management Shillong of which he was a Visiting Professor. Only five minutes into his lecture, he collapsed and was rushed to the nearby Bethany Hospital, but could not be revived. His inspiring thoughts, vision of a corruption-free India and contributions to India's space and missile programmes will remain and inspire forever.

Biman Basu



Har Gobind Khorana

Har Gobind Khorana (9 January 1922 – 9 November 2011) played a crucial role in deciphering the genetic code. Khorana, jointly with Robert William Holley and Marshall Warren Nirenberg, was awarded the 1968 Nobel Prize for Physiology or Medicine "for their interpretation of the genetic code and its function in protein synthesis." They worked independent of one another and showed the translation of genetic information into proteins and functions of a living cell. Khorana was the first scientist to achieve synthesis of an artificial gene.

His researches opened genetic engineering as a new branch of science. His research career spanned over six decades. He published over 500 research papers in chemistry and biology. He rose from a very humble background to become one of the greatest scientists working in molecular biology in the 20th century because of his extraordinary drive, discipline and striving for excellence.

Khorana gave a lot of thought before selecting a research problem. The difficulty or the time needed to solve a problem did not really bother him as long as it was of fundamental importance. An oft-quoted statement made by Khorana was: "If you want to get far, you have to travel alone." He was a pioneer and visionary. One of Khorana's colleagues at the Massachusetts Institute of Technology, Uttam L. Raj Bhandary, wrote: "As a mentor, Khorana set high standards. He was loyal to the people who helped him and to the institutions at which he worked. He could be demanding, but he was no more so of others than he was of himself. One associate said: 'He showed us what excellence in science was and we learnt to recognise it.' Gobind was modest, humble and avoided publicity. He loved music, swimming and long walks, and had a curiosity that lasted until the end."

Khorana was born on 9 January 1922 in a small village named Raipur in the state of Punjab of undivided India (now in Pakistan). His father was a Patwari, a village taxation clerk. Though his financial condition was not very sound, Khorana's father made sure his children had education. In fact Khorana's family was the only literate family in the village inhabited by about 100 people. His early education was under a tree in his village where the local teacher continued open classes. He later attended D.A.V. High School in Multan. At school he was greatly influenced by one of his teachers, Ratan Lal. He was awarded a government scholarship for higher studies. He studied chemistry in Punjab University, Lahore from where he obtained a BSc degree in 1943 and an MSc degree in 1945. While he was still a MSc student at Lahore he published two short research papers in the journal of the Lahore Philosophical Society. His papers were on the synthesis on xanthones.

In 1945, a Government of India Scholarship made it possible for Khorana to go to England where he worked for a PhD degree at the University of Liverpool under the supervision of Roger J.S. Beer. After completing his PhD, Khorana went to the Swiss Federal Institute of Technology (Eidgenossische Technische Hochschule) in Zurich, where he worked as a postdoctoral research student for 11 months on alkaloid chemistry with the Swiss chemist Vladimir Prelog. It may be noted that Prelog was awarded the Nobel Prize in Chemistry in 1975 "for his work into the stereochemistry of organic molecules and reactions". Khorana's stay at Zurich was short but it played a decisive role in shaping his scientific career. Khorana was greatly influenced by Prelog. Acknowledging his debt to Prelog, Khorana said in his Nobel Lecture: "Fortunately, I was accepted by Professor Prelog of the Eidgenossische Technische Hochschule, Zurich, as a postdoctoral student. The association with this great scientist and human being influenced immeasurably my thought and philosophy towards science, work and effort."

Khorana returned to India in India in 1949. Khorana's family was uprooted over partition and moved to the Punjab Province of India. He could not find a suitable job in India in spite of having a PhD degree from the Liverpool University, UK. However, he managed to get a fellowship to work in the laboratory of Alexander Todd– a future Nobel Prize winner in chemistry 'for his work on nucleotides and nucleotide coenzymes'– at Cambridge University. Khorana was helped to get the fellowship by George Krenner, whom he had earlier met at Vladimir Prelog's laboratory at Zurich. Alexander Todd ignited Khorana's interest in nucleic acid research. In 1952, Khorana moved to Vancouver, Canada, where he became the Director of the British Columbia Research Council's Organic Chemistry Section in the University of British Columbia. For Khorana it was a great opportunity in his professional career because he could have his own research group. At Vancouver he had all the freedom to do whatever he wanted to do. But there were very little facilities to carry out research. Khorana took up the challenge. Jointly with his colleague John G. Moffat, Khorana developed a process for synthesising acetyl coenzyme

A – an essential molecule in biochemical processing of proteins, fats and carbohydrates within the human body.

In 1960, Khorana joined the University of Wisconsin, USA as Co-Director of the Institute of Enzyme Research. In 1962, he became a professor of biochemistry. Khorana became a naturalised US citizen in 1966. At the Wisconsin University, Khorana became interested in unravelling the genetic code. He carried out valuable synthesis of polynucleotides with known base sequences. He established the 'genetic code word dictionary by synthesising all the 64 nucleotides. In 1970, Khorana joined the Massachusetts Institute of Technology (MIT) as Alfred P. Sloan Professor of Biology and Chemistry where he served until retiring in 2007.

At MIT, Khorana extended his work on synthesis of oligonucleotides to synthesis of long DNA polymers using non-aqueous chemistry and assembled these into the first synthetic gene, a gene with 126 nucleotide base pairs. He achieved this feat by using polymerase and ligase enzymes that linked pieces of DNA together, as well as methods that anticipated the invention of polymerase chain reaction (PCR). Later such custom-designed pieces of artificial genes found wide use in biology laboratories for sequencing, cloning and engineering new plants and animals. Khorana's inventions became automated and commercialised. And today anyone can order a synthetic gene from any of a number of companies with the desired sequence. The method of chemically synthesising genes made possible controlled, systematic studies of how genetic structures function. Towards the end of his professional career, Khorana got involved in research exploring the molecular mechanisms underlying the cell signalling pathways of vision of vertebrates. He primarily focused on the structure and function of rhodopsin, a light-sensitive protein found in the retina of the vertebrate eye. He also studied mutations in rhodopsin.

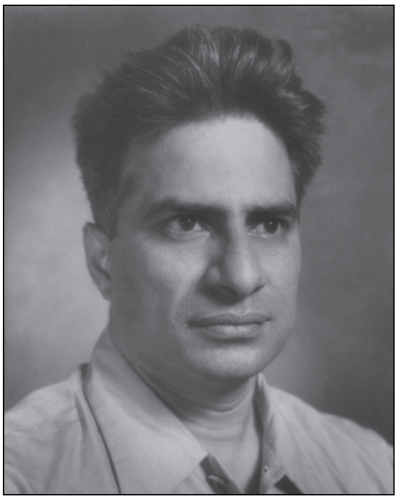
Khorana received numerous awards which include Albert Lasker Foundation Award for Basic Medical Research (1968), the US National Medal of Science (1987), H. Firodia Award for Excellence in Science and Technology (1997), and Gujar Mal Modi Innovative Science and Technology Award (2004). The Government of India recognised Khorana's path-breaking contributions by bestowing on him its prestigious civilian awards Padma Sri (1998), Padma Bhushan (2009) and Padma Vibhushan (2009).

Dr. Nitya Anand, Professional friend of Dr. Har Gobind Khorana and former Director, CSIR-CDRI, Lucknow, described Khorana as a "legendary figure in science". He recalled, "The special traits marking his 'inspired mind' showed up from a very early stage of his professional life. I had the great privilege of getting to know him personally from early 1950 when I was at Cambridge (UK) finishing my Ph.D. with Prof. Alexander Todd (later Lord Todd) and Khorana joined as a post-doctoral fellow after his Ph.D. from University of

Liverpool and a brief stint of about 10 months at Federal Institute of Technology (ETH) in Zurich (Switzerland) with Prof. Prelog. As I had already been at Cambridge, I could help Khorana in finding suitable Paying Guest accommodation etc. and also settle him well in the Laboratory, which brought us even more close together. What struck me immediately was his total dedication and devotion to his research work, with utmost discipline and striving for excellence; his life was in the Lab. and meals etc. were a part of his stay in the Lab. from early morning to 10.15 p.m., when the Lab. used to be locked. I used to follow this routine already, but seeing Gobind doing this further strengthened my resolve to follow this routine, which saved so much valuable time."

Khorana was member of many distinguished professional bodies including that of US National Academy of Sciences and American Academy of Arts and Sciences. He was member of the Board of Governors of the Scripps Research Institute. He received numerous awards in recognition of his outstanding contributions. The University of Wisconsin, the Department of Biotechnology, Government of India, and the Indo-US Science and Technology Forum jointly created the Khorana Programme in 2007 to provide graduate and undergraduate students with a transformative research experience, engage partners in rural development and food structure; and facilitate public-private partnership between the US and India. Khorana's career amply demonstrated the saying: "Where there is a will, there is a way." Khorana once said: "I have met people who believed they knew at a very young age what they wanted to do in their lives. I envied them, but my own life was not like that."

Subodh Mahanti



Damodar Dharmanand Kosambi

Damodar Dharmanand Kosambi (31 July 1907 – 29 June 1966) worked in diverse fields—mathematics, statistics, physics, genetics, numismatics, Sanskrit literature and archaeology. While working in diverse fields he not only raised significant new questions but also offered original answers. He demonstrated that formal training and degrees as markers of knowledge may not be always relevant and boundaries across disciplines are at best transient. He made notable contributions to the development of higher mathematics and statistics. In mathematics, he mostly worked on tensor analysis and path-geometry, a term he coined. Describing Kosambi's fascination with mathematics, P.V. Sukhatme wrote in *Biographical Memoirs of the Fellows of the Indian National Science Academy (1994)*: "He had only a Bachelor's degree in mathematics and yet had a complete grasp over the latest developments in mathematical research in Europe. He regarded mathematics as the language of Nature, giving preciseness to the results of other sciences, but was also aware that Nature has its own philosophy. He was very much fascinated by the clarity and exactness which mathematics can give and brought to bear the same in all branches of science he handled."

Kosambi worked in theoretical and nuclear physics. His formula for finding the distance between chromosomes is regarded as a significant contribution to classical genetics. It gave satisfactory estimates of map lengths irrespective of the kinds of organisms and lengths of their chromosomes. He established the science of coins or numismatics as an exact scientific branch through his extensive and painstaking work on Indian coins by using statistical methods. He was also the first to recognise the presence of microliths characteristic of the Stone Age at the Vetal Hillson the Western Ghats. He discovered several trade routes. Based on his extensive field work he suggested the use of Malshej Ghat, a mountain pass in the Western Ghats range in Pune district, as a key road from

Mumbai to Ahmednagar. He discovered many Neolithic routes, Buddhist caves, and old inscriptions by undertaking extensive field work.

Kosambi developed a new interpretation of the Indian history. His classic works on Indian history marked a new stage in Indian historiography. Hethrew light on the most vital missing link in the Robert Greaves' researches on the life of Christ by establishing the presence of Christ in Kashmir from some rare documents in Srinagar Fort. As a versatile linguist, he learnt Sanskrit, Brahmi and Prakrit languages; studied several European languages, namely French, German, Italian, and Russian. He had enough working knowledge in Latin, Greek and Hebrew. It was Kosambi who first deciphered the Brahmi inscription at the KarlaCaves, a complex of ancient Indian Buddhist rock-cut cave shrines located in Karlanear Lonavala in Maharashtra.

Kosambi was born on 31 July 1907 in a village named Kosben in Goa. His father Dharmanand Kosambi was a renowned Buddhist scholar; taught Pali at the Fergusson College in Pune and was a Visiting Professor of the Harvard University, USA. In 1918, Kosambi and his sister went to Cambridge, USA along with their father, for whom it was a second visit to Harvard University. Kosambi was first admitted in Cambridge School and later in Cambridge Latin School. After four years his father and his sister returned to India, but Kosambi had to stay back to complete his schooling. Eventually he came back

Ferguson College in Pune

to India after completing his school education and he wanted to continue his education in India. But he failed to get admission because the school education system of USA was not compatible with the Indian system. So, after spending a year he returned to Cambridge, USA and joined Harvard University. In 1929, Kosambi graduated from Harvard University with distinction. Kosambi wanted to pursue his doctoral studies at Harvard, but he could not manage financial support because in view of the on-going economic depression it was extremely difficult to get a scholarship.

After coming back to India in 1929, Kosambi joined Banaras Hindu University (BHU), Varanasi as Professor of Mathematics. At BHU, where he stayed for about two years, he also taught German language in addition to mathematics. From BHU, he went to Aligarh Muslim University (AMU) at the invitation of its Head of the Department of Mathematics, Andre Weil, a French mathematician. After spending about a year at AMU he then went to the Fergusson College at Pune. He resigned from the Fergusson College after serving about 13 years because of his differences with college authorities. He was not happy with the 'examination-ridden system and uninspiring standards of education.'

In 1946, Kosambi joined the newly established Tata Institute of Fundamental Research at Mumbai at the invitation of its founder Homi Jehangir Bhabha. In 1949, he was a visiting Professor at the University of Chicago. He also spent some time at the Institute of Advanced Study at Princeton as a guest faculty and where he took part in extensive discussion with Albert Einstein on theory of relativity. In 1962, Kosambi left TIFR because his contract was not renewed. Initially he had a very cordial relationship with Bhabha, but because of his aversion to nuclear energy and fierce independent mind his relation with Bhabha gradually worsened. Kosambi was appointed Scientist Emeritus by the Council of Scientific and Industrial Research in 1964 and was affiliated with Maharashtra Association for the Cultivation of Science, Pune.

Kosambi studied old Indian coins in great detail and while studying them he developed an intellectual urge to know about the kings who struck those coins. He realised that in order to know the kings, he ought tohave a fairly good knowledge of Sanskrit literature. He had no formal training in Sanskrit literature though he had some knowledge of it through informal studies with his illustrious father. He decided to study Sanskrit literature in a systematic way. He began with Bhartrihari's three *Shatakas*. He found Bhartrihari's text defective and he undertook text-criticism. He studied about 400 manuscripts within a span of five years. He not only revived the works of 50 poets who went into oblivion but also added to the knowledge of works of other lesser-known poets. He prepared a critical edition of the poetry of Bhartrihari (*The Satakatrayam* of Bhartrihari with the commentary of Ramarsi) and which he edited in collaboration with K.V. Krishnamoorthi Sharma (1945). After Bhartrihari's *Shatakas*, he took up the Sanskrit literary anthology *Subhasita-ratna-kosa*,

one of the oldest examples of Sanskrit literature. He edited this work with V.V. Gokhale. These works of Kosambi are considered landmarks in text criticism.

Kosambi was attracted to Indian history while he was studying Sanskrit literature. He redefined the nature and scope of Indian history. Realising the fact that written words would not suffice, he engaged himself in studies in archaeology and ethnography and made significant contributions in these fields. He brought in fundamental insights in understanding the nature of India's feudalism and led several scholars to study the feudal structure of Indian society and state. For Kosambi, history was not a subject which dealt only with the dead past. For him history lived on in the past.

His major works on Indian history included *An Introduction to the Study of Indian History* (1956), *Myth and Reality: Studies in the Formation of Indian Culture* (1962), and *The Culture and Civilisation of Ancient India in Historical Outline* (1965). These works became a must read for researchers and students of history both in India and abroad and they were translated into several foreign languages. Kosambi's writings on history evoked great admiration as well as severe criticism. Some considered him a pioneer of genuine Marxist scholarship of India's history while others accused him of using a framework developed at an alien land that was not appropriate for studying Indian cultural heritage.

He led the Indian delegation to the World Peace Conference held at Helsinki, Finland, in June 1955. The Helsinki Conference was chaired by the French physicist and Nobel Prize winner Frederick Joliot-Curie and among the participants were the Irish crystallographer and a polymath John Desmond Bernal and the French existentialist philosopher and writer Jean-Paul Sartre.

Based on Kosambi's style of looking at Indian history, Arvind Narain Das, a well-known activist and social scientist, produced a 13-episode serial titled "Indian Invented" in the early 1990s. In 2008, the Department of Post, Government of India issued a postal stamp in memory of Kosambi. A Kosambi Chair has been established at the University of Pune.

Subodh Mahanti

Daulat Singh Kothari

Daulat Singh Kothari (6 July 1906 –4 February 1993) was an outstanding scientist; regarded as the architect of defence science in India. He was a great educationist. His contribution to the entire spectrum of Indian education from elementary school-level to the university-level is well-known. Kothari once said: "The true aim of education is to understand the world around us, to develop self-discipline and contribute to the happiness to our home and the community. This makes education enjoyable and most exciting, inspiring adventure." He was a student of the illustrious Indian physicist Meghnad Saha. Kothari had the highest regard for truth and non-violence. Above all he believed in rationality.

D.S. Kothari was born on 6 July 1906 in Udaipur, Rajasthan. At the time of his birth, Udaipur was in the Princely State of Mewar in Rajasthan. His father, Fateh Lal Kothari, was a school teacher. Kothari had three brothers and one sister. His father died in 1918 at the age of 38 years. At that time Kothari, who was the eldest of five children, was just 12 years old. His father's early death plunged the family into severe economic difficulties. He was brought up by his mother, a devout Jain and a generous lady. She was always willing to help others in need. Kothari was much influenced by his mother.

After his early education in his hometown, Kothari was invited by his father's friend Sir Siremal Bapna, then Chief Minister of Indore State, to stay with him and study with his children. Kothari matriculated in 1922 from Maharaja Shivajirao High School of Indore. After his matriculation he came back to Udaipur and joined the Intermediate College. In his Intermediate examination, which he passed in 1924, he stood first in the Rajputana Board. He secured distinction in three science subjects – physics, chemistry and mathematics. For his outstanding performance in Intermediate examination, the Maharaja of Mewar granted him a monthly scholarship of Rs.50 per month to help pursue higher studies.

In those days it was an exceedingly generous grant. Kothari passed his BSc in 1926. At the time Kothari came to Allahabad University, Meghnad Saha was heading the Physics Department. Kothari passed his MSc in 1928 from Allahabad University, specialising in wireless (now renamed electronics).

After his MSc, in which he stood first in order of merit, Kothari was appointed demonstrator in the Department of Physics of Allahabad University. After working for two years as demonstrator he went to England for higher studies. This was possible by the scholarship that he got from the United Provinces State Government for going abroad for higher studies and an interest-free loan of Rs.3,500 from the Mewar State Government. In September 1930, he sailed to England, where he worked at Cavendish Laboratory, Cambridge under the supervision of Ernst Rutherford, to whom he was recommended by Meghnad Saha. After obtaining his PhD degree from the Cambridge University he returned to India and resumed his duties as demonstrator in the Physics Department of Allahabad University.

In May 1934, Kothari joined Delhi University as Reader and Head of the Physics Department. In those days the science departments of Delhi University functioned in a hired building in Kashmiri Gate. The University imparted education only up to BSc level. The laboratories did not have adequate facilities. However, soon after his joining, a number of developments took place towards the improvement of the University. The University moved to the Viceregal Lodge Estate. It was decided to extend teaching in chemistry and physics to MSc level. Kothari was appointed Professor of Physics in 1942. The first batch of five students passed MSc physics in 1944.

Kothari was able to persuade some of the outstanding physicists of the world to visit the Department. Among those visited included P.M.S. Blackett, Niels Bohr, P.A.M. Dirac, P. Kapitza, I. Prigogine, C.V. Raman, H.J. Bhabha, M.N. Saha, and K.S. Krishnan. Kothari established the New Physics Laboratory. While sending his good wishes for the New Laboratory, Albert Einstein through a letter said: "This is the sentence expressing my good wishes for your new Physics Laboratory: Keep good comradeship and work with love and without pre-conceived ideas and you will be happy and successful in your work." Kothari often referred to Einstein's remarks.

Kothari established an active research group in physical science at Delhi University. He published a number of research papers in various branches of physics and astrophysics including plasma physics, magneto-hydrodynamics, quantum electrodynamics and relativistic quantum statistics. His work on pressure ionisation was highly acclaimed. The theory found an interesting application in connection with the structure of white dwarfs. Kothari observed that a stellar body composed of degenerate matter cannot be larger in size than Jupiter. It found wide-ranging applications. Sir A.S. Eddington wrote:

"I mentioned that we only gradually came to realise that ionisation could be produced by high pressure as well as high temperature. I think the first man to state this explicitly was D.S. Kothari. Stimulated by some work H.N. Russell, Kothari has made what I think is an extremely interesting application." In a sense his theory connected the planets and the white dwarf stars. Thus Arnold Sommerfeld wrote: "It is noteworthy that the Indian D.S. Kothari developed an audacious relationship between the old fashioned planets and the now discovered newest heavenly bodies, the white dwarfs." Kothari developed a theory of fragmentation of stellar bodies. He was one of the first to underline the role of neutron in astrophysics. He studied in detail the relation between neutrons, degeneracy and white dwarfs.

Kothari played an important role in shaping the University library. This is because he realised that without a good library no teaching and research could be done. In May 1936 he was unanimously elected Secretary to the Library Committee, a post he held till October 1943. He organised the Third All India Library Conference at the University of Delhi in December 1937. He persuaded the Vice Chancellor to Invite S.R. Ranganathan, who is regarded as father of library science in India, for suggesting a reorganisation plan of the University library.

In 1948, the Government of India appointed Kothari as the first Scientific Adviser to the Ministry of Defence, a post he held until 1961 when he was appointed as Chairman of the University Grants Commission. Later he also served as the Chairman of the Defence Research and Advisory Committee. For organising the defence science in India Kothari had no precedents to go by. He identified the thrust areas of relevance in the country's geopolitical context and carefully chose scientists mostly working in universities and guided them on developing these areas on healthy line. A.P.J. Abdul Kalam, in his book *Ignited Minds* wrote: "Dr. D.S. Kothari, a professor at Delhi University, was an outstanding physicist and astrophysicist. He is well-known for his theory of ionisation of matter by pressure in cold compact objects like planets. This theory is complementary to the epoch-making theory of thermal ionisation of his guru, Dr. Meghnad Saha. Dr. D.S. Kothari set a scientific tradition in Indian defence tasks when he became Scientific Adviser to the Defence Minister in 1948. The first thing he did was to establish the Defence Science Centre for research on electronic materials, nuclear medicine and ballistic science. He is considered the architect of defence science in India." While working towards laying strong foundations of defence science in India Kothari kept his association with Delhi University. After his formal retirement he was appointed Emeritus Professor of Delhi University and he continued to keep close contact with students and teachers almost till his death.

In 1961, Kothari was appointed Chairman of the University Grants Commission and he remained in this post for almost 13 years. He initiated a number of new activities in colleges

and universities. He was Chairman of Indian Education Commission established by the Government of India in 1964. The Commission prepared a report entitled "Education and National Development". The report, which was hailed as landmark in educational sectors in India and other developing countries, clearly reflected Kothari's vision of education. Kothari's deep concern for education led to his association with the National Council of Educational Research and Training (NCERT), since its inception. He conceptualised the role and functions of NCERT and gave a blueprint for its future development. He believed scientific and technical education, were directly linked to nation development and prosperity.

Kothari was the Chancellor of the Jawaharlal Nehru University for two terms (1982-1992). He was the President of the Indian National Science Academy (1973-1974). He was the General President of the Indian Science Congress Association (1961-1962). Kothari died on 4 February 1993. Delhi University has established the D.S. Kothari Centre for Science, Ethics and Education, in his honour. Kothari's book, *Nuclear Explosions and Their Effects* is regarded as a valuable contribution to the subject. The book has been translated into German, Russian and Japanese.

Subodh Mahanti

Kariamanikkam Srinivasa Krishnan

Kariamanikkam Srinivasa Krishnan (4 December 1896 – 14 June 1961) was the co-discoverer of the Nobel winning findings of C.V. Raman and a physicist who had earned international repute. Krishnan was recognised for his work on scattering of light in liquids, magnetic properties of crystals in complex structures as well as electrical conductivity of metals and alloys at low temperatures. Krishnan did all this work in modest experimental settings. Yet his contributions made him a leading physicist of his time and he was made a Fellow of the Royal Society in 1940.

The early decades of the twentieth century are considered the golden age of Indian science, particularly physics. A number of research groups were working in different universities and research institutes on scientific problems. Calcutta (now Kolkata), Allahabad, Dacca (then Dhaka) and Lahore were leading centres of learning and scientific research. Bangalore (now Bengaluru) was beginning to be recognised as a hub of academic institutions, with the setting up of the Indian Institute of Science there in 1909. The crowning glory was a Nobel Prize in physics – awarded to Chandrasekhar Venkata Raman in 1930 for discovery of the *Raman Effect*. Krishnan was a product of this golden age.

Krishnan was born on 4 December 1896 in the family of a school teacher and grew up in Watrap village in Tirunelveli district of the erstwhile Madras Presidency (now Tamil Nadu). He had his early schooling in Srivilliputtur town and then went to the American College in Madurai and Christian College in Madras (now Chennai). But his inclination towards science was clear in his school days and his interest in science was kindled by one of his teachers, Subramanya Iyer in high school. "Even though my teacher was not a professional scientist, he was good at explaining science in a clear and captivating

fashion. His lessons not only sunk deep into our mind but also made us crave for more science. Whether it is physics, geography or chemistry, his teaching style was unique. He did not simply reproduce the lessons from the book. He demonstrated many simple experiments for us and also encouraged us to do experiments ourselves," Krishnan had recalled. The streak of experiment made Krishnan work by himself and he 'developed' a small instrument to measure density of solids. A young Krishnan was surprised when, after a few days, his physics teacher asked the class to write an 'essay' about the very same instrument for measuring the density of solids. He then realised that he had only a pre – existing Nicholas hydrometer. With a burning desire for research in physics, after graduation, he went to Calcutta to work with C.V. Raman at the Indian Association for the Cultivation of Science (IACS). Raman did not take him into the research group right away and advised him to study further. Krishnan then completed MSc from Calcutta University and joined Raman as a research scholar.

At IACS, Raman made Krishnan his 'disciple' in a modern version of the age-old '*guru-shishya*' tradition followed in *gurukuls*. Krishnan described the five years he spent with Raman as '*gurukulavasam*.' This meant total dedication to research work and extreme hard work. It is unimaginable today, but Krishnan used to reach the laboratory at 6 am after taking bath with cold water and a morning walk. Raman had begun working on scattering of light in 1921, after his famous journey by sea from Britain to India during which he observed blue colour of the sea and looked for a plausible explanation. In two papers sent to scientific journal *Nature* while still on this voyage, Raman postulated that the colour of the sea was due to light scattering by the water molecules. He called this phenomenon molecular diffraction, which finally led to the discovery relating to molecular basis of light scattering.

In experiments, performed by Krishnan and others, Raman observed frequency-shifted scattered light in more than 50 liquids and by 1927, he noticed that the scattered light was polarised. The phenomenon of 'modified scattering' was then described in a paper in *Nature*. Krishnan was deeply involved in experiments and data collection in these experiments of Raman at IACS using some very rudimentary instruments.

Raman recognised the contribution of Krishnan in the discovery of *Raman effect* in his Nobel speech. In a recommendation letter he explicitly mentioned, "If the Nobel Award for physics made in 1930 had been for the work done in the year 1928 alone instead of the entire work on the scattering of light done at Kolkata from 1921 onwards, Krishnan could justly have come in for the share of the prize". This sets at rest the controversy regarding Krishnan not sharing the Nobel Prize along with Raman.

At Dacca University, where he moved in 1928 as a Professor of Physics, Krishnan got the benefit of working with another great Indian physicist – Satyendra Nath Bose who was

the head of the Physics Department. Here he worked on magnetic properties of crystals with regard to their structure and published pioneering papers on crystal magnetism and magnetochemistry. After a brief stint in Dacca, Krishnan returned to IACS to become Mahendralal Sircar Professor of Physics and continued working on crystal magnetism, a work for which he was invited to the Cavendish Laboratory, Cambridge to give lectures. In 1942, Krishnan joined the Allahabad University as head of the Department of Physics. A new facet was added to Krishnan's scientific career when he was appointed as Director of the National Physical Laboratory (NPL) in New Delhi in 1948. He was also involved in overall organisation of science in the post-independent period, particularly with the Council of Scientific and Industrial Research (CSIR), the University Grants Commission (UGC) and the Department of Atomic Energy.

Besides his scientific – and later administrative accomplishments – Krishnan was a well-read man. He was deeply interested in literature, philosophy and spirituality. He was well versed in Sanskrit and Tamil literature, and a great supporter of communicating science and teaching science in vernacular languages like Tamil. He used to write articles about science and other subjects frequently in Tamil. In addition, he was a sport enthusiast and used to play tennis, bridge and football. While in Kolkata, he was a regular to the Eden Gardens to watch football matches.

Paying tributes to Krishnan on his 60th birthday in December 1958 at a function held at NPL, Prime Minister Jawaharlal Nehru had commented, "Dr Krishnan is a man endowed with rich human qualities that have made him more valuable to society. One feels young and active all one's life by developing a sense of fun – not in the trivial sense but deeper sense. That is the reason he continues to be youthful and active…. What is remarkable about Krishnan is not that he is a great scientist but something much more. He is a perfect citizen, a whole man with an integrated personality." Despite all his achievements, awards and such adulation from the country's Prime Minister, Krishnan continued to be humble all his life and was always thinking of scientific problems. Krishnan passed away on 14 June 1961 following a heart attack.

Dinesh C. Sharma

Prasanta Chandra Mahalanobis

Prasanta Chandra Mahalanobis (29 June 1893 - 28 June 1972) was a scientist and applied statistician who did pioneering research on large scale sample survey and introduced D^2 statistic, a new statistical measure, known today as the 'Mahalanobis distance'. A number of statistical techniques introduced by Mahalanobis are now integral part of modern analytical tools and find innumerable applications in interdisciplinary research. He played a key role in national planning during the early phase of independent India. He founded the Indian Statistical Institute, one of the oldest and most prestigious institutions focussed on statistics.

P.C. Mahalanobis was born in Calcutta (now Kolkata) to Prabodh Chandra and Nirodbashini Devi. He was the eldest of two brothers and three sisters. Mahalanobis received his early schooling at the Brahmo Boys School in Kolkata. During his early age, Mahalanobis came under the influence of Rabindranath Tagore. Tagore was impressed by his love of literature with a flair for logical analysis. Mahalanobis joined the Presidency College, Kolkata, and graduated with a BSc with honours in physics in 1912. Jagadis Chandra Bose and Prafulla Chandra Ray were among the teachers who taught Mahalanobis in Presidency College. Meghnad Saha was a year junior and Subhas Chandra Bose was two years his junior in college.

Mahalanobis went to England in 1913 with an intention to study at the University of London. He took admission for a BSc course. The course was to begin in a few weeks time. During this time he made a trip to Cambridge and visited King's College. Mahalanobis was overwhelmed by the architectural beauty of the chapel of King's College. He missed the train back to London and stayed the night with a friend. In the friend's house, he

met a student who was studying at King's College. On hearing that Mahalanobis found the chapel so attractive, the friend suggested he could apply to study there. Interestingly, he was interviewed the next day and given admission at the King's College. Mahalanobis passed Part I of the Mathematical Tripos in 1914 and Natural Sciences Tripos in 1915. He obtained a first class pass in Part II and was awarded a Senior Scholarship by King's College. During his time in Cambridge, he interacted with Srinivasa Ramanujan.

P. C. Mahalanobis receiving the Mayor-of-Paris Award for exemplary work in Statistics, 1963 (Photo credit: http://www.isical.ac.in/)

Mahalanobis wanted to do research in physics and started working with Scottish physicist and meteorologist C.T.R. Wilson (1869–1959) at the Cavendish Laboratory. In July 1915, Mahalanobis visited India for a short holiday, but never returned to England. Before his journey to India, he came across a few volumes of *Biometrika*, a peer-reviewed scientific journal with principal focus on theoretical statistics. Mahalanobis found the papers so interesting that he purchased the whole set of available volumes and brought these back to Kolkata. A window was opened for Mahalanobis to a new area of science, permanently changing the direction of his life. Mahalanobis realised that statistics was a new science connected with measurements and their analysis, and as such capable of modelling a wide range of applications. Before Mahalanobis, statistics was almost unknown in India and the subject was not taught in any Indian University. He brought about profound changes which influenced the future development of statistics in India.

Once back in India, his uncle, Subodh Chandra Mahalanobis, a professor of physiology at Presidency College, introduced him to the Principal of the College. It was the time of World War I and the senior physicist of Presidency College was on war duty. Mahalanobis was offered a temporary teaching job at Presidency College, which he accepted. He soon became so involved with his work in the College that he gave up the idea of returning to Cambridge. Mahalanobis first analysed the examination results of Presidency College using statistical tools. He discovered the utility of statistics to problems in meteorology, anthropology and began working on it. During this time Mahalanobis met Nelson Annadale, the then Director of Zoological and Anthropological Survey of India, who had collected anthropometric measurements on Anglo-Indians of Kolkata.

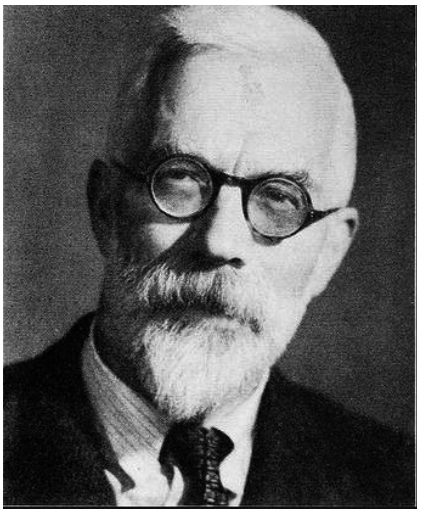
Sample Survey for rice yield
(Photo credit: http://www.isical.ac.in/)

Annadale requested Mahalanobis to analyse the data. Mahalanobis was influenced by the anthropometric studies published in the journal *Biometrika* and readily accepted to do statistical analysis. During the course of these studies, he found a way of comparing and grouping populations using a multivariate distance measure. This measure denoted "D^2" and now eponymously named 'Mahalanobis distance', is independent of the measurement scale. Based on the statistical analysis, Mahalanobis wrote his first paper in 1922 entitled 'Anthropological Observations on Anglo-Indians of Calcutta, Part I: Male Stature'. This paper attracted the attention of Sir Gilbert Walker, Director General of Observatories, who requested Mahalanobis to undertake a systematic study of some meteorological problems. While working on this, Mahalanobis discovered that the region of highest control for changes in weather on the surface of the Earth is located about 4 kilometres above the sea-level, a result, which was rediscovered several years later by Franz Bauer in Germany from physical consideration. Subsequently, he took up responsibility as a meteorologist in the Alipore Observatory in Kolkata in addition to his duty as professor of physics at the Presidency College.

P. C. Mahalanobis and Nirmal Kumari at their Amrapali residence on his 70th Birthday, 1964
(Photo credit: http://www.isical.ac.in/)

The most important contribution of Mahalanobis is large-scale sample surveys. He introduced the concept of pilot surveys and advocated the usefulness of sampling methods. Mahalanobis designed statistical tools to analyse agriculture yield. He introduced a method for estimating crop yields, which involved statisticians sampling in the fields by cutting crops in a circle of diameter 4 feet (about 1.22 metres). Mahalanobis extended the method of sampling survey to analyse consumer

expenditure, tea-drinking habits, public opinion, crop acreage and plant diseases. Famous mathematical statistician and economic theorist Harold Hotelling wrote: "No technique of random sample has, so far as I can find, been developed in the United States or elsewhere, which can compare in accuracy with that described by Professor Mahalanobis".



Sir Ronal Fisher

Perhaps the most important contribution by Mahalanobis, other than his scientific papers, was setting up the Indian Statistical Institute. During 1920, while working as a part-time teacher in Presidency College, Mahalanobis started his research on statistics. Many of his colleagues also joined him and started doing research. Soon it acquired the name of the Statistical Laboratory and was located in Mahalanobis's room in the Physics Department. The official setting up of Indian Statistical Institute came after a decade, with tireless effort of Mahalanobis. During this period, almost all statistical works done in India were by Mahalanobis. Finally, the Indian Statistical Institute was formally founded on 17 December 1931. As the Director and Secretary of the Institute, Mahalanobis persuaded many bright young physicists and mathematicians to join the Institute. They included Raj Chandra Bose, Samarendra Nath Roy, and C.R. Rao. In 1959, by an act of the Indian Parliament, the Institute was declared as an "Institution of National Importance".

The renowned mathematician and statistician C.R. Rao, student of P.C. Mahalanobis, described him as "mentally alert and physically active throughout his life" in his memoir. He wrote, "Even after he was admitted to the nursing home in Calcutta (now Kolkata), he was constantly thinking of the new statistical tool he was developing."

The English statistician Sir Ronal Fisher once commented about Professor Mahalanobis' works in the following words: "What at first most strongly attracted my admiration was that the Professor's work was not imitative…it is the work of striking originality. These words reflect the outstanding contributions of Mahalanobis to statistics. It is therefore not surprising that his works are the backbone of several application areas of modern statistical sciences. Apart from his academic excellence, he made an untiring effort to expand the knowledge of statistics in India and applied the technological innovations for the welfare of people. The originality of ideas coupled with a zeal and conviction to implement new ideas was the hallmark of Mahalanobis' personality".

Rintu Nath

Ashesh Prasad Mitra

Ashesh Prasad Mitra, popularly known as A.P. Mitra, was an internationally renowned climate scientist who carried forward India's post-independence vision of using science for development. He did pioneering work on the ionosphere and climate change. He was the first scientist to take up the cudgels against the US Environmental Protection Agency (US-EPA) for their flawed data on methane generation in Indian rice fields. In the early 1990s, the US-EPA had come out with a report incriminating Indian rice fields of emitting 38.6 million tonnes of methane per year and thus adding significantly to global warming. Mitra initiated pioneering measurements of methane emission from paddy fields which showed that Indian rice fields actually emitted just about one tenth of the estimates made by US-EPA and that it was the carbon emission from developed countries of the West that was responsible for global warming. He catalysed several inter-disciplinary studies on climate change and its impacts on various sectors like agriculture, health, water, etc., in India.

Born on 21 February 1927 in Kolkata, Mitra learnt high standards of academics and discipline from his father who was a school teacher. He nurtured and actively practised these values throughout his life. A brilliant student all through his educational career, he stood first in all his examinations. He studied at Bangabasi College and completed his MSc in physics from Calcutta University, before joining Prof. Sisir Kumar Mitra, the doyen of ionospheric research in India, for a DPhil degree. It was Prof. S.K. Mitra who had laid the foundation for ionospheric research in India and his illustrious student and successor A.P. Mitra carried the programme forward. Besides ionospheric research, Mitra's contributions to science cover many fields that include chemistry of the atmosphere, space research, climate change and global warming.

In 1954, after completing DPhil from Calcutta University, Mitra joined the National Physical Laboratory (NPL), New Delhi, which marked the first step of his brilliant scientific career. His early work at NPL involved Earth's near-space environment, with both ground-based and space techniques. He set up the Radio Science Division at the NPL and was closely associated with it till his very last days. Mitra was largely responsible for developing the Radio Science Division of NPL into one of the front-ranking research centres of the world.

National Physical Laboratory (NPL), New Delhi

Mitra initiated research in ionospheric physics at the NPL in 1970 when K.S. Krishnan was Director, and contributed significantly to major improvements in radio communication capabilities in the country. Research on the ionosphere has always depended largely on the prevailing technology. In the 1960s the upper atmosphere was probed using rocket-borne payloads. In the 1970s the Satellite Instructional Television Experiment (SITE) used radio beacons to study the upper ionosphere. In the1990s satellites in conjunction with radars, studied the atmosphere from the ground level to heights of 1,000 km. Physical properties like density and temperature were measured at various levels along with a host of other parameters. Mitra coordinated and oversaw all these successful developments and also developed an ionospheric prediction system that has been supporting broadcasting and point-to-point communication systems for more than four decades. He also established an International Radio and Geophysical Warning Centre serving India, West Asia and South East Asia, and established one of the most extensive radio flare detection systems. His work on cosmic radio noise for studying the upper atmosphere led to a series of discoveries in ionosphere, solar physics and cosmic rays.

Mitra was the driving force behind the Indian programme of the International Geophysical Year (IGY) during 1957-58, and the International Quiet Sun Year (IQSY), 1964-65. In the 1970s, Mitra introduced radio research in the troposphere region which contributed significantly to India's radio communication capability. By introducing tropospheric radio research in India, he contributed to major improvements in radio communication capabilities in the India. He helped the Indian Air Force's radar communication systems, which gave them superior detection capability. He spearheaded the Indian Middle Atmosphere Programme (IMAP), which started in 1982 to examine

the role of middle atmosphere in determining climatic change. This was the beginning of climate change research in India. The IMAP saw extensive use of balloons and rockets to carry equipment up to ionospheric levels.

During the 1990s, Mitra focused on understanding global environmental changes due to human activities and their consequences on the biosphere and provided leadership to several on global change related programmes. He also helped formulate the Indian response to climate change. His landmark contributions in studying the ozone layer, atmospheric chemistry and measuring greenhouse gases in India had an international impact. He was of the opinion that the Intergovernmental Panel on Climate Change was far behind in its research. He was a leading figure in the widely known international programmes 'Indian Ocean Experiment (INDOEX)' and the earlier 'Asian Least Cost Greenhouse Gas Abatement Strategy (ALGAS)'Programme.

Mitra wanted climate studies to be based on good home-grown science. As P.K. Gautam of Institute of Defence Studies and Analysis reminisces, "Mitra believed that foreign-funded research agencies in the region always carried an agenda suited to their own national interests. He was keen that a South Asian Association for Regional Cooperation (SAARC) network be established with India assuming the leadership role." With this objective, he was keen to set up a new high-altitude lab at Hanle in Ladakh with a great potential for studying atmospheric data. There was a station in Darjeeling in West Bengal located in the house of J.C. Bose; one in the Sunderbans in West Bengal set up by Jadavpur University, Kolkata; and another station in Port Blair in Andaman & Nicobar Islands to collect atmospheric data on a regular basis. Mitra was keen to involve the army in this work, especially in the rugged, remote and high-altitude region of Eastern Himalayas, which he felt did not have adequate number of stations to collect atmospheric data.

Mitra played a key role in setting up some large National and International facilities like the mesospheric-stratospheric-tropospheric, or MST Radar at Tirupati, Free Air Carbon Dioxide Enrichment (FACE) facility at the Indian Agriculture Research Institute, New Delhi, and the Bose Institute of High Altitude Centre for Astro-particle Physics and Space Science in Darjeeling. He was instrumental in developing both institutional and individual capacities across the South Asian Region in the area of global climate change research. He was the chairman of South Asian START Committee (SASCOM) during 1994-98, but continued as the Director of the South Asian START Regional Centre (SAS RC) located at NPL until his death.

Mitra's concern for global climate change comes out in the following statement made in Kolkata in 2006: "The most precious commodity in this changing world is a stable climate. This in the changing world is a resource. The question of equity is raised.

Every citizen should in the long run have an equal emission quota. A new approach is the concept of Contraction and Convergence. It is a policy that to us seems reasonable. It urges that global emissions be cut from the present global average of 1 tonne CO_2 per capita to 1/3rd of this value, equally shared, by 2040." Although a brilliant student himself, Mitra was against laying too much stress on exam results. He said "We lay too much emphasis on academic excellence in student life. We should see how a researcher fares and stop looking for just rank holders." Known to be assertive, Mitra combined the qualities of an administrator and a scientist well during his tenure as Director of the National Physical Laboratory and Director General, CSIR. But he treated his juniors and research students with lot of care and was always available for discussion and guidance.

Mitra occupied top positions in several international bodies. He was President of the International Union of Radio Science (URSI) during 1984-87. He was the first Indian and second Asian to be elected to this high office. He was a member of the General Committee of International Council of Scientific Union (ICSU) during 1984-88 and was associated with several policy-making bodies. He also served on the Committee on Space Research (COSPAR) in various capacities.

He was elected Fellow of the Royal Society of London in 1989. He was a Fellow of all the three national academies of India, but also of some of the most prestigious academies of the world including the Russian Academy of Sciences, the Third World Academy of Sciences (TWAS), and of the International Academy of Astronautics. He was President of the National Academy of Sciences and Secretary, INSA during 1979-82.Mitra had been bestowed with several awards and medals. He was winner of the Bhatnagar Award, besides the C.V Raman Award, FICCI Award, G.M. Modi Award, and Meghnad Saha Award, to name a few. He had over 200 publications to his credit and had also written and edited several books and monographs. He was awarded the Padma Bhushan by Government of India in 1987. He was a multifaceted scientist-administrator who has left his mark on a wide range of international issues and put India in a leading position in global climate change research.

Biman Basu

Sisir Kumar Mitra

Sisir Kumar Mitra (24 October 1890 – 13 August 1963) is regarded as the doyen of radio science in India. He made significant contributions to enhance our understanding of upper atmospheric phenomena. Mitra's treatise *The Upper Atmosphere* published by the Asiatic Society of Bengal (now The Asiatic Society) in 1947 received world-wide acclaim. British physicist Sir Edward Victor Appleton termed this heroic.

Mitra started post-graduate teaching and research activities on radio science for the first time in India. He established an independent postgraduate department of electronics and radio physics in Calcutta University in 1947 that later evolved into the Institute of Radio Physics and Electronics. He established the first ionospheric field station in India. It was Mitra, who felt the need for an all India radio research organisation and the Radio Research Committee was formed by the Government of India in 1942 under Mitra's chairmanship. Mitra's concern for industrial development is well-known, and he initiated industrial projects in his laboratory.

Sisir Kumar Mitra was born on 24 October 1890 in Kolkata. His father JoykrishnaMitra was a schoolteacher. At the time of Sisir Kumar Mitra's birth, his mother Saratkumari was a student of Campbell Medical School (later renamed as Nil RatanSarkar Medical College) in Kolkata. After passing the final examination in 1892, Saratkumari got an appointment in Lady Dufferin Medical Hospital in Bhagalpore (now usually written as Bhagalpur) in Bihar (now in Jharkhand) and the whole family moved there. His father also managed to get an appointment as a clerk in the local municipal office. Joykrishna had married Saratkumari against the wishes of his parents and because of this he was not only disinherited from his parental property, he was also banished from home.

Mitra studied at the Bhagalpore Zilla (District) School. He then proceeded to the T.N.J. College, Bhagalpore to clear the FA Examination. Just before he passed his FA examination, he lost his father. In 1908, he joined the Presidency College, Kolkata as a BSc student, where he came under the influence of Jagadis Chandra Bose and Prafulla Chandra Ray, two pioneers of modern scientific research in India. At the Presidency College, he was fascinated by instruments designed and constructed by J.C. Bose used to study properties of microwaves and detect various responses of plants. In 1912, Mitra secured his MSc degree in physics as a topper.

The stalwarts referred above inspired him to dedicate himself to scientific research. He got an opportunity to work under J.C. Bose soon after he cleared his examinations. Importantly it was not easy to get a research fellowship those days. His widowed mother supported his education in Kolkata and them as a family needed financial help. Her income was not sufficient at this stage of his career. So when Mitra got an appointment as a lecturer in the T.N.J. College at Bhagalpore, he left Kolkata to take it up. From Bhagalpore he moved to Bankura in West Bengal on securing a job as a lecturer at the local Christian College.

While teaching in colleges, Mitra continued to harbour a burning desire to pursue a research career. However, there was no scope for carrying out research in these mufassil colleges. Mitra tried to use his time as best as he could. He devised indigenous demonstration experiments with whatever he could collect from the impoverished college laboratory to make his lectures more enjoyable and instructive. He wrote popular science articles in Bengali.

Mitra could finally realize his dream of carrying out research when AsutoshMookerjee, the then Vice-Chancellor of Calcutta University, invited him to join the newly created Physics Department of the University College of Science. Mitra worked under Raman's guidance on interference and diffraction of light for his doctoral thesis, in the latter's laboratory at the Indian Association for the Cultivation of Science. His doctoral thesis earned him a DSc degree from Calcutta University in 1919.

In 1920, Mitra proceeded to the University of Sorbonne in Paris to join the research group of Charles Fabry (1867-1945), who had discovered ozone in the upper atmosphere in 1913. At Fabry's laboratory Mitra worked on determining the wavelength standards (2000-2300 Angstrom of the copper spectrum). This fetched his second doctorate in 1923. He then got the chance to work under Marie Curie. He then went ahead to the Institute of Physics at the University of Nancy, Paris, where he worked on radio valve circuits. Though he spent only a few months at the Institute of Physics, he finally made up his mind to make his career in radio research. It was a bold decision because in those days radio science

in India was still in its infancy. Radio science was not a part of the curriculum in any university in India. A research facility in this subject was just not available. Mitra was not deterred and wrote to Asutosh Mookerjee about his decision to move to India. Mookerjee in his reply dated 10 May 1923 wrote: "I am glad to receive your letter dated 18th April and to hear that you have been so successful in your work. The course of investigation you suggest as to signals by wireless telegraphy is very attractive. Do please draw up a scheme and make it as inexpensive as possible. I shall see what we can do. But you must rest assured that there will be plenty of opposition. That need not frighten us; we shall have to fight our way through." On his return to India, he was appointed Khaira Professor of Physics.

He became a member of a team that had C.V. Raman, D.M. Bose, and others. They organised post-graduate teaching in physics at the Calcutta University. Mitra established the 'wireless section' and launched into postgraduate teaching and research in this area. He could motivate a small team of young and enthusiastic individuals to take up the challenging task of studying the ionosphere, which plays a major role in long-distance radio communications.

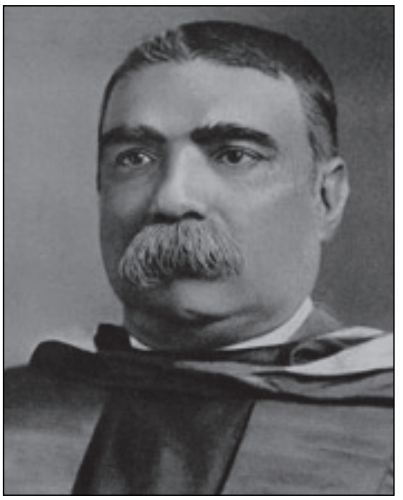
Mitra and his group measured the heights of different layers of the ionosphere using an instrument designed and built indigenously. These investigations provided the first overview of the ionospheric condition in a low altitude sub-tropical region. This also threw considerable light on the effect of thunderstorm, magnetic storm and meteoric shower on upper atmospheric ionisation. Mitra and his co-workers conclusively established the existence of the D-layer.

While developing teaching and research facilities in radio science at Calcutta University, Mitra was involved in the development of broadcasting in India. He and his co-workers constructed a transmitter and installed it in the newly established Wireless Laboratory at the University College of Science. Interestingly for quite some time Mitra's transmitter in his Wireless Laboratory and the transmitter of the Radio Club of Bengal at Dalhousie Square were the only ones that broadcast programmes in the Eastern region of India regularly.

Prof. J.N. Bhar, a student of Sisir Kumar Mitra in his memoir, narrates the unique communication ability of Prof.Mitra. "While delivering lectures in the post-graduate classes of the University or scientific conferences or outside, addressing a much less sophisticated audience on popular or semi-popular topics, Prof.Mitra appeared to be equally at ease. What marked his talks as outstanding was his clarity of exposition. There was a complete absence of superfluity in his talks, yet nothing was left unsaid. Every word seemed to have been chosen with care. Every sentence that he uttered was meaningful."

Mitra established a field station for ionospheric work at Haringhata, a village about 50 km from Kolkata in 1949 with financial assistance provided by the Council of Scientific and Industrial Research (CSIR). This was the first ionosphere field station of its kind in India. Mitra was appointed as Emeritus Professor by Calcutta University after his retirement in 1955. After his retirement, he was persuaded by the then Chief Minister of West Bengal to head the State's Board of Secondary Education. When he took over, the Board was in bad shape. HE transformed the Board into an efficient institution within a short span of time. He received many awards for his significant scientific contributions. In 1958, he was elected Fellow of the Royal Society of London for his contribution to the study of upper atmospheric phenomena. In 1963, he was appointed as National Research Professor by the Government of India. He planned to utilise this opportunity for preparing a revised third edition of his acclaimed treatise *The Upper Atmosphere*. This remained an unfulfilled dream on account of his demise.

Subodh Mahanti



Asutosh Mookerjee

Asutosh Mookerjee (28 June 1864 – 25 May 1924) was a distinguished mathematician of his time and one of the architects of Modern India. He was elected a member of the London Mathematical Society just after he passed his BA examination. He published the book titled *Geometry of Conics*. He founded the Calcutta Mathematical Society in 1908 and directed its activities as its President till his demise.

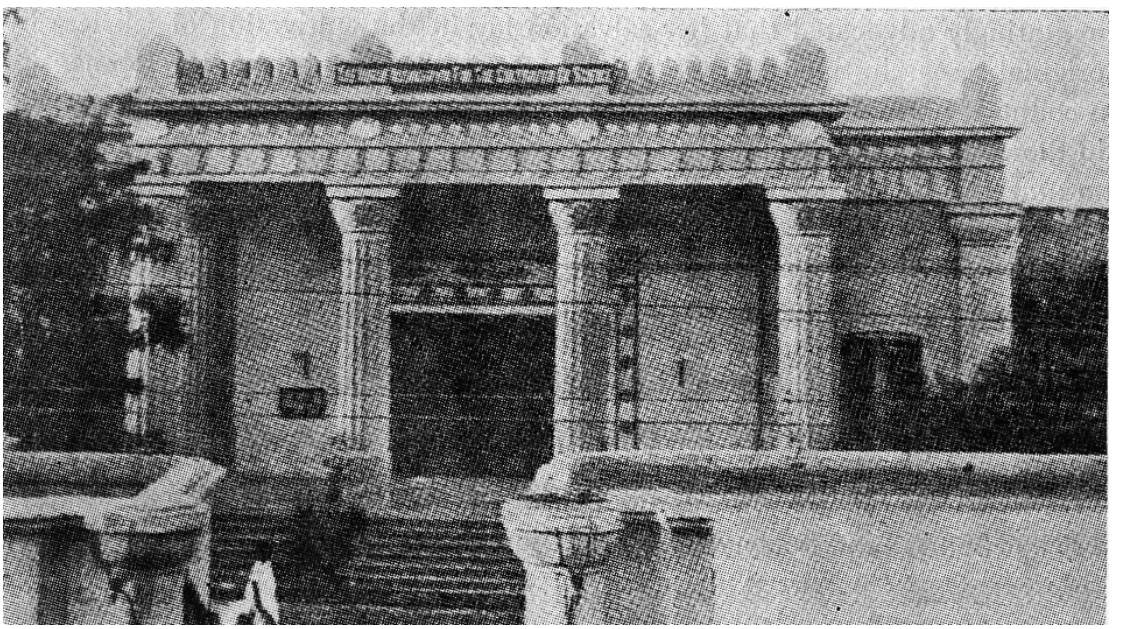
Mookerjee served as a lecturer of mathematics and mathematical physics at the Indian Association for the Cultivation for Science from 1887 to 1889. He presided over the first Indian Science Congress in 1914; was elected President of the Asiatic Society four times, a record in the annals of the Society up to his time. He also excelled as an eminent legal luminary of pre-independent India and his judgements as a Judge of the Calcutta High Court is still quoted as masterpieces of judgment.

Mookerjee's long association with Calcutta University started in 1889 as a Fellow and the same year he became a Member of the Syndicate of the University at the age of 25. He served as President of the Board of Studies in Mathematics. In 1906, Mookerjee was invited by the Viceroy of India, Lord Minto, to be the Vice Chancellor of the University. He remained as Vice Chancellor for four consecutive two-year terms till 1914. He was again appointed as Vice Chancellor in 1921 and remained in the post till 1923. He did not continue further as Lord Lytton tried to impose conditions on his appointment. He is best known for his pioneering role in broadening the scope of higher education in the country. As Vice Chancellor of Calcutta University, he started postgraduate studies and research in the University and integrated teaching and research at the university level for the first time in the country. Before Mookerjee became the Vice-Chancellor, Calcutta University was merely

an examining body. Mookerjee started some post-graduate departments in science. He also played an instrumental role in strengthening the teaching of arts subjects. Mookerjee was responsible for the foundation of the Bengal Technical Institute.

Asutosh Mookerjee's Father and Mother

As Vice Chancellor, his priority was to establish post-graduate teaching departments, both in science and arts. His move was strongly opposed by the British Government. He could not expect any additional financial support for his move. However, Mookerjee achieved his goal against all odds. He could achieve his goal because of the spontaneous support from TaraknathPalit and Rash BehariGhosh. TaraknathPalit made an initial donation of Rs.13.66 lakh to the University for two Professorships– one each in chemistry and physics. Palit also donated to the University a plot of land and a residential building. The first Palit Professorship was offered to Prafulla Chandra Ray who took up the assignment in 1916 after his retirement from the Presidency College.



The original building of Indian Association for the Cultivation of Science at at Bowbazar, Kolkata

The new building of Indian Association for the Cultivation of Science in Jadavpur, Kolkata

Mookerjee invited Chandrasekhar Venkata Raman to become the first Palit Professor of Physics. Raman joined the University in 1917. Rash BehariGhosh made an initial donation of Rs.10.46 lakh, out of which four Professorships were created, one each in applied mathematics, physics, chemistry and botany. The first incumbents to these four Ghosh Professorships were: Ganesh Prasad, D.M. Bose, P.C. Mitter and S.P. Agharkar. During 1919-21, Rash BehariGhosh made another donation of Rs. 14 lakh, out of which the technology faculty with a department each in physics and chemistry was established.

Mookerjee appointed Meghnad Saha, S.N. Bose, and S.K. Mitra as lecturers in the Physics Department. Saha and Bose were first appointed in the Department of Applied Mathematics, but they were transferred to the Physics Department at the instance of Mookerjee. The persons who were hand-picked by Mookerjee in various positions in the science and art faculty of the Calcutta University earned international fame. It was Mookerjee who brought S. Radhakrishnan, then a lecturer in Mysore University, to Calcutta University.

Asutosh was born in Calcutta (now Kolkata) on 28 June 1864 to Gangaprasad Mukhopadhyay and Jagattarini Devi. His father was a well-known physician, and his mother was known to be a woman of courage and considerable strength of character. He was highly devoted to his mother and never went against the wishes of his mother. So when he was personally nominated by Lord Curzon, the then Viceroy and Governor General of British India, as the representative of the citizens of Kolkata to attend the coronation of King Edward VII, he declined the offer as his mother did not want his son to go abroad. It has been reported that Lord Lytton told Asutosh: "Tell your mother the Viceroy and Governor General of India commands her son to go." To this Mookerjee replied: "Then I will say that AsutoshMookerjee refuses to be commanded by any other person except his mother, be he Viceroy or somebody higher still."

Mookerjee studied at the South Suburban School from where he passed the Matriculation examination from Calcutta University in 1879. He then joined Presidency College. He passed the FA examination in 1881 and joined the BA course. While an undergraduate student, he published a research paper in mathematics in the journal *Messenger of Mathematics.* The paper was titled "Some extension of a theorem of Salmons". In 1884, he passed the BA examination, standing first in the university. H.G. Reynolds, the then Vice-Chancellor of Calcutta University, in his Convocation Address referred to Mookerjee's achievement: "The senior wrangler of the year, if I may borrow the phrase from Cambridge, is AsutoshMookerjee of the Presidency College who stands first in the list of BA graduates and is in receipt of the Ishan and Vizianagram Scholarships and HurrishChander Prize." The same year, in which he passed his BA examination, Mookerjee was elected a member of the London Mathematical Society. *The Statesman* in its12 February 1884 issue wrote: "We understand that BabuAsutoshMookerjee, who stood first in the last BA examination, has been elected a member of the London Mathematical Society. He is the first Indian on whom the Society has conferred this honour."

Mookerjee passed his MA examination in mathematics, securing the first position in the order of merit in 1885. C.P. Ilbert, the then Vice Chancellor of Calcutta University mentioned Mookerjee's outstanding performance in his Convocation Address: "In the MA examination Mr. AsutoshMookerjee to whose achievements my predecessor referred to in 1884 retains his pre-eminence as a mathematician, and for the sake of the profession to which I belong, I am glad to see that he has devoted himself to the study of law and has carried off the gold medal recently offered for competition among law students by my friend Maharaja Sir JyotindraMohun Tagore." He received his MA degree in Natural Science too from Calcutta University in 1886. The same year he qualified in the special competitive examination for the award of the prestigious Premchand Roychand Scholarship. He also studied law at the City College and stood first in all the three examinations of law. Consent from his mother. For a brief period, he served as the Chief Justice of the Calcutta High Court.

Asutosh Mookerjee died on 25 May 1924 in Patna, Bihar where he had gone in connection with his legal practice. Remembering Mookerjee, Michael Sadler, who was Chairman of Calcutta University Commission during 1917-1919, wrote: "In Asutosh Mookerjee India has lost one of her greatest men; the world one of its outstanding personalities. He was mighty in battle. He could have ruled an empire. But he gave the best of his powers to education because he believed that in education rightly lie the secret of human welfare and the key to every empire's moral strength."

Subodh Mahanti

Yelavarthy Nayudamma

YelavarthyNayudamma (10 September 1922 –23 June 1985) was a chemical engineer and scientist. He was born in the remote village of Yelavarru in Andhra Pradesh as the eldest son of Anjaiah, a farmer and Raghavamma. Joseph H. Hulse, of International Development Research Centre (Canada), described Nayudamma in these words, "*For more than a decade and a half I had heard him advance the concept of 'technologies for humanity', of the need 'to apply high-level science and technology to ground level problems', to bring modern science to bear on the problems and needs of the rural poor*."

YelavarthyNayudamma went to a primary school in Yelavarru and high school in Thirumella. From A.C. College, Guntur where did his Intermediate, he went on to earn his undergraduate degree in Industrial Chemistry at Banaras Hindu University, Varanasi. Then he joined the Madras Law College. At around this time his path crossed that of SeshachalamChoudhary, who was the Head of the Leather Technology Institute in Madras(now Chennai) and also a Member of the Leather Research Committee set up by the Council of Scientific and Industrial Research (CSIR).This fortuitous meeting turned his attention to leather research. Nayudamma joined the Institute of Leather Technology in 1943 at a salary of Rs.17 per month. Subsequently, he was sent to the UK by the Government of India for advanced training in leather science. He earned his doctoral degree from Lehigh University, USA. On his return to India, he joined CSIR-Central Leather Research Institute (CLRI), Chennai in 1951. He served as Director CLRI from 1958-1973.

At just 36 years of age, when he was interviewed for the post of Director CLRI, the Prime Minister asked what a young man like him could do for the Leather Industry. He replied, "I'll endeavour to infuse scientific temper to the tradition-bound (practices of the) leather industry, being pursued by the socially and economically downtrodden leather

artisans and help in their socio-economic uplift." His answer touches the heart even today. On 27 August 1971, he took over as Director General of CSIR – a conglomerate of scientific institutions that he would deftly steer till 27 June 1977.On 12 June 1981, he assumed charge as Vice-chancellor, Jawaharlal Nehru University; a post he graced for sixteen months before returning to CSIR-CLRI and his true love– leather research.

Dr. Nayudamma is remembered most for his commitment to social inclusiveness. His dream was to synergise research laboratories with Academia and Industry for the benefit of the underprivileged. This mission earned him the epithet "People's scientist", but he always called himself "a farmer by birth and cobbler by profession." From his words, it is clear how closely he identified himself with the people he served. He was acutely aware that the leather workers were an ostracised section of society. He realised that much of the stigma arose from the noxious effluents and stink that emanated from the processing of hides for leather. He decided to use modern science to address the problem. His efforts in this direction led to modernisation of methods and the minimising of foul emissions.

However, he took care never to push the use of modern technology at the cost of overwhelming the humble traditional practitioners of the craft. He managed this by creating 'extension workers' who lived in the villages and demonstrated the use of know-how. Dr. Nayudamma called it the 'show-how' of the 'know-how'! The workers requested the tanners to use 'CLRI-medicine packets' and judge for themselves if the packages worked. It is no surprise that this unobtrusive way of introducing a new technology won over the tanners without antagonising them. Dr. Nayudamma also established Poly-Technology Clinics to encourage the scientists and the ultimate users to come closer. These Clinics provided great service to the small-scale entrepreneurs by identifying their problems and customising the necessary technological solutions.

In one of the early examples of inter-disciplinary approaches to ushering in technology-led change, Dr. Nayudamma brought together eight CSIR laboratories with expertise in diverse fields such as physics, chemistry, geology, water, instrumentation, and structural engineering. Karimnagar– a remote district in Andhra Pradesh was identified as the first beneficiary of a project that envisaged overall improvement using an innovative multi-pronged approach. The project involved scientists in not only testing the soil, repairing/updating instruments and providing the necessary interventions but also in paying attention to other, more personal, aspects. Purifying the drinking water, helping improve the nutrition of the people all came under the aegis of this project, which was to be extended later to other districts. Dr. Nayudamma wished to show how even the most advanced of technologies such as satellite imaging could be used to address the simplest needs of a humble farmer. Unfortunately, this pioneering project dedicated to social

inclusive and affordable innovation and which excited even the World Bank President did not witness the success it deserved. Perhaps it was an experiment ahead of its time.

However, Dr. Nayudamma's efforts were rewarded in the area of leather research. CSIR-CLRI established itself firmly on the world's leather map; a position it has consolidated over the years. The world recognised his sterling contributions to science and society and called him to the global platform. He served as Senior Consultant and Adviser to various United Nations technical agencies, such as FAO, UNDP, UNIDO and UNESCO. He was on the Board of Governors for International Development Research Centre (IRDC), Canada. As a consultant to the UN, Dr. Nayudammacatalysed the growth of the leather industry in countries such as Ethiopia, Iran, Kenya, Nigeria, Rwanda, Somalia, Sudan, Tanzania, and Turkey, to name a few.

Dr. Nayudamma seeded early awareness about environmental issues when he created a division in CSIR-CLRI dedicated to developing technologies for wastewater treatment in tanneries and persuaded tanners to establish a waste water treatment plant based on CSIR technologies. He was not one to sit on his laurels, and he knew that only a prepared mind is ready to face the challenges of the future. In 1965, he established the National Centre for Leather and Allied Information at CSIR-CLRI and carried out 'Futurology' exercises to predict future trends in global leather technology.

Dr. Nayudamma was a good mentor. He was instrumental in introducing a scheme, named Package Deal, in CSIR wherein Indian scientists and technologist who had settled abroad, were invited back. The 'package' included industrial licences, capital goods licences, import licences, access to industrial infrastructure, and other necessary assistance. He believed in investing in youth because in their hands lay the future of the nation. He was sent abroad by the Government of India to personally spot brilliant young scientists in an attempt to reverse brain drain. One such scientist was Ragunath A. Mashelkar, who came back to India to join CSIR-National Chemical Laboratory in Pune and went on to head CSIR. Dr. Nayudamma's way of working was understated, yet extremely effective. Unassuming in manner, managing by consensus yet decisive, he could politely stick to his decision in the face of pressure.

Dr. Nayudamma overcame the humble circumstances of his birth to rise to the top as a Scientist-bureaucrat. He remained rooted in rural realities; his heart beat for the tanners and farmers...the sons of the soil. He was dedicated to social inclusive; his vision was a holistic one. For example, he wanted a cluster of industries to be set up around every species of plant being cultivated. The paddy plant could serve not only as a source of rice and rice bran oil but the straw could be used to make cardboard boxes, wrapping paper, roof thatch, bed for mushroom cultivation and of course, animal fodder. Paddy

husk could be used as fuel and the ash used to produce sodium silicate, solar-grade silica, silica sol, ceramic material and refractory products. It could also be used to make particle board, furfural fillers, paddy husk bricks...the list is endless. As Dr. Nayudamma saw it, everything from "leaf to root" could be used; 25 industries could be sustained by sugarcane while cotton and groundnut could cater to 7-12. It is incredible how deeply he had thought through the clustering of industries around a single plant/animal/fish. Converting waste to wealth is a matter of immense importance today; Dr. Nayudamma was a pioneer in this area too.

His clarion call in 1974 was "*The country today is in a crisis in which everybody has to give up something. Let us, in all fairness, give up our...non-profitable, individual-oriented researches and concentrate on a few nationally relevant technological tasks as multi-disciplined, multi-organisational projects which are time-targeted*." Dr. Nayudamma received several awards and recognitions in his life. Some of the notable ones are PadmaShri of the Government of India, Fellowships of the Indian Academy of Science and the National Academy of Science. However, perhaps the most lasting legacy of all was in the ripple effect he created in the lives of the ostracised cobblers and tanners. In the words of his biographer, K. Chandrahas, "*He lives in the lights of the lamps that he lit in the homes of people of tanners and cobblers, treated as untouchable, neglected and ignored for centuries. Stigma removed; leather industry is like any other industry*."

There is much talk about "Making a difference." Dr. Yelavarthy Nayudamma walked the talk; he made a perceptible and visible difference. He touched the lives of thousands. He remains relevant today, decades after his death. The *Kanishka* air crash did not just take away a person who had become a legend in his lifetime, but someone who 'walked with Kings yet lost not the common touch'...it took away a scientist who still had much to give the world.

Sukanya Datta

Autar Singh Paintal

Autar Singh Paintal (24 September 1925– 21 December 2004) was such a giant figure in the field of cardio-respiratory sensory physiology that his peers such as Nobel laureate Cornellie Heymans coined the terms "Pre-Paintal" era and "Post-Paintal" era to refer to the impact of his discoveries in physiology. It can safely be said that his contributions opened new vistas in physiology.

Autar Singh Paintal was born on 24 September 1925 in the ruby mining town of Mogok, Burma (now Myanmar) to Man Singh, a physician in the British Medical Services, and RajwansKaur. He received his early education at St. Paul's School in Rangoon and St. Peter's School in Mandalay. From Mandalay, the family moved to Kalaw, where he attended Kingswood School. He changed schools often because of his father's nationalistic fervor that transferred hm often across towns. These were "punishment postings" to remote "mosquito-infested towns." A year before Autar Singh passed away; he had the opportunity to visit his school in Mandalay and to see that the goalposts on the football field where he had played with gusto in his school days remained untouched by time. To his joy, there were other children playing there as he watched from the sidelines.

As a kid, Autar Singh used to go fishing in the moat around the palace in Mandalay and was caned so often for playing truant that he took to wearing two pairs of shorts to lessen the pain of the punishment! Many who knew him believe that this was an early indication of his ability to find simple, yet effective solutions to vexing problems. He moved to Lahore to live with an aunt because Japanese occupation of Burma seemed imminent. He was fourteen and was admitted to Khalsa High School from where he completed his matriculation. Although under a lot of peer pressure from his cousins who went to fancier schools, young Autar Singh held his own by excelling in studies. It was on the River Ravi

that he picked up boating skills...later in life, he would own a yacht which he would sail on the River Yamuna when he went bird watching or entertained his friends.

He studied for the Intermediate Examination at the Forman Christian College, Lahore. In 1943, thanks to financial aid from the Burmese Government, he could take admission in King George's Medical College, Lucknow. He had to sign a bond that he would serve Burma after completion of his medical studies. Unfortunately, when he got his degree, conditions prevailing at the time prevented him from travelling there.

As a youngster he had spent a lot of time observing his father at work; perhaps that early exposure had lit the flame of interest in physiological responses and medical procedures to prime him intellectually for the role he played later in life. His results were spectacular, and he was awarded the coveted Hewitt Gold Medal for getting the highest marks in the MBBS examination. He subsequently earned his MD degree (Physiology) from the same institute. His thesis was entitled "Electrical resistance of the skin in normals and psychotics." He chose the topic himself and worked unaided on the project, often making the required apparatus with his hands. He collected an extraordinary amount of significant data which he arranged in an index devised by him. He called it the 'Paintal Index.' For many years, till more advanced methods became available, it remained a valuable compilation of data.

He was soon appointed as a Lecturer in the Physiology Department of King George's Medical College. However, in 1952 he received a Rockefeller Fellowship which allowed him to join the Physiology Department of the Medical School, Edinburgh, the UK where he began to work for his Ph.D. degree under David Whitteridge. His interest in electrophysiology of visceral sensory receptors was catalysed during this time and remained a lifelong passion.

Very early in his research, he pioneered two innovative techniques in electrophysiology. The first one involved immersing nerves being dissected in liquid paraffin and recording from them. Interestingly when he first tried out the technique, Whitteridge warned him that many others before him had failed. A friendly warning was issued, "You are throwing away the Professor's box, you know! I hope you have a return ticket on the ship to Bombay." To the apprehension of his peers, Paintal persisted... to be rewarded with success and Whitteridge's generous appreciation. His second pioneering technique involved injecting certain chemicals into the circulatory system to discover 'silent' sensory visceral receptors. So dramatic were the results of these techniques that he was elected to the British Physiological Society in 1953.

He returned to India after obtaining his Ph.D. and joined the Technical Development Establishment Laboratories of the Ministry of Defence in Kanpur as a Technical Officer. There he served from 1952 to 1954. However, he soon moved to the Vallabhbhai Patel Chest Hospital, Delhi as Assistant Director and served there till 1956. Over 1956-1958, he served as Visiting Professor at Albert Einstein College of Medicine, New York, USA, University of Utah, Salt Lake City, USA and University of Göttingen, Germany. In 1958 he joined the Physiology Department of the All India Institute of Medical Sciences (AIIMS), New Delhi, as Research Professor and served for six years. He joined as Director of the Vallabhbhai Patel Chest Institute in 1964.From 1986 to 1991 he graced the post of Director-General of the Indian Council for Medical Research (ICMR).From 1990 onwards he was also Program Director of the Centre for Visceral Mechanisms at the VP Chest Institute.

Paintal's main assignment at his first job in India included testing clothes and drugs for the Army. It allowed him to pursue his real interests and soon he discovered gastric stretch receptors. These receptors control the amount of food and water that a person takes in. He realised that these receptors constituted the peripheral mechanism for the immediate satiation of hunger and thirst. This discovery catalysed the study of the electrophysiology of the gastro-intestinal tract.

During his Ph.D. studies, he achieved a breakthrough by developing the single-fibre technique for recording afferent impulses from individual sensory receptors. This technique stood him in good stead. During the years spanning 1952-1960, he discovered several sensory receptors in the viscera. These included type-B receptors, ventricular pressure receptors, gastric stretch receptors, mucosal mechanoreceptors of the intestines, and the pain pressure receptors of muscles. He cleared up misconceptions about some of these receptors too. For example, he showed that the type-B atrial receptors were located in the atrium (heart) and not in the great veins/pulmonary veins as Whitteridge believed. In 1955, he described the location of ventricular pressure receptors. He is best remembered for his discovery of J-receptors. He introduced the concept of viscera-somatic inhibition and showed that J-receptors were responsible for the J-reflex–a feedback mechanism. It had been known for long that muscles need to be protected from the effects of metabolites produced during physical activity. Paintal's work revealed the body's in-built mechanism to do so. Stimulation of these receptors gives rise to breathlessness and limits muscle activity during exercise.

His work demonstrated that the reflex-mediated termination of exercise provided protection against excessive pulmonary pressures. He showed that the J-reflex explained the rapid heartbeat, breathlessness, dry cough and throat sensations associated with such heavy exercise. J-receptor activity also explained the occurrence of symptoms associated with certain types of heart failure, some lung diseases, and blockage of major lung vessels

(pulmonary embolism). In all these cases, there is an increase in pressure in the capillaries of the lung. His work on the conduction and block in mammalian nerves enabled the distinction between the myelinated and non-myelinated nerve fibres. In the early days when AIDS was just spreading its tentacles in India, it was Paintal's clarion call for awareness that was one of the first alerts for the nation.

Apart from his scientific successes, Paintal is remembered for setting up the Society of Scientific Values. Its main objective was to promote integrity, objectivity and ethical values in the pursuit of science.

His personal life was as fulfilling as his scientific career. In 1949 he married Iris Clara Helms, who was also an accomplished pianist. They had two daughters and a son. The marriage was dissolved in 1985. Three years later, he married AshimaAnand with whom he collaborated to carry out research. The scientist couple collaborated to study the many facets of the J-receptors, including high-altitude physiology and the breathlessness triggered by exertion. This had great relevance to the physiology of the armed forces stationed at strategic locations in high altitudes. Paintal and Anand also introduced a new method to measure (*in vivo*) the blood concentration of J-receptor excitants and showed that these diffuse out of the capillaries and are not filtered out.

Paintal received many honours and awards. Chief amongst these was Fellowship of the Royal Society of Edinburgh (1966), and election to the National Academy of Medical Sciences, and the Indian National Science Academy. He was the first medical scientist to be elected Fellow of the Royal Society (The UK, 1981). He was awarded the Padma Vibhushan in 1986.

Sukanya Datta

Benjamin Peary Pal

Benjamin Peary Pal (26 May 1906 –14 September 1989) known for his seminal work on agriculture and horticulture was recognised as a "Scientist's Scientist" in his lifetime. His multi-faceted contributions encompassed areas as different as research, education, policy-making institution building, outreach programmes, and international cooperation. He was the first Indian Director-General of the Indian Council of Agricultural Research (IARI), New Delhi. Nobel laureate Dr. Norman Borlaug, one of Agriculture's greatest spokesperson, has gone on record stating, "*It was during Dr Pal's leadership that the agronomic research on wheat in India equalled the best in the world. He was truly the architect of India's Green Revolution.*"

Benjamin Peary Pal's research was crucial to the development of superior quality, high-yielding, disease-resistant varieties of wheat; particularly to the rust-fungus. Green Revolution in the nineteen sixties transformed India's begging bowl to a bread basket for all. Anyone who played a significant role in that transformation deserves the gratitude of the nation. Benjamin Peary Pal deserves these best.

He was born in Mukandpur, Punjab to Medical Officer Rala Ram and Inder Devi. He was the youngest of nine children (three of whom did not survive infancy). He was originally named Brahma Das Pal, but in 1914, when he entered St. Michael's School in Maymyo (now Pyin U Lwin), Burma (now Myanmar), his name was changed to Benjamin Peary Pal. He was academically gifted and almost always stood first in class. He received his BSc degree in 1924 from the University of Rangoon. Then he did his MSc in botany (1929) winning the Matthew HunterPrize for topping all science streams in the University of Rangoon. He was awarded a scholarship. This allowed him to go to Cambridge, UK,

where he earned his Ph.D. in 1933. Interestingly, his thesis was on wheat-hybrids. He was one of the first to demonstrate the value of heterosis (hybridisation) in wheat; this foreshadowed subsequent work on rice and other staple cereals, globally. At Cambridge his interest in agricultural advances such as hybridisation was honed by exposure to talks by top-rated scientists, which expanded his mental horizons. In retrospect, it is interesting to see how the influences and choices, of his academic career, led to the moulding of Benjamin'sscientific personality. These trends manifest very early. St. Michael's school had a lovely rose garden, and many of the teachers could paint well. When Benjamin received a paint box as a prize for topping the examinations his love for roses converged with his love for painting, in which he received ample guidance. In later years, his love for roses would take a scientific turn and his talent for painting would give him creative avenues to explore all his life. Later on, the research he did for his Ph.D. thesis would stand him in good stead in ushering in India's Green Revolution.

In March 1933 he was appointed Assistant Rice Research Officer, at the Burmese Department of Agriculture. However, just a few months later, he joined the Imperial Agricultural Research Institute (now IARI) in Pusa, Bihar as Second Economic Botanist. By 1937, he had been promoted to the rank of Imperial Economic Botanist. But tragedy had struck a year earlier when a devastating earthquake had seriously damaged the building at Pusa where he worked. In 1936, the institute was shifted to New Delhi; Pal too moved to the city. Post Independence, the Imperial Agricultural Research Institute was renamed the Indian Agriculture Research Institute. In 1950, Pal became its Director and later, also served as the Director General from (1965-72). At IARI, he reorganised the institute to make it more effective. He established the Plant Introduction Division at IARI to systematically search for desirable genes. This subsequently evolved to become the National Bureau of Plant Genetic Resources (NBPGR). During his tenure as Director General, Pal reached out to collaborate with the best. He chose Mexico for wheat research and Philippines for rice research.

Pal believed that the problems faced by the farmers in the field had to be solved on priority. "From lab to the field" was his motto. He realised the necessity of bringing together education and research with demonstration and training of farmers. He initiated the All India Coordinated Research Projects on crops, animals, and fisheries. This in turn catalysed the setting up of a large number of All-India Coordinated Research Projects, which helped connect the nation's State Agricultural Universities and the Central Institutes of the Council into an integrated national network. In later years, this served as a template for organising agricultural research in many developing countries. Palset up the Post-Graduate School at IARI and in 1958, it was granted the status of "deemed university" by University Grants Commission. The alumni of this institution have played a stellar role in consolidating the lead given by Pal and his contemporary agriculture scientists.

Some of the wheat varieties developed under Pal, were NP 809, NP 823, NP 824, NP 830, NP 825, NP 797, NP 798, and NP 799. NP 809 was the first Indian wheat variety that was resistant to all three types of rusts: stem rust, stripe rust and leaf rust and loose smut. Pal was convinced that agricultural productivity should be linked to sustainability and biological diversity. He introduced modern technology to breed new varieties of potato, tomato, and tobacco. He knew that scientific productivity had to be sustainable and for that, a continuous chain of young researchers was mandatory; as was an active collaboration with diverse partner institutes.

Pal's childhood love for roses never left him. He was an excellent rose breeder who created many new varieties; some named after eminent scientists such as HomiBhabha and C.V. Raman. He was founder President of the Rose Society and Bougainvillea Society. He was the first Chairperson of the National Committee on Environmental Protection and Coordination. He was also a prolific author and wrote both research papers and scholarly books alongside popular articles. His books namely: *The Rose in India*, *Beautiful Climbers of India*, *Flowering Shrubs of India*, *Bougainvilleas and Environmental Conservation and Development,* were well-received. He also authored many monographs, including one on wheat.

He was a bachelor who took care of two unmarried sisters all their lives. Like many well-known scientists, his life was a true entwining of the arts and the sciences. In his words, "*The gate of life swings to and fro; all too soon it closes. That is why beside my door I like to grow red roses*." He donated his property, including the houses in New Delhi and Shimla, as well as his rare collection of roses to IARI. The doors of life may have swung close for Benjamin Peary Pal in 1989, but the results of his actions linger like the scent of roses in the air.

He was elected Fellow of the Royal Society of London (1972); Honorary Fellow, Linnaean Society, London; Foreign Member, Lenin All-Union Academy of Agricultural Sciences, and French Academy of Agriculture; Honorary Member, Japan Academy, Genetics Society of Japan. The nation honoured Dr. Pal with Padma Shri (1959); Padma Bhushan (1968); and Padma Vibhushan (1987). His memory too has been honoured by the scientific community. The Dr. B.P.Pal National Environment Fellowship Award for Biodiversity was instituted in 1993 by the Government of India. The Indian National Science Academy (INSA) has instituted the INSA B.P. Pal Chair to recognise distinguished scientists from all over the world and to facilitate their visit to India and interactions with the Indian scientist's in various scientific Institutions. The Indian Science Congress awards a Gold Medal in his memory once every two years. IARI organises the Dr. B.P. Pal Memorial Lecture annually.The Government of India released a memorial stamp the

'Father of Roses in India' in tribute for developing different varieties of roses, was released in 2008.

Paying his tribute to Dr. Pal, one of his students Dr. H.K. Jain wrote, "Dr. Pal will also be remembered for grooming a large number of young scientists who rose to take up important positions in the field of agricultural research and development in India in later years. Nothing gave him greater pleasure than helping bright young scientists to develop their full potential and make important contributions."

Sukanya Datta

S. Sivasankaranarayana Pillai

SubbayyaSivasankaranarayanaPillai (5 April 1901 – 31 August 1950) was an Indian mathematician specialising in number theory. His contribution to Waring's problem has been described as "almost certainly his best piece of work and one of the very best achievements in Indian Mathematics since Ramanujan".SrinivasaRamanujan, one of the greatest mathematicians of all time, has virtually eclipsed in the popular imagination, other Indian mathematicians of his generation. The untimely death of Ramanujan did does not deter spread of his influence during the early years of India's forays into modern mathematics. With the establishment of Indian Mathematical Society and its journal, mathematics gained a fillip during the early nineteenth century. British mathematicians such as G.H. Hardy encouraged and provided patronage to these budding young mathematicians. Although since the 1970s, Indian mathematics has gone well beyond number theory to embrace many other emerging frontier areas, number theory continues to be an important component of Indian mathematics research even today.

Generations of mathematicians have been inspired by Ramanujan's eventful life of struggle and tribulations. Mathematicians who followed in Ramanujan's tradition include names such as K. Ananda Rau, S.S. Pillai, T. Vijayaraghavan, S. Chowla, L.G. Sathe, S. Minakshisundaram, and K. Chandrasekharan, who have done worthy of mathematics as well as the country proud. Their contributions, mostly in number theory, established what came to be known and internationally acclaimed as the Indian school of number theory. Of these men of mathematics, S. SivasankaranarayanaPillai, popularly known as S.S. Pillai, whose life was also cut short by a plane crash when he was just 50 years old, has a special place in the annals of number theory.

S.S. Pillai was born in Vallam near Courtallam, in Tirunelveli district of Tamil Nadu. His parents were Subbayya Pillai and Gomati Ammal. His mother died just a year after his birth, which placed S.S. Pillai in foster care. As was the custom in those days, when he attained the age of five, home tuition was arranged to teach the child rudiments of reading, writing, and arithmetic. At the age of nine, Pillai was enrolled at a government middle school at Shencottah. His father passed away, while Pillai was still a student at high school, which made his educational future uncertain. Considering his orphan status and realising his potential, one of his school teacher called 'Sastriar' not only provided emotional succour but also came forward to meet his educational expenses. Thanks to the support from his teacher, Pillai was able to complete his matriculation exam. His academic performance in the school earned him a scholarship which enabled him to complete his intermediate at Scott Christian College, Nagercoil and BA at the Maharaja's College (now University College), Thiruvananthapuram. Encouraged by a student research fellowship with a stipend awarded by the University of Madras, Pillai moved to Madras (now Chennai) in 1927.

It was at the University of Madras that Pillai came into contact with able teachers and mathematicians of repute like Ananda Rau and R. Vaidyanathaswamy. Pillai carried out research in number theory and obtained his Ph.D. under Ananda Rau. During his graduate student days, Pillai made interesting contributions to mathematics.

After obtaining his Ph.D., Pillai joined Annamalai University as a lecturer, where he continued to undertake research along with strenuous teaching work load. Most of his seminal work was done during the period 1929-1941 when he was a lecturer in Annamalai University. His contributions to mathematics during this period were so much acclaimed by the world of mathematics that, the University of Madras honoured him with DSc for his research achievements. In fact, he was the first to be honoured with such a research degree in mathematics by the University of Madras. Subsequently, he shifted to the University of Travancore in 1941. A year later, he joined Calcutta University as a lecturer.

Pillai's mathematical achievements were acclaimed internationally and the Institute of Advance Studies, Princeton, USA, which later become the home of Einstein, invited him to visit for a year. He also had received an invite from the International Congress of Mathematicians at Harvard University as a delegate of Madras University. While he was proceeding to the USA, on 31 August 1950, the plan carrying him met with a fatal accident near Cairo, and all the passengers perished. Indian Mathematical Community lost one of the best-known mathematicians.

The crowning glory of S.S. Pillai, who worked mostly in the area of analytical number theory, is his seminal contribution to solving Waring's Problem. Edward Waring,

an English mathematician, known for his penchant for obscure areas of mathematics, in 1770, in his book *MeditationesAlgebraicae*, made the statement that "every positive integer is a sum of nine cubes, is also a sum of not more than 19 fourth powers, and so on." Some simple computations show that 7 requires four squares, 23 requires nine cubes, and 79 requires 19 fourth-powers; these examples show that $g(2) \geq 4$, $g(3) \geq 9$, and $g(4) \geq 19$. Waring conjectured that these values were, in fact, the best possible.

This became what is now known as 'Waring's Conjecture.' This conjecture states that for a given positive integer "k" there is a number depending only on "k," say "g," such that every positive integer can be expressed as a sum of at most "g" number of "k-th" powers. In the very same year, Lagrange had proved that every positive integer could be written as a sum of not more than four squares.

Let us understand this with an example. Let k=2. That is we are talking of squares. Now the square numbers are 1,4,9,16,25,36,49,64.... and so on. Suppose you want to write a number, say 103, as the sum of squares.

You can write 103 as 1+1+1+... (103 times). Note, 1 is a square number.
Or you can write 103 as 4+4+.... (25 times)+1+1+1.

Alternatively, you can write 103 as (sum of squares)
1+1+1+25+25+25+25
1+1+1+36+64
1+4+49+49

Now the least number of squares needed to write 103 as the sum of squares are "4." We say g(2)=4.

Now you may say $25=5^2$. It needs only one square. Sure ..

Also $29= 2^2 + 5^2$, which need only two square numbers to express as a sum

30 = 1+4+25, that is, you need only three squares.

What the theorem implies is that if you take any arbitrary number, however huge, say,

98467239765106633003, then you need only a *maximum* of four square numbers A, B, C,D
such that A+B+C+D =98467239765106633003

Perhaps you can write 98467239765106633003 as the sum of three squares m,n,p. Perhaps you can also write it as the sum of five squares a,b,c,d,e. That is not the point. It needs just a maximum of four squares. In fact, the conjuncture states that for ANY x, a positive integer, you need to find four or less square numbers to express it as a sum of squares. This is the real implication.

Now move to cubes. Waring claimed that g(3)=9. That is, for ANY number x, you need at-most NINE cube-numbers to express it as a sum.

Although Waring made these claims, the final proof for the case of g(3) was given by Wieferich (1909) and Kempner (1919), and for the case g(2), the famous Lagrange proved it, coincidentally in 1770, the very same year the conjecture was published by Waring.

Over the years various bounds were established, using increasingly sophisticated and complex proof techniques. Some mathematicians including Hardy and Littlewood attempted to find the formula. For example, Liouville showed that g(4) is at most 53, while Hardy and Littlewood showed that all sufficiently large numbers are the sum of at most 19 fourth powers. An important technique used to tackle Waring's problem is the 'circle method'; originally developed by Srinivasa Ramanujan to study the asymptotics of the partition function. This was later used by Hardy and Littlewood to address Waring's problem.

In 1936 S.S. Pillai (as well as independently by Dickson, and later improved by Niven) was able to show that for k> = 6

$$g(k) = 2^k + \left[\left(\frac{3}{2}\right)^k\right] - 2$$

provided that

$$2^k \left\{\left(\frac{3}{2}\right)^k\right\} + \left[\left(\frac{3}{2}\right)^k\right] \leq 2^k.\#$$

In the case of (#) not holding true also they have given the formula, g(k) will be one less than the term on the RHS of the above formula.

Pillai's work in solving Waring's problem is a significant advancement of number theory. Renowned mathematician, K. Chandrasekharan in his obituary on Pillai says, his work on Waring's problem was "almost certainly his best piece of work and one of the very best achievements in Indian mathematics since Ramanujan." Famous British mathematician, Littlewood said 'Dr. Pillai's work is fresh and original. I consider him as one of the very best of Indian mathematicians." His contemporary, T. Vijayaraghavan

said, "Since the time Ramanujan died, the work of no other Indian mathematician has brought to Indian mathematics greater credit than Dr. Pillai's on Waring's problem."

S.S. Pillai was interested in Diophantine equations as early as 1930 and subsequently, during the 1940s he investigated a linear Diophantine equation and the question of Diophantine approximation, which was studied by Hardy and Littlewood using continued fractions as well as by transcendental methods. In addition to this, his work on Diophantine approximations and his elegant new proof of Bertrand's Postulate are also significant. He also studied irrational numbers. He also extended Ramanujan's work on highly composite numbers.

Although a doyen of mathematicians, Pillai was simple in his living and humane in approach to others. He was a man of honesty known for thrift and humbleness. He used to serve food in traditional South Indian style; food served on plantain leaves and the guest seated on the floor and using her or his hands to eat the filling, tasty, tangy South Indian food. He had strong views on public issues and opposed the atomic bomb as unethical and wanted nations to refrain from its first use. He also supported India coming out of Commonwealth even while English is retained as a link language. Once, an editor of a newspaper wanted to get his photograph. Shy of projecting himself, Pillai initially refused and could be persuaded only when the photographer lied that he had been tasked to take photograph by the Institute of Advanced Studies. Even then he refused to wear a coat saying that he wanted his picture to be "just as I am, with warts and all."

T.V. Venkateswaran

G.N. Ramachandran

Gopalasamudram Narayana Ramachandran (8 October 1922 – 7 April 2001) is seen amongst the best of researchers for his contribution to the discovery of the triple-helical structure of collagen. Ramachandran was drawn to collagen by J.D. Bernal's remarks that structural proposals for collagen were unsatisfactory. Bernal made these remarks in a casual conversation during his visit to Chennai in 1952.

The triple-helical structure of collagen was first published in 1955. Ramachandran co-authored the paper with crystallographer Gopinath Kartha. Their concept of the coiled-coil structure was a fundamental advancement in understanding polypeptide structures. The coiled-coil structure of collagen means each of its three polypeptide chains is arranged together in the form of a helix, and then three chains together form a second helix.

Ramachandran and his team introduced a two-dimensional map; now known as the "Ramachandran phi-psi diagram" or simply "Ramachandran plot". This provided a rational basis to describe stereo-chemically possible structures of polypeptides. The triple-helical structure of collagen proposed by Ramachandran is an important milestone in molecular biology. Ramachandran had many lucrative assignments for research in advanced western countries but like his mentor, C.V. Raman, he decided to work in India against all odds.

Ramachandran was born in Ernakulam near Kochi (then Cochin) in Kerala. He was the eldest son of G. R. NarayanaIyer and Lakshmi Ammal. His father was a well-known professor of mathematics in Maharaja College of Cochin, who retired as its Principal. Ramachandran was greatly influenced by his father; about whom he said: "Because of

his ability and thoroughness he became the most senior and respected member of the department and retired as the Principal. He had a very sharp mind in mathematics, and he used to teach me mathematics. I had been exposed to most of the theories in analytical geometry even before I went to college. When I was in high school, he would bring books on mathematics from the library and give me some challenging theorems to prove every day. He would write equations and ask me to solve them. He was a wizard in mathematics." Ramachandran developed a deep interest in mathematics since his childhood.

Ramachandran had his early schooling in a government school in Ernakulam. After the Intermediate examination, in which he stood first in the entire Madras State, Ramachandran joined the St. Joseph's College in Trichy in 1939. Here he enrolled himself in BSc (Honours) degree in physics. Ramachandran's decision to study physics instead of mathematics in which he always got a perfect score of 100 was largely influenced by his father.

In this context, his biographer RaghupathySarma, who was also a student of Ramachandran, wrote: "Ramachandran, with his extensive interest and knowledge, could have easily studied for the honours degree in mathematics. But his father, himself a professor of mathematics, discouraged his son from joining the honours programme in mathematics. He rightly felt that Ramachandran already knew mathematics to such an extent that if he did join the honours programme, his college teachers would have "nothing new" to teach him. Therefore, he advised Ramachandran to join physics honours and ask for special permission to study chemistry in place of Mathematics as a subsidiary subject. Ramachandran always felt that this was a very wise decision on his part, as this introduction to chemistry helped him substantially in his later research". Among his teachers in St. Joseph's College who stimulated Ramachandran's interest in physics were P. E. Subramaniam and Father Rajam. Ramachandran stood first among all the physics honours students in the entire Madras Presidency.

Ramachandran's father wanted his son to take up the Indian Civil Service examination. However, he failed to persuade his son in doing so. He then sent Ramachandran to Delhi to take the Indian Railway Engineering Service examination. But even this was not liked by Ramachandran. It is said that he deliberately performed poorly in the examination to ensure that he was not selected. After this digression, Ramachandran joined the Electrical Engineering Department of the Indian Institute of Science, Bengaluru. However, soon he realised that his interests lay in physics and so he decided to switch over. It is very likely that his decision might have been influenced by the fact that at that time the legendary C.V. Raman was the Director of the Institute as well as the Head of the Department of Physics. Knowing Ramachandran's interest, Raman requested the Head of the Electrical Engineering Department to allow Ramachandran to join the Physics Department.

However, when the request was persistently refused, Raman told the Head of the Electrical Engineering Department: "I am admitting Ramachandran into my department as he is a bit too bright to be in yours…" And in this way Ramachandran not only came to the Physics Department, but he eventually became the most distinguished of Raman's students.

Ramachandran obtained his MSc degree in 1944 from the Madras University. In those days the Indian Institute of Science was not a degree granting institution. Ramachandran's thesis for his MSc degree contained the results of the theoretical and experimental investigations that he carried out on the propagation of light through optically heterogeneous media. The external examiner of his thesis was K.S. Krishnan, who was then Professor of Physics at the University of Allahabad.

After obtaining his Master's degree, Ramachandran continued his research work for a doctoral degree under the supervision of Raman. His doctoral research involved photo-elasticity and thermo-optic behaviour of different solids such as diamond, fused quartz, fluorspar, and zinc blende. Research publications resulting from his doctoral work contained some of the earliest applications of X-ray diffractions to the study of variation in the perfection of crystals. He also coined the term 'topograph' for such pictures. Ramachandran obtained his Doctor of Science degree in 1947 and decided to go to Cambridge to England to work in the Cavendish Laboratory, where Sir William Lawrence Bragg was the Director. Ramachandran succeeded in getting a prestigious scholarship for higher studies in England provided by the Royal Commission for the Exhibition 1851.

As he had already studied X-ray diffraction for his doctoral work at the Indian Institute of Science, he could easily become a part of the Cavendish group of crystallographers. However, he could not get the opportunity to work directly under Lawrence Bragg; he was assigned to work with W.A. Wooster. In Cambridge, he met Linus Pauling for the first time. This was a great time for young Ramachandran, at the time he was 25 years old. For Ramachandran, Pauling was a great hero, who had recently discovered the alpha-helical structure of polypeptides. Moreover, Ramachandran's vision of chemistry was shaped by reading Pauling's books and articles. Ramachandran admired Pauling throughout his life.

Ramachandran returned to India in June 1949 after his post-doctoral work at Cambridge and joined the Department of Physics of the Indian Institute of Science as Assistant Professor. He was made in-charge of the X-ray Diffraction Laboratory. After about two years Ramachandran shifted to the Madras University as Head of the Department of Physics. At the time Ramachandran was just 30 years old. C.V. Raman had recommended him for the post. The Department of Physics started functioning with two faculty members, Ramachandran in experimental physics and AlladiRamakrishnan in theoretical physics.

The department was first located in a single room of the main building of the University on the Marina beach in Chennai. Ramachandran's research work carried out at Madras University brought an unprecedented level of recognition to the University. He organised two international conferences in 1963 and 1965 and was successful in bringing some of most famous scientists in molecular biology and biophysics to Chennai; they included Linus Pauling, Severo Ochoa, Maurice Wilkins, and Paul Flory.

In 1970, Ramachandran came back to the Indian Institute of Science, Bengaluru, where he had earlier studied and worked. Satish Dhawan was the Director of the Institute. Ramachandran was given the responsibility of starting a new Department of Molecular Biophysics. The department, which was formally started in 1971, grew into a major centre of structural biology. Ramachandran was elected a Fellow of Royal Society of London in 1977. As a part of its Golden Jubilee Celebration, the Indian National Science Academy created five special research professorships and the first one; the Albert Einstein Research Professorship went to Ramachandran. P. Balaram and S. Ramaseshan in an editorial tribute in *Current Science* wrote: "Ramachandran was a clearly a Nobel Class scientist, to borrow a phrase from Eugene Garfield…His achievements will serve as a source of inspiration for generations to come. Ramachandran was undoubtedly one of the most outstanding scientists of post-independence India and truly, a jewel in the crown of India's science."

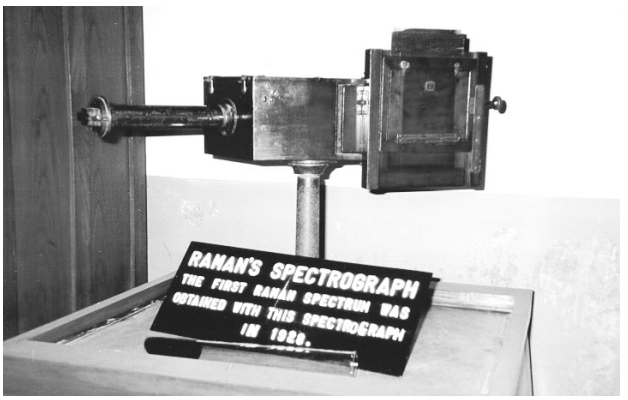
Subodh Mahanti

Chandrasekhara Venkata Raman

ChandrasekharaVenkata Raman (7 November 1888 - 21 November 1970), commonly known as C.V. Raman, was a legendary figure in modern Indian Science. He was the first Indian and an Asian to receive a Nobel Prize in science and remains so till date from the former perspective. There are three Indian-born scientists, namely HarGobind Khorana, Subrahmanyan Chandrasekhar, and VenkatramanRamakrishnan who are also Nobel Prize winners in science, but all of them were US citizens.

Raman's interests in science encompassed as far apart areas as astronomy, meteorology and physiology. He made many scientific discoveries in acoustics, optics, magnetism, and crystal physics. Raman's work on the musical instruments of India was epoch-making, which revealed the acoustical knowledge of ancient Indians. However, Raman's most celebrated discovery was the *Raman Effect*. Raman, jointly with K.S. Krishnan, experimentally demonstrated that light quanta (photons) and molecules do exchange energy, and that manifests itself as a change in the colour (wavelength) of the scattered light. It was the most convincing proof of the quantum theory of light. The phenomenon had been earlier predicted mathematically, but Raman first proved it experimentally.

Albert Einstein is commenting on Raman's discovery, said: "C.V. Raman was the first to recognise and demonstrate that the energy of a photon can undergo partial transformation within matter. I still recall vividly the deep impression that the discovery made on all of us." Raman's discovery had a catalytic effect on research in other parts of the world. It proved to be a powerful tool (Raman spectroscopy) in studying the structure of different materials. Raman Effect is considered as one of the most important discoveries in experimental physics of the early twentieth century.



Raman's spectrograph

It is interesting to note that Raman got interested in the phenomenon of light scattering during his return to Mumbai from London in 1921 aboard *S.S. Narkunda*. He was fascinated by the deep blue colour of the seawater. He could not stop asking the question: Why does the sea water look blue? His probing mind realised that Lord Rayleigh's explanation that the colour of the sea was just a reflection of the blue colour of the sky was not true. After coming back to Kolkata, he started doing serious experiments. He found the answer and got involved in further studies on light scattering.

Raman developed a vibrant and excellent school of physics in India. He established the Indian Academy of Sciences (1934) and the Raman Research Institute (1948). Both the institutions are located in Bengaluru.

Raman was a staunch patriot. In this context, it is worthwhile to quote Raman describing his impression on receiving the Nobel Prize: "When the Nobel award was announced I saw it as a personal triumph, an achievement for me and my collaborators – recognition for a very remarkable discovery, for reaching the goal I had pursued for seven years. But when I sat in that crowded hall I saw a sea of western faces surrounded me and I, the only Indian in my turban and closed coat, it dawned on me that I was representing my people and my country. I felt truly humble when I received the Prize from King Gustav; it was a moment of great emotion, but I could restrain myself. Then I turned around and saw the British Union Jack under which I had been sitting. It was then that I realised that my poor country, India, did not even have a flag of her own–and it was this that triggered off my complete breakdown."

Raman had great faith in India's potential for progress. He worked under the most trying circumstances. Raman believed in excellence *per se*. He never compromised on quality and firmly believed that if India was to make any economic advance it could only be based on such excellence. He had a great fascination for art and music. He was not confined to a particular narrow speciality. He believed that 'real fundamental progress is always due to those who had ignored the boundaries of science and treated science as a whole.'

Raman was a great populariser of science. "He was perhaps the greatest salesman of science has ever had in this country", said S. Ramaseshan, a pioneer of X-ray crystallography in India and a nephew of Raman. During his popular science lectures (or 'performances' as Raman called them) Raman held his audience spellbound. His lectures were always accompanied by demonstrations. Raman was a lecturer *per excellence*. Throughout his life, he lectured to diverse audiences. Raman also gave radio talks. The text of his nineteen talks was brought out in a book form. The book was titled *The New Physics: Talks on Aspects of Sciences*; it was published by the Philosophical Library in New York. The topics covered by Raman ranged from the microscopic world of atoms to the universe itself.

C.V. Raman was born on 7 November 1888 in his maternal grandfather's house, in a small village of Thiruvanaikaval near Tiruchirapalli (Trichinopoly in those days), on the banks of Kaveri in Tamil Nadu. Raman's maternal grandfather SaptarshiSastri was a great Sanskrit scholar, who in his younger days travelled on foot to distant Bengal (over 2,000 km away) to learn *navyanyaya* (modern logic). Raman's parents were R. ChandrasekharaIyer and ParvatiAmmal. Raman's father taught in a local school for many years, but later became a lecturer in mathematics and physics in Mrs A.V. Narasimha Rao College, Vishakapatnam in Andhra Pradesh. Raman passed his matriculation examination at the age of 11, and he passed his FA examination (equivalent to today's Intermediate examination) at the age of 13. In 1903, Raman joined the Presidency College in Madras (now Chennai) from where he passed his BA and MA examinations. He stood first in both the examinations and won all the prizes available.

While Raman was a student, he independently undertook original investigations in acoustics and optics. He was the first student of Presidency College, Chennai to get a research paper published, that too in a prestigious international journal. His first paper "Unsymmetrical diffraction bands due to rectangular aperture" was published in *Philosophical Magazine* (London) in November 1906. This was the result of Raman's measuring the angles of the prism using an ordinary spectrometer in his college. His first paper was followed by a note, on a new experimental method of measuring surface tension, which also got published in the same journal. Lord Rayleigh, an outstanding mathematical physicist and good experimenter, who was awarded the Nobel Prize for the discovery of argon, took note of the papers published by Raman as a student. Raman and Lord Rayleigh exchanged some correspondences. It is interesting to note that Lord Rayleigh addressed Raman as Professor.

Though Raman proved his brilliance in scientific investigations, he was not encouraged to take up science as a career, as were the norms of those days in India. At the instance of his father Raman took the Financial Civil Service examination. He stood first in the examination and in the middle of 1907 he proceeded to Calcutta (now Kolkata) to join

the Indian Finance Department as Assistant Accountant General. He was then eighteen-and-a-half years old. His starting salary was Rs. 400 per month, a fabulous sum in those days. At that point of time perhaps nobody would have even dreamt that Raman would again venture into the pursuit of science; Raman's prospects in Government service were too lucrative.

During those days opportunities for doing research were rare. One day, Raman saw a signboard with the words 'Indian Association for the Cultivation of Science' written on it. He was on his way to his office. The address was 210, Bowbazar Street. On his way back he visited the Association where he first met an individual named AshutoshDey (AshuBabu) who was to be Raman's assistant for 25 years. AshuBabu took Raman to the Honorary Secretary of the Association, AmritLalSircar, who was overjoyed when he came to know about Raman's intention–to do research at the Association's laboratory. AmritLal had reason to be overjoyed because it was his father MahendraLalSircar, a man of vision, who had established the Association in 1876. The Association happened to be the first institute to be established in India solely for carrying out scientific investigations.

Raman started doing research at IACS in his spare time. Even while doing research in his spare time and with very limited facilities, Raman could publish his research findings in leading international journals like *Nature*, *The Philosophical Magazine* and *Physics Review*. Initially, his only collaborator was AshuBabu, who never entered the portals of a university. However, this did not prevent AshuBabu from becoming a joint author in many papers that Raman published. In 1917, Raman was invited by AsutoshMookerjee to be the Palit Professor in the newly established Science College of Calcutta University. The salary was about half the amount that Raman was getting in the Finance Department. Raman was very successful as a Finance Officer, and the Finance Department was rather reluctant to let him go. However, Raman happily accepted the offer and joined Calcutta University as Palit Professor in July 1917. The terms of Raman's appointment to the Palit Chair did not entail any teaching responsibilities. However, being a born teacher he could not be away from the classroom. He played a prominent part in MSc teaching.

Even after joining Calcutta University, Raman was allowed to continue his work at IACS's laboratories. In fact, the IACS became the research arm of the University. Following the death of AmritLalSircar in 1919, Raman was elected as Secretary of the IACS, the post he held till 1933 when he left Kolkata for Bengaluru. In 1933, Raman became the Director of the Indian Institute of Science. He was the first Indian to become its Director, succeeding Sir Martin Foster, FRS. He served IISc both as its Director (1933-1937) and head of the Physics Department (1933-1948). After his retirement from the IISc, Raman concentrated his attention on building an institute of his own – the Raman Research Institute. The Institute was built on a plot of land gifted by the Maharaja of Mysore way back in 1934 for

establishing the Indian Academy of Sciences and for its related activities. Raman travelled extensively for raising funds for constructing the building for housing the Institute. To earn money for the Institute, he started a few chemical industries in association with one of his former students. He gifted away most of his personal properties to the Academy for the benefit of the Institute, as also the Lenin Peace Prize money. A museum was built to house Raman's collection of crystals, gems, minerals, rock specimen, shells, stuffed birds, butterflies and so on. Raman had a fascination for colours and so he collected everything that had colours.

Raman was of the view that science alone could solve India's problems. He said: "There is only one solution for India's economic problems and that is science and more science." But he also insisted that India should not be dependent on others for ideas because he believed India is capable of tackling her problems. He believed that the future of any country rests with its accumulated knowledge and the younger generation. He displayed great faith in Mahatma Gandhi's ideas. He remarked: "Each textbook must contain as frontispiece a portrait of Gandhiji and there must be lessons containing the sermons of Gandhiji from Sabarmati to Birla House. This would be the best and the most potent way of offering homage to the greatest man and the Father of the Indian Nation, and is better than building memorials and erecting statues." In the honour of Gandhiji, Raman instituted the Gandhi Memorial Lecture at Raman Research Institute. Till his death, Raman never failed to deliver this lecture. Raman loved children and derived immense pleasure in showing them his museum and the laboratories of the Raman Research Institute.

Raman was elected as a Fellow of the Royal Society of London in 1924. However, he resigned the Fellowship of the Royal Society in March 1968, the only FRS ever to do so. He was conferred Knighthood by the British Government in 1929. He received the Nobel Prize in Physics in 1930. The Government of India awarded him its highest civilian award, "Bharat Ratna" in 1954. The erstwhile Soviet Union honoured him with the International Lenin Prize in 1957.

Subodh Mahanti

Raja Ramanna

Raja Ramanna (28 January 1925 - 24 September 2004) was director of the Bhabha Atomic Research Centre and is famously known as the father of the Indian nuclear bomb. Today, India is among the handful of nations that has a well-developed nuclear power programme in the world, encompassing a chain of nuclear power stations, research reactors, nuclear weapon development and peaceful uses of nuclear energy in several fields. Much credit for this goes to Ramanna.

India's preeminent position in nuclear energy and related matters is also a result of early investments made in the nuclear energy sector soon after the independence, with the establishment of a separate Department of Atomic Energy (DAE) and the Atomic Energy Establishment (AEE, later renamed as the Bhabha Atomic Research Centre or BARC). Earlier one of the problems Bhabha faced was a lack of trained manpower to conduct nuclear research. Promising young graduates and post-graduates used to be sent abroad on government fellowships for higher studies. The J.N. Tata Trust also conferred fellowships for studies abroad. People returning to India after doctorate were then recruited for the nuclear programme. Raja Ramanna was one such promising young man who was sent abroad on Tata Fellowship and hired by Bhabha on his return. Ramanna rose to become director of BARC and is famously known as the father of the Indian nuclear bomb.

Ramanna was a multi-faceted personality, much like his mentor, Bhabha, though both came from different social backgrounds. Both had an interest in music and this common interest led to their first meeting, which resulted in Ramanna joining Bhabha in his nascent research in nuclear physics. Ramanna was born on 28 January 1925 in Tumkur in the erstwhile princely state of Mysore (now Karnataka) and got interested in music, particularly playing the piano, early in his childhood. He was introduced to Western music

at the age of six at the Good Shepherd Convent School, the nuns of which had taught the members of the Mysore royal family. It seems Ramanna became a sort of child prodigy, and the news reached even the Maharaja of Mysore. He first played in the front of the Maharaja in 1937.

Ramanna used to visit Mysore often and during one such trip in 1944, he met Alfred Mistowski– an examiner from the Trinity College of Music – who knew of Ramanna's interest in science (and music). Mistowski told him that an Indian scientist, HomiBhabha, and his mother were staying at the State Guest House and he could arrange a meeting. (Bhabha had close ties with Mysore as his grandfather, HormasjiBhabha, had been Inspector of General Education in the state of Mysore.) Ramanna agreed and met Bhabha, and also played the piano for him in the State Guest House. They struck a chord, literally. Bhabha suggested to Ramanna that he should apply for J.N. Tata Trust for a fellowship to go to London to pursue Ph.D. in physics. Ramanna took the advice seriously and got the fellowship. He went to the King's College London for his Ph.D. in neutron physics and fission physics – which remained his areas of research for next few decades. Upon his return from London in 1949, Bhabha directed him to the TIFR. On the ground floor of the hostel building, Ramanna began his work on nuclear fission and neutron scattering – the research that would give India its first nuclear bomb in 1974. Many youngsters as Ramanna who worked out of a makeshift laboratory in the Yacht Club rose to become distinguished scientists, occupying top positions in the nuclear research laboratories and establishment over the next two to three decades. India's nuclear programme had humble beginnings and scientists with motivation and dedication like Ramanna made it a success.

It was not easy to secure foreign exchange to import equipment for research in the 1940s. One of the first tasks of scientists was to fabricate equipment from whatever resources were available. One had to build one's equipment. Ramanna has recalled in his autobiography that A.S. Rao (another young recruit of Bhabha) who was in charge of nuclear electronics division used to visit the '*chor bazaar*' in Muhammed Ali Road in Mumbai to look for war surplus electronics material that could be used to fabricate basic instruments like Geiger Muller counters. Rao then fabricated analog computers and other electronics needed for nuclear reactor being developed by Bhabha then. Over the next few years, the electronics division grew substantially and was hived off into a separate public sector enterprise, Electronics Corporation of India Limited (ECIL), which played a pivotal role in ushering in electronics and computer revolution in India. Recalling his early days in TIFR, Ramanna wrote in his autobiography: "I joined the TIFR when it was in its fifth year, and the initial problems of administration and finances had been overcome. To begin with, it was essentially a laboratory confined to aspects of science in which Bhabha was primarily interested. However, by the time I arrived the institute had expanded and now even had a School of Mathematics which helped it gain a stronger foothold as a major centre of learning. Among others, the school boasted on its faculty, D.D. Kosambi, who

was not only an expert in differential geometry but was a numismatist, historian, linguist, Sanskrit scholar and a pleasant man."

The first piece of imported equipment at TIFR was a 1 MV cascade generator which was installed in a hut-like structure called Holiday Camp in Navy Nagar in Colaba while the permanent building of TIFR was under planning and construction. This instrument was used for investigations into the process of neutron thermalisation in different types of moderating assemblies. It had great relevance for the research reactor Bhabha was developing at AEE. Later, Ramanna moved to AEE at Trombay to work on the swimming pool reactor, *Apsara* which was commissioned on 4 August 1956. Once commissioned, *Apsara* made intense thermal neutron beams available for basic research. This prompted Ramanna to undertake a programme of experimental investigations of secondary radiations emitted in thermal neutron-induced fission of uranium-235. Over the years, Ramanna built experimental facilities, trained manpower and developed research networks relating to physics of neutrons and fissions – which were all critical for India's nuclear programme. He also led strategic research teams whose work culminated in the first nuclear explosion at Pokhran in 1974. The Pokhran explosion, according to him, was a landmark in the history of nuclear research in the country and "an assertion of the technological advancement India had determined to perfect in the post-independence era". Overall, he played a major role in translating Bhabha's dream of making India self-sufficient in nuclear power.

As nuclear research grew, it needed a large pool of trained manpower. The programme could not depend on personalised talent hunt as done by Bhabha in the formative years. The DAE took a far-reaching decision in 1957 to establish a training school at AEE under the leadership of Ramanna. Over the years this training school has produced thousands of scientists and engineers for the Indian nuclear programme and has proved to be a landmark initiative. Such a training school became necessary because "universities had become rather ineffectual in imparting useful scientific education and we did not want to deplete the universities of the few good teachers by recruiting directly," noted Ramanna in his autobiography. The training school has successfully prevented the flight of bright engineers for greener pastures abroad.

Ramanna was a gifted musician, had a deep interest in both Indian classical and Western music, authored a major book on the structure of *Ragas*, nurtured Bangalore School of Music and occasionally gave a public performance of playing piano in Bengaluru. All these are rare qualities in a scientist. He had more than a cursory interest in Sanskrit literature and had translated Sanskrit poems into English. India needs such multi-faced scientists who can overcome odds and work tirelessly for the country, and equally enjoy art and culture. Ramanna passed away on 24 September 2004 in Mumbai.

Dinesh C. Sharma

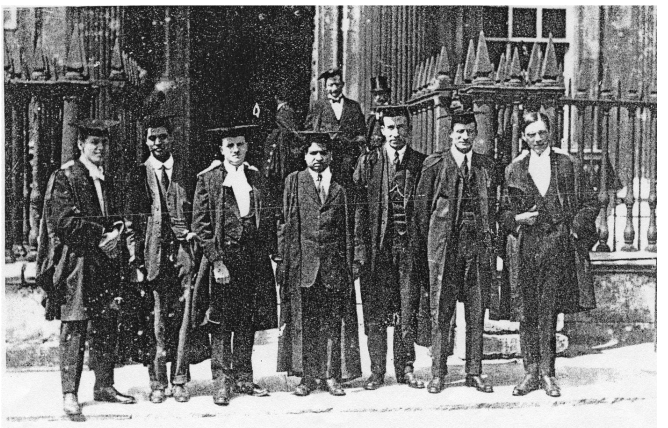
Srinivasa Ramanujan

Srinivasa Ramanujan (22 December 1887 – 26 April 1920) was one of the greatest mathematicians of all time. The influence of Ramanujan on number theory is without parallel in mathematics. His papers, problems, and letters would continue to captivate mathematicians for generations to come. Within a short time he rediscovered a century of mathematics and made new discoveries.

Srinivasa Ramanujan Iyengar (best known as Srinivasa Ramanujan) was born on 22 December 1887, in Erode, about 400 km from Madras (now Chennai). Ramanujan's father Srinivasa Iyengar worked as an accountant for a cloth merchant. Ramanujan was the first child born to his mother Komalatammal.

G.H. Hardy

Ramanujan showed a strong inclination towards mathematics from early age and won numerous awards for his calculating skills in elementary school. He passed his primary examination in 1897 and then joined the Town High School. While at school, Ramanujan came across a book titled *A Synopsis of Elementary Results in Pure and Applied Mathematics*, authored by the British mathematician George Shoobridge Carr. This book had a great influence on Ramanujan's career. G.H. Hardy, an eminent English mathematician, wrote about the book: "He (Carr) is now completely forgotten, even in his college,



Ramanujan (centre) with other scientists at Trinity College

except in so far as Ramanujan kept his name alive". Ramanujan solved all the problems in Carr's *Synopsis*. While working on the problems in the book, he discovered many other new formulae and provided results which were not there in the book. He jotted the results down in a notebook, which he showed to people he thought might be interested. Between 1903 and 1914 he had compiled three notebooks.

In 1904, Ramanujan entered Kumbakonam's Government College as FA student. He was awarded a scholarship. However, after school, Ramanujan's total concentration was focussed on mathematics and he neglected other subjects. As a result he failed and lost his scholarship. During 1906–1912 Ramanujan was constantly looking for support. Without a university degree it was very difficult for him to find a suitable job and he had to struggle financially. Unfortunately he did not have anyone to direct him in his mathematical research. But that did not lose his enthusiasm for mathematics. He noted his results in his notebooks. These notebooks were his treasures. He looked for a job for livelihood and to support his parents and two brothers. He tutored a few students in mathematics. However, because of his unconventional methods, he was not considered to be a good teacher. Ramanujan's mother Komalatammal was on the lookout for a bride to get her eldest son married. On 14 July 1909 Ramanujan was married to Janaki.

Komalatammal, Ramanujan's mother

Janaki, Ramanujan's wife

In 1910 Ramanujan met Professor V. Ramaswami Iyer, an ardent scholar of mathematics and founder of the Indian Mathematical Society. He saw Ramanujan's records and was convinced he was a gifted mathematician. Ramanujan's earliest contribution was in the form of question/answer in the *Journal of the Indian Mathematical Society*. Ramanujan proposed 58 questions and their solutions during the period February to October 1911. The first full-length research paper of Ramanujan, entitled "Some properties of Bernoulli numbers", appeared in the *Journal of the Indian Mathematical Society* in 1911.

In 1912, Ramanujan secured a job as a clerk in the accounts section of the Madras Port Trust. Meantime his mathematics work caught the attention of other scholars who recognized his abilities. He was encouraged to contact English mathematicians in the hope that they would be able to assist him. Professor C.L.T. Griffith of Engineering College, Chennai, forwarded some of Ramanujan's results on divergent series to Professor M.J.M. Hill of the University of London. Unfortunately, Professor Hill could not study the results in detail and suggested a book and adviced him on publishing his paper.

In 1913 Ramanujan wrote a letter to the famous English mathematician G.H. Hardy, who discussed Ramanujan's letter with his collaborator and friend, mathematician John Littlewood. After studying and discussing the letter, both realised that Ramanujan was a world-class mathematician and decided to bring Ramanujan to Cambridge. He arrived in London on 14 April 1914. For the next five years, he was associated with Hardy. Their collaboration represents the efforts of two great talents. Ramanujan was awarded the BA degree by research, in March 1916, for his work on highly composite numbers. He was the first Indian mathematician to be awarded the prestigious Fellowship of the Royal Society, in February 1918. P.C. Mahalanobis was a student at King's College, Cambridge at that time and he became a good friend of Ramanujan.

The period of Ramanujan's stay in England almost overlapped with World War I. During his five-year stay in Trinity College, Cambridge, Ramanujan published 21 research papers, five of which were in collaboration with Hardy. During this time Ramanujan also published short notes in the *Journal of the Indian Mathematical Society.* After World War I, Ramanujan returned to India in 1919. On his return, his health deteriorated. Even during those months of prolonged illness Ramanujan jotted mathematical calculations and results on sheets of paper. In January 1920, he wrote letter to Hardy and communicated his work on 'mock' theta function. Despite all the tender attention from his wife and the best medical attention from doctors, his health deteriorated further. He breathed his last on 26 April 1920, at the age of 32.

After Ramanujan's death, Hardy tried systematic verification of Ramanujan's results from the second notebook. However, it was a daunting task and he persuaded the University of Madras to undertake the task. In 1931, the University of Madras requested Professor G.N. Watson to edit the notebooks in a suitable form for publication. This was

quite formidable since the notebooks contained over 300 theorems. Watson edited the notebooks with Professor B.M. Wilson. Unfortunately, Wilson passed away in 1935, virtually marking the end of the efforts to edit the notebooks. The collected edition of Ramanujan's works was later edited by Hardy. The first edition of this book was published in 1927 by Cambridge University Press. This resulted in a flurry of research papers during the period 1928–38. In 1999, the American Mathematical society and London Mathematical Society reprinted the collected papers.

Much of Ramanujan's mathematics falls in the domain of number theory — the purest realm of mathematics. During his short lifetime, Ramanujan independently compiled nearly 3,900 results (mostly identities and equations). He stated results that were both original and highly unconventional, such as the Ramanujan prime and the Ramanujan theta function, and these have inspired a vast amount of further research in mathematics. As Robert Kanigel, author of the book *The Man Who Knew Infinity: A Life of the Genius Ramanujan*, says "…..few can say much about his work, and yet something in the story of his struggle for the chance to pursue his work on his own terms compels the imagination, leaving Ramanujan a symbol for genius, for the obstacles it faces, for the burdens it bears, for the pleasure it takes in its own existence".

Rintu Nath

Darshan Ranganathan

Darshan (Markan) Ranganathan (4 June 1941 – 4 June 2001) was an organic chemist. At the time of her death, she had already earned the title of being "the most prolific organic chemist in India," having, in the previous five years, a dozen publications in the *Journal of the American Chemical Society*, six in the *Journal of Organic Chemistry* and dozens more in others. Much more were published posthumously. In her lifetime she was recognised for "*her outstanding contributions to bio-organic chemistry, particularly in supramolecular assemblies, molecular design and chemical simulations of key biological processes, as well as for designing hybrid peptides leading to a new class of cyclic receptors and membrane ion carriers;*" yet few outside the sphere of academia would have heard of her or known about her quiet attempts to break through the glass ceiling in the arena of science. It was her "*...invincible armour of obsession for scientific re-search*" that etched out for her a niche of her own at the altar of science.

Daughter of Shanti SwarupMarkan and VidyawatiMarkan, DarshanKumari was born and brought up in Delhi. As a child, she loved drawing, singing and dancing. She apparently once even danced on the teacher's table!

DarshanKumari earned her BSc (1961), MSc (1963) and PhD in organic chemistry (1966) from Delhi University. While doing her PhD research, she also served as a Lecturer in Chemistry in Miranda House, Delhi and subsequently became Head of the Chemistry Department in the College. Then she won the Senior Research Scholarship of the Royal Commission for the Exhibition of 1851 and went to London to work at the Imperial College, under Sir Derek Harold Richard Barton (Nobel laureate in 1969). At

the Imperial College, her research focussed on natural organic products, especially on the structural elucidation of cycloartenol from jackfruit (*Artocarpusheterophyllus*) and on photochemical reactions of steroids.

Cycloartenol is an important compound found in plants, and it is the starting point for the synthesis of almost all plant steroids. Cycloartenol was considered to be an intermediate in the biosynthesis of tetracyclic triterpenoids and steroids in plants. Barton was interested in elucidating the exact structure and stereochemistry of cycloartenol. DarshanKumari's work not only answered the many questions, but her work as a member of Barton's team established that cycloartenol could be synthesised from lanosterol– a compound that is largely of animal origin. Interestingly, steroids are not common in plants nor are they abundant when present. Thus, the cycloartenol found in jackfruit was unusual and had the potential to be very useful; it was the starting point of a treasure trove of compounds.

DarshanKumari's research findings were published to great appreciation, but few know how she had overcome the problem of finding jackfruit in London. Ingeniously, she had roped in her mother to send her five kilos of dried jackfruit by airmail!

DarshanKumari returned to Delhi in 1969 and took up a teaching job at one of the colleges under Delhi University. However, side-by-side she continued her research. In 1970, at the Indo-Soviet Bi-national Conference on Natural Products held in Delhi, she met SubramaniaRanganathan, whom she married on 4 June. Her wedding day was not only her birthday but by an odd twist of time, would also be the day, 31 years later, that she would breathe her last.

The couple joined the Indian Institute of Technology (IIT), Kanpur where she worked as S. Ranganathan's research associate. The Ranganathans were a couple dedicated to research. They worked together and supported each other, synergising their scientific strengths. They published research papers jointly. They co-authored scholarly books such as *Challenging Problems in Organic Reaction Mechanisms* and *Further Challenging Problems in Organic Reaction Mechanisms*. Also, they co-published (1971–1979) a monthly journal called *Current Highlights in Organic Chemistry*. In an era predating the Xerox machine and electronic publishing, they did this the hard way by cyclostyling. The chemical structures were all hand drawn by DarshanRanganathan.

In time, a son Anand was born to them, but such was their dedication to science that the kid was encouraged to memorise the periodic table and chant it before visitors instead of the most traditional recitation of nursery rhymes. Darshan's mother, ever the unseen support in her daughter's life, extended enormous help by taking care of the newborn.

During her period of stay at IIT-Kanpur DarshanRanganathan had to make do with Fellowships but never a Faculty position because it was an "unwritten rule" that both spouses could not be granted tenure at the same time. Later in life, S. Ranganathan would lament about the situation, "Therefore, throughout her long stay in Kanpur, she had to hop from fellowship to fellowship and for some periods none at all! We count on small mercies, and both of us were truly grateful to IIT-K(Kanpur) and the chemistry department for permitting her to do research. I knew from the beginning that she was better than me and was proud to share my funds and students with her so that she could work on her problems and publish on her own. That was all she wanted, brushed away all other irritations and slowly blossomed into an organic chemist who won international peer recognition, even before she accepted an independent position at CSIR-Regional Research Laboratory, (renamed CSIR – National Institute for Interdisciplinary Science and Technology), Trivandrum (now Thiruvananthapuram), in 1993 and subsequently moved to IICT (CSIR-Indian Institute of Chemical Technology), Hyderabad in 1998."

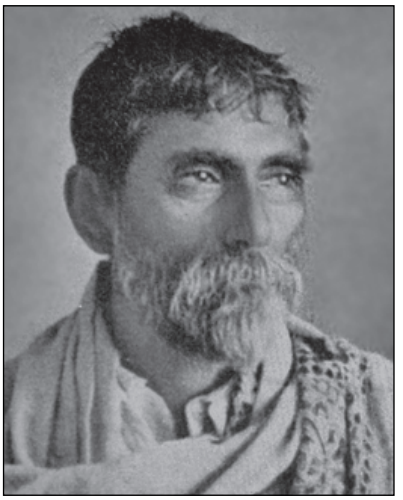
Given a well-equipped full laboratory to call her own and adequate research grants, she became a beacon for bright students. Her talents flowered, and her efforts began to get the recognition they deserved. She was interested in studying the strategies adopted by living things to metabolise, replicate or even interact with their environments. She attempted to simulate these in the laboratory. Perhaps her two best-known achievements in this area are: the chemical simulation of the 'ATP-Imidazole cycle' and the synthetic organic chemical simulation of the 'urea cycle.' Thus in her laboratory, she successfully mimicked what happens naturally inside cells. Her book *Art in Biosynthesis: The Synthetic Chemist's Challenge* is still sold online by reputed websites. The tagline says, "The book projects Nature as an organic chemist supreme, and presents representative examples whose biosynthetic pathways are known by experimentation." That was the essence of her lifelong work.

DarshanKumari next directed her attentions to self-assembling molecular systems. Just assembling or synthesising these was not enough. She began to test if these were indeed capable of carrying out the functions for which these had been designed. She reached out to collaborators across India and overseas. Interestingly, as if to underline the fact that access to technology can help bridge the gender divide, she collaborated, for over seven years, with Isabella L. Karle of the Laboratory for the Structure of Matter, Naval Research Laboratory of USA at Washington DC. They published two dozen papers together yet never once met face to face.In 1998 she moved to CSIR-IICT, and S. Ranganathan joined the Institute too, as a Distinguished Scientist. Her work continued apace despite the fact that during 1997-1998 she was fighting cancer

It was only in the 1990s that awards and honours began to flow to her. She was elected to the Fellowship of the Indian Academy of Sciences in 1991 and elected Fellow of the Indian National Science Academy in 1996. She was given the Third World Academy of Sciences (TWAS) Award in Chemistry in 1999 and awarded the Jawaharlal Nehru Birth Centenary Visiting Fellowship in 2000. The TWAS award was given to her at the meeting of TWAS in Tehran, Iran in October 2000 where it was apparent that she was not in the best of health; cancer had returned. She died a few months later, on 4 June 2001, of metastasis of cancer.

Prof. S. Ranganathan had always known that his wife was a star...perhaps because a star's light is its own. So his touching obituary to her is entitled "She was a Star"... something he told her often. He established endowment lectures in her name in The Andhra Pradesh Academy of Sciences, Hyderabad, the Chemical Research Society of India, Bengaluru, and the Indian National Science Academy, New Delhi.

Sukanya Datta



Prafulla Chandra Ray

Prafulla Chandra Ray is regarded as the founder of the Indian School of modern chemistry. He was a pioneer of chemical industries in India. Ray's activities were not confined to his laboratory and teaching. His activities concerned other spheres of human interest—educational reform, industrial development, employment generation and poverty alleviation, economic freedom and political advancement of the country. He occupied a unique position in India in his days.

Prafulla Chandra Ray was born on 2 August 1861 in a village in the district of Jessore (subsequently of Khulna), now in Bangladesh. He was greatly influenced by his parents. His father Harish Chandra Ray, a scion of a local *zamindar,* was a man of learning and liberal views. Ray's mother Bhubanmohini Devi was an accomplished lady of enlightened views.

After his early education at the village school, he came to Calcutta (now Kolkata) in 1870. He passed the entrance examination of the Calcutta University from the Albert School of Keshab Chandra Sen, the founder of the new dispensation order of the *BrahmoSamaj*. In 1878, Ray joined the Metropolitan Institution (later named as Vidyasagar College) established by PanditIswar Chandra Vidyasagar. It was at the Metropolitan Institution that Ray came under the influence of SurendraNath Banerjee, usually regarded as the father of Indian nationalism. Ray used to attend lectures on chemistry at the Presidency College as an external student. While still a student in the BA class he successfully competed for the Gilchrist Prize, for which knowledge of at least four different languages was essential. This award enabled him to proceed to Edinburgh University, England in 1882. In 1885, Ray obtained his BSc degree and in 1887 he was awarded the DSc degree of Edinburgh University. He was awarded the Hope Prize Scholarship, which enabled him to stay one

more year in England. He was elected Vice President of the Chemical Society of Edinburgh University.

After about six years in England, Ray came back to India in 1888. It was not easy for him to secure a teaching assignment. He was without one for about one year. Finally, in July 1889 he joined the Presidency College as Assistant Professor of Chemistry on a temporary basis under the Provincial Educational Service. After retiring from the Presidency College in 1916 he joined the University College of Science, Calcutta University as Palit Professor of Chemistry. He retired from the University College of Science in 1936 but continued as Emeritus Professor of Chemistry until his death.

Ray published about 120 research papers mostly in research journals of repute. Ray conducted a systematic chemical analysis of some rare Indian minerals with the object of discovering in them some of the missing elements in the Mendeleeve's Periodic Table. He isolated mercurous nitrite in 1896, which brought him international recognition, as the compound was not known till then. Describing this event, Ray wrote in his autobiography: "…the discovery of mercurous nitrite opened a new chapter in my life." The discovery of mercurous nitrite was an accidental one. Ray wanted to prepare water soluble mercurous nitrate as an intermediate for the synthesis for calomel (mercurous chloride). Ray first published his findings in the *Journal of the Asiatic Society of Bengal* and which was immediately noticed by *Nature*, the famous international science journal. The discovery of mercurous nitrite led to many significant publications.

Another important contribution made by Ray was the synthesis of ammonium nitrite (NH_4NO_2) in pure form. Before Ray's synthesis it was believed that ammonium nitrite undergoes fast thermal decomposition yielding nitrogen (N_2) and water (H_2O). Ray presented his findings at a meeting of the Chemical Society of London. William Ramsay, the British chemist and the winner of the 1904 Nobel Prize in Chemistry, was greatly impressed by Ray's findings. Commenting on Ray's contribution to chemical research Priyadaranjan Ray, a noted Indian chemist and a student of Ray wrote: "One must not, however, lose sight of the important fact that Ray's real contribution to the development of chemical research in India rests not so much on his personal research publications as on his inspiring and initiating a generation of young workers who, dedicating themselves to a scientific career, succeeded in building up what is now known as the Indian School of Chemistry".

Ray started the Bengal Chemical and Pharmaceutical Works Ltd (or Bengal Chemical as it is popularly known) in 1892 to create job opportunities for the youth. He was also involved in the management of a large number of industrial and business concerns in the country. He was a staunch patriot. In 1885, while a student of BSc at Edinburgh

University, Ray took part in the essay competition announced by the Lord Rector of the Edinburgh University. The title of the essay to be written was, "India before and after the Mutiny." Ray's essay was very critical of the British Rule in India. In those days it required a lot of conviction and courage to write such an essay. It demonstrated Ray's patriotic vigour. A copy of the essay was sent to John Bright, the celebrated Parliamentarian whose sympathetic reply to Ray appeared in almost all the leading newspapers of the United Kingdom under the heading '*John Bright's Letter to an Indian Student*'. It almost created a stir in political circles in England at that time. Ray was connected with the movement for India's independence in many ways. He was in regular contact with the top leaders of the Indian National Congress, which was spearheading the freedom struggle. It was Ray who took the initiative to bring Mahatma Gandhi to Kolkata. Ray's patriotism reflected in his saying: "Science can wait but *Swaraj* can not."

Ray was a voracious reader of literature, history, and biography. To quote him: "The prescribed textbooks never satisfied my craving. I was a voracious devourer of books and when I was barely 12 years old, I sometimes used to get up at 3 or 4 o'clock in the morning so that I might pore over the contents of a favourite author without disturbance…History and biography have even now a fascination for me. I read *Chamber's Biography* right through several times. The lives of Newton, Galileo—although at that time I did not understand or realise the value of their contributions—interested me much." Ray could read half-a-dozen languages and wrote extensively on a variety of subjects both in English and Bengali. He was an ardent advocate of the use of the mother tongue as a medium of instruction in schools and colleges. In recognition of his contribution towards the advancement and enrichment of Bengali language, he was elected the General President of the BangiyaSahityaParishad (1931-1934).

Ray wrote a book on zoology titled *Simple Zoology* in 1893. For writing this book he not only studied many authoritative books on zoology but also visited museums and zoos. It has been reported that he even went to the extent of dissecting a few carcasses with the help of NilratanSarkar, the famous physician. Ray wrote a series of scholarly articles on Shakespeare in the *Calcutta Review* during 1939-1941. Ray frequently contributed articles to many Bengali periodicals such as *Basumati*, *Bharatbarsha,Bangabani,Banglarbani,Prabashi*, *AnandabazarPatrika*, *Manushi*, etc. He once claimed that he "…became a chemist almost by mistake."

Ray wrote *The History of Hindu Chemistry* in two volumes. The first volume was published in 1902, followed by an enlarged revised edition in 1904. The second volume of the book came out in 1909. An enlarged and revised edition of the book was brought out in 1924. Ray was inspired by the great French chemist Marcellin Pierre Eugene Berthelot in undertaking this monumental work. Ray's *Hindu Chemistry* was recognised as a unique

contribution to annals of history of chemistry soon after its publication. Berthelot himself wrote a 15-page review in *Journal desSavant* in its issue of January 1903. Renowned international journals like *Nature* and *Knowledge* wrote very highly of the book. Ray wrote his autobiography titled *The Life and Experience of a Bengali Chemist* in two volumes, which he dedicated to the youth of India. Besides giving his life sketch, it gives glimpses of the intellectual renaissance in Bengal as a part of the larger enlightenment of India in the nineteenth century and the early decades of the twentieth century.

He symbolised the best of Indian tradition and philosophy. He lived a life of extreme self-denial. He was the symbol of plain living. Towards the later part of life, he lived in a single room at the University College of Science, Calcutta University. Its furniture consisted of a bedstead, a small table, a small chair and an *almirah* with shelves full of books, most of which were English classics. Commenting on Ray, Mahatma Gandhi once said: "It is difficult to believe that the man in simple Indian dress wearing simple manners could be the great scientist and professor." He gave away most of his earnings to charity. Many poor students used to get regular financial support from him. He left a substantial portion of his earnings to a Trust for supporting poor widows and orphans and for promotion for hand-spinning. Many institutions were beneficiaries of his generosity.

Ray was amongst the pioneers of social reform in the country. He took to social service with a missionary zeal. He deliberated on the prevailing caste systems in the Hindu society. In his Presidential address to the Indian National Social Conference held at Kolkata in 1917, he made a passionate appeal to remove caste systems from Hindu society. He had imbibed the principles of rational thinking in his childhood largely influenced by his father. Several times Ray came to the rescue of his countrymen suffering from famine and flood. On witnessing the elaborate arrangements for relief work undertaken by Ray on one such occasion a reporter of the *Manchester Guardian* wrote: "If Mr. Gandhi (Mahatma Gandhi) could produce two more P.C. Rays, India could have attained *Swaraj* within a year."

P. Ray, a relative of P.C. Ray and INSA Fellow wrote in his memoir, "Ray was a teacher all his life, though essentially a student throughout. His only love in life was his books - scientific and classics - and the pupils whom he inspired, some of whom always use to constitute his household and manage his daily affairs of life. His relation with his pupils was ever close and cordial as that between father and sons.

"He was always alert about the economy of time, material and money. Any wastage of chemicals, filter paper, gas, water or electricity in the laboratory by anybody would work him up into a fury. He was equally intolerant of any misuse of time and himself would strictly adhere to a rigid time-table in his everyday life. To him, the waste of time was equivalent to the loss of opportunities for work."

In 1920, Ray was elected General President of the Indian Science Congress. He helped establish the Indian Chemical Society in 1924 as its Founder President. He was elected an Honorary Fellow of the Chemical Society of London and the Deutsche Akademie of Munich. Ray passed away in his living room in the University College of Science of the Calcutta University surrounded by his students (whom he loved most), friends and admirers. "A more remarkable career than that of P.C. Ray could not well be chronicled", wrote *Nature*, the international scientific journal, while commenting on the first volume of Prafulla Chandra Ray's autobiography.

Subodh Mahanti

Ronald Ross

Ronald Ross (13 May 1857 – 16 September 1932) was a British medical doctor who discovered in 1897 that malaria-causing pathogens – parasites belonging to the genus *Plasmodium* – are transmitted to humans by mosquitoes. He received the Nobel Prize in Physiology or Medicine in 1902 for his work on malaria, becoming the first British Nobel laureate, and the first born outside of Europe.

Malaria is one of the ancient diseases of the humankind. It is often said that malaria played a big role in bringing down many ancient civilisations like the Greek and the Roman. Some of the very powerful emperors in the world such as Alexander the Great and Genghis Khan are believed to have succumbed to malaria. It continues to be a difficult infectious disease to deal with and kills more than 6,00,000 people every year, mainly in hot tropical countries. Significantly, YouyouTu, a Chinese traditional medicine professor, won half of the 2015 Nobel Prize in Physiology or Medicine for discovering artemisinin, a powerful antimalarial drug, from a Chinese herb. She shared it with two others – of Irish and Japanese origin – who developed a novel therapy to fight roundworm parasites, making them eligible for the other half of the coveted prize.

The 2015 Nobel is one among a string of Nobel prizes won by scientists for working on malaria. The very first among them – the second-ever Nobel Prize in Physiology or Medicine – was conferred on Ronal Ross, a young medical officer in British Indian Medical Service whose work unravelled to the world how malaria is transmitted. Ross was awarded the 1902 Nobel Prize for his epoch-making discovery of the transmission of malaria parasite by mosquitoes.

Ross was born to Sir C.C.G. Ross, who went on to become a General in the British Indian Army, and his wife Matilda, in Almora in the present-day Uttarakhand on 13 May 1857. Incidentally, his birth took place a few days after the famous Indian Mutiny, a great rebellion against the erstwhile British East India Company by native soldiers and civilians, which was written in golden letters in the history of Indian independence movement.

During his early years, the young Ronald had a natural proclivity towards literature, music, and arts. While all of these stayed close to his heart all through his life, he picked a keen interest in mathematics during his school days. At the age of eight, he was sent to England for education, and he spent much of his childhood with an aunt and uncle on the Isle of Wight. It is said that studying medicine was not his first choice. He wanted to read literature in college but finally went to a medical school as his father wished him to be a doctor in the British Indian Medical Service. However, he continued to dabble in writing and painting all through his busy life.

There is an account how young Ross got interested in working on malaria, a disease he has seen killing a large number of people in India. In fact, his father himself had once suffered from malaria but was lucky to have recovered from it. In India, in those days at least a million people used to die of malaria. According to this account, when Ross was a medical student at St. Bartholomew's Hospital in London, he happened to encounter a lady living near salt marshlands in the southern parts of the country, who complained of nagging headaches, pain in her muscles, fever, and intermittent chills. Ross suspected that the lady was suffering from malaria. The observation made by the medical student at the first instance scared her so much that she didn't come back for follow-ups subsequently, making it impossible for him to confirm the diagnosis. He suspected so because he had seen, as a young boy growing up in India, most malaria patients complaining of similar symptoms. But then, malaria was known to be a disease of hot tropical countries. This incidence, it is said, kindled his interest in malaria.

Around the time Ross was finishing his medical schooling, there was a major development concerning malaria. In 1880, while working in a military hospital in Algeria, Charles Louis Alphonse Laveran, a French scientist who hailed from Paris, discovered that the causative agent for malaria is a protozoan parasite. In peripheral blood films taken from a patient, Laveran observed the exflagellation– formation of microgametes in sporozoans of the parasite – a process which would subsequently prove to be the key to resolving the malaria puzzle.

It was Laveran who first proposed a vector hypothesis – that mosquitoes transmit the parasite to humans. This hypothesis was further elaborated by Patrick Manson, who is widely regarded as the father of tropical medicine. Manson, who had earlier

discovered filariae (slender threadlike roundworms) of those suffering from elephantiasis were ingested by mosquitoes, also suspected that mosquitoes might have a role to play in spreading malaria. The exflagellation of protozoan that Laveran described could not take place in the human bloodstream, Manson argued. This can happen only outside the human body but inside the gut of an insect which is moist and experiences temperatures lower than the human gut, he argued.

In 1881, Ross returned to India and joined the British-Indian Medical Services and worked in Madras (now Chennai), Burma (now Myanmar), and the Andaman Islands. In Chennai, a substantial part of his work was to treat soldiers down with malaria. The drug quinine was found effective against malaria, but many patients, unfortunately, succumbed to the disease as they failed to get the treatment in time. In 1888, Ross took a one-year break and went back to Britain to study for Diploma in Public Health from the Royal Colleges of Physicians and Surgeons and enrolled for a course in bacteriology. Before he returned, he married Rosa Bloxam, who accompanied him to Bangalore (now Bengaluru) where he took up a position as a surgeon.

Scientific discoveries are seldom made in isolation. Expanding the scope of the vector hypothesis propounded by Laveran, Manson wrote a paper in the *British Medical Journal* in December 1894. Manson argued that mosquitoes supported an essential phase of parasitic development during which ex-flagellation took place within the stomach of the mosquitoes whereby the free flagellum was able to pierce the stomach wall and somehow develop into a larval malaria parasite. According to him, without this, the parasite would not have been able to infect the humans. However, Manson didn't have an idea how the larval parasites moved from one host to the next; that is, from mosquitoes to humans. A favourite hypothesis was that the route of infection was through contaminated water. The germs get deposited in water as mosquitoes laid eggs. When a person drinks this water, the parasite gets a chance to get lodged inside the human body.

One of the turning points in Ross's life was a chance meeting that he had with Manson when the former had gone to England on a period of leave in 1894. Manson actually filled him with knowledge about malaria that Ross was desperately seeking. Moreover, he demonstrated to Ross that Laveran's parasitic bodies could be clearly identified in a stained specimen of malarial blood. In a previous work, which is equally celebrated, Manson had already discovered that mosquitoes play a vital role in causing and spreading filariasis. This idea appealed to Ross immensely. He was determined to prove the idea that mosquitoes carried malaria. He also realised that there are not many better places than India to carry out such experimental studies in mosquitoes.

In an obituary written in the journal *Current Science* in 1932, John Alexander Sinton, a malariologist who worked with Ross and later became director of the newly-formed Central Malaria Bureau of India in 1921 says: "It was in such an uncharted sea that Ross embarked on his return in 1895. Through 2½ years of unceasing toil, hampered by heart-rending disappointments and technical difficulties, with indomitable perseverance he struggled on, sustained by the counsel and sympathy of Sir Patrick Manson. About noon on 20 August 1897, in the heat of an Indian summer, he saw for the first time oocyst state of the development of human malaria parasite in the Anopheline mosquito, thus opened up a new era in the history of disease transmission."

Despite the exciting results, Ross was not able to complete his research for almost one more year. Subsequently, while he was on special duty in Calcutta (now Kolkata), he proved the mosquito cycle of the malaria parasite by studying how Culex mosquitoes infect birds with malaria. "Although Ross sometimes spoke of the luck which attended his great discovery, one cannot but think that a lesser man is not possessing his grit, energy, determination and ability, would have given up in despair before the enormous difficulties which beset his path," said Sinton.

Ross left India in 1899 and was appointed to a teaching position at the newly-formed School of Tropical Medicine in Liverpool. He travelled to many countries particularly in Africa, but also to Greece and Mauritius as part of expeditions to investigate and prevent malaria. In 1901, Ross was elected a Fellow of the Royal College of Surgeons of England and also a Fellow of the Royal Society. In 1926, he became Director-in-Chief of the Ross Institute and Hospital for Tropical Diseases, which was established in honour of his works. He remained there until his death on 16 September1932.

Although Ross will always be remembered for his contributions to medical research, he left an imprint in the field of art too. He was not only a musician but a poet and a novelist too. It is said that at one point in time, he seriously thought about abandoning medicine for literature. Ross similarly contributed to pure mathematics and pathometry, a lesser-known discipline involving epidemiological studies of diseases.

T.V. Jayan

Meghnad Saha

Meghnad Saha was an astrophysicist whose theory of thermal ionisation, explaining the origin of stellar-spectra regarding the physical conditions prevailing in the stellar atmosphere, was one of India's most important contributions to the world of science during the 20th century. Saha's theory relates the ionisation state of an element to the temperature and pressure. It was an epoch-making discovery. Besides its application in astrophysics, the theory later found other important applications, for example, in the study of the ionosphere, conductivity of flames, electric arcs, and explosion phenomenon.

Arthur Stanley Eddington, the British astrophysicist, and mathematician, while writing on stars in the fourteenth edition of the *Encyclopaedia Britannica,* described Saha's theory of thermal ionisation as one of the twelve most important landmarks in the history of astronomy since the first variable star (Mira Ceti) was discovered by David Fabricius in 1596. Saha became a Fellow of the Royal Society in 1927 at the age of 34. "MeghnadSaha's place in the history of astrophysics and the in the history of modern science in India is unique," wrote the Nobel Laureate astrophysicist Subrahmanyan Chandrasekhar.

Meghnad Saha was born on 16 October 1893 in the village of Seoratali in the Dacca district (now Dhaka in Bangladesh) of undivided India. He was the fifth child of his parents, Jagannath Saha and Bhubaneswari Devi. His father was the owner of a petty grocery shop, and somehow he was able to make ends meet and maintain his big family of eight children. Given their social and economic background, his parents had neither the means nor the inclination to educate their children beyond the primary level. So, after the completion of his primary education, there was no certainty that young Saha's education would continue. There was no middle school near his village. The nearest middle school

was at Simulia, which was 10 km away from his village. His parents could hardly afford the expenses, and they would have preferred to have him work in the family's grocery shop.

However, his elder brother Jainath, who was working in a jute company, came to Saha's rescue by locating a sponsor in Ananta Kumar Das, a local doctor. The kind-hearted doctor agreed to provide free boarding and lodging in his house provided Saha washed his plates (a condition that reflected the prevailing rigid caste system) and attended to minor household works including the taking care of the cow. Saha readily accepted all the conditions. He completed his middle school by topping the list in the entire district, and he also secured a scholarship of Rs.4 per month. In 1905, Saha went to Dhaka and joined the Collegiate School.

There were widespread political disturbances in Bengal in 1905, the year in which Lord Curzon, the then Viceroy of India under the British Rule, had decided to partition Bengal. Saha, like many others, was affected by this political upheaval. He, along with some other students, was rusticated from the Collegiate School because of their participation in the demonstration against the visit of the Bengal Governor, Sir Bampfylde Fuller, to the school. Besides being rusticated, Saha was also deprived of his scholarship. Fortunately, a private school named KishoriLal Jubilee School accepted Saha with a free studentship and a stipend.

In school, Saha's favourite subject was mathematics. He also liked history. He was particularly fond of reading Todd's *Rajasthan*. Among his favourite books were Rabindranath Tagore's *Katha O Kahini,* which glorifies the values of the Rajput and Maratha warriors, and MadhusudanDutt's epic poem *Megnadhbadh.* During the school days, he also attended the free Bible classes conducted by the Dhaka Baptist Mission. He stood first in one of the competitive examinations on Bible conducted by the Mission and received a cash prize.

In 1909, Saha passed the Collegiate Entrance examination, standing first amongst all the candidates from the erstwhile East Bengal. After passing the Intermediate examination of Calcutta University in 1911 from the Dhaka College, Dhaka, Saha joined Presidency College. Among his classmates in Presidency College was SatyendraNath Bose. Prasanta Chandra Mohalanobis, the founder of the Indian Statistical Institute, was his senior by a year. His teachers included Prafulla Chandra Ray in chemistry ad Jagadis Chandra Bose in physics. Saha passed his BSc Examination with Honours in Mathematics in 1913 and MSc (Applied mathematics) examination in 1915. Saha stood second in order of merit in both the examinations. The first positions in both cases went to S.N. Bose.

Saha was appointed Lecturer in the Department of Applied Mathematics in 1916. However, after one year both Saha and S.N. Bose, who had also joined the Department of Applied Mathematics, got themselves transferred to the Physics Department. In the Physics Department Saha started giving lectures to the post-graduate classes on topics like hydrostatics, spectroscopy, and thermodynamics. For teaching physics to the postgraduate classes, Saha had first to learn it himself, as he had studied physics only in undergraduate classes. Besides teaching, Saha also started doing research. It was not an easy task. In those days there was no laboratory in the Department of Physics of the University College of Science. Saha had no guide for supervising his research work. He totally depended on knowledge acquired from his studies. Working under the most adverse circumstances, Saha forwarded his theory of thermal ionisation.

He submitted his thesis on radiation pressure and electromagnetic radiation for the degree of Doctor of Science of Calcutta University in 1918. He was awarded the degree in 1919. The same year he was awarded the PremchandRoychand Scholarship for his dissertation on the 'Harvard Classification of Stellar Spectra'. The scholarship enabled Saha to spend about two years in Europe. He first went to London where he spent about five months in the laboratory of Alfred Fowler (1868-1940). From London, he moved to Berlin where he worked in Walther Nernst's Laboratory. In November 1921, Saha returned to India and joined the University of Calcutta as Khaira Professor of Physics, a new chair created from the endowment of Kumar Guruprasad Singh of Khaira.

In 1923, Saha went to the Allahabad University to join the Physics Department. Saha is credited with making the Physics Department of the Allahabad University one of the most active centres of research in the country, particularly in the field of spectroscopy. He also initiated and organised research in statistical mechanics, atomic and molecular spectroscopy, the electron affinity of electronegative elements, high-temperature dissociation of molecules, propagation of radio waves in the ionosphere, and physics of the upper atmosphere. The Department attracted students from all over the country. At Allahabad, Saha wrote his famous textbook, which was first published under the title of *A Textbook of Heat.* The book was jointly written with B.N. Srivastava. A concise version was published for science graduates. It was titled *Junior Textbook of Heat.* Later Saha wrote another book (jointly with N.K. Saha) titled *Treatise on Modern Physics*.

Saha returned to Calcutta University in July 1938. He became the Palit Professor and Head of the Department of Physics. He remodelled the MSc syllabus in physics of Calcutta University. It was Saha who first started teaching and training in nuclear physics in the country. He introduced a general paper and a special paper in nuclear physics in 1940; soon after the phenomenon of the nuclear fission was discovered by Otto Hahn and Fritz Strassmann. Saha played the lead role in building the first cyclotron in the country.

Saha, jointly with S.N. Bose, prepared an English translation of Einstein's papers on the theory of relativity and published them in the form of a book. This translation of Einstein's work on the theory of relativity form German into English happened to be the first on record. Thus Subrahmanyan Chandrasekhar wrote: "…In 1919, only three years after the founding of the general theory of relativity, Saha and S.N. Bose should have taken the time and the effort to translate and publish Einstein's papers, which have since become epochal. At a celebration of the Einstein Centennial at Princeton University, three years ago, reference was made to a Japanese translation of Einstein's papers as the first on record and I was glad that I was able to correct the impression. A Xerox copy of the Saha-Bose translation is now in the Einstein Archives at Princeton."

Saha was an active member of the National Planning Committee constituted by the Indian National Congress in 1938 with Pandit Jawaharlal Nehru as its Chairman. In fact, it was Saha who had persuaded NetajiSubhash Chandra Bose, then President of the Indian National Congress, to set up the National Planning Committee. He was the Chairman of the Indian Calendar Reform Committee constituted by the Council of Scientific and Industrial Research in 1952. He was an elected Independent Member of the Indian Parliament. He advocated large-scale industrialisation for social development.

Saha was a great institution builder. In 1930, he founded the UP Academy of Sciences at Allahabad, which was later renamed as the National Academy of Sciences, India. The Academy was formally inaugurated on 1 March 1932 and Saha was its first President. In 1933, Saha established the Indian Physical Society at Kolkata. The Society published the *Indian Journal of Physics*. Eminent scientists like C.V. Raman and K.S. Krishnan regularly contributed important papers to the *Indian Journal of Physics*. With Saha's initiative, the National Institute of Sciences of India was established in Kolkata in 1935, which was moved to New Delhi in 1946. In 1970, it was renamed as the Indian National Science Academy (INSA).

Saha was closely associated with the planning and establishment of the Central Glass and Ceramic Research Institute, a constituent laboratory of the Council of Scientific and Industrial Research at Kolkata. Saha was elected the Honorary Secretary of the Indian Association for the Cultivation of Science, and he was its President during 1946-050. After his retirement from Calcutta University in 1953, Saha became the full-time Director of the laboratories of the Association, a post he held until his death. Under his leadership, there was a large-scale expansion of the activities of the Association. Saha played a significant role in the establishment of the Departments of Radio Physics and Electronics and Applied Physics of the Calcutta University. In 1950, Saha founded the Institute of Nuclear Physics (later renamed as the Saha Institute of Nuclear Physics). The foundation stone of the Institute was laid by Dr. Shyama Prasad Mookerjee – the then Civil Supplies Minister of

the Government of India. The Institute, which was formally inaugurated by Iren Joliot-Curie on 11 January 1950, was originally situated on the campus of Calcutta University. Among those who attended the inauguration were Robert Robinson and J.D. Bernal.

Saha founded the Indian Science News Association in Kolkata in 1935. Its main objective was to disseminate science amongst the public. The Association started publishing a journal called *Science and Culture*. Saha himself wrote more than 200 articles in the journal on a wide range of topics which included: organisation of scientific and industrial research, atomic energy and its industrial research, river valley development projects, planning the national economy, educational reforms and modification of Indian calendar.

Renowned physicist and science populariser ShantimayaChatterjee, a colleague of Meghnad Saha, wrote, "Whenever Saha wanted to write or express his ideas on any topic he would work very hard to prepare for it. He would try to understand the crux of the problem, study all the available information on the subject and then by his analysis would try to find a solution for it. I had the opportunity to go to Asiatic Society, National Library, Victoria Memorial and other libraries of Calcutta with Professor Saha. I saw how perfectly and meticulously he would prepare his report and documents after a deep study. When he became a member of parliament, he took full advantage of apartment Library, and he used to speak very highly about it."

Saha died suddenly due to a massive heart attack on his way to the office of the Planning Commission in New Delhi on 16 February 1956. As D.S. Kothari, a student of Saha and founder of defence research in India, wrote: "The life of Saha was in a sense an integral part of the growth of scientific research and progress in India and the effect of his views and personality would be felt for a long time to come in almost every aspect of scientific activity in the country. His dedication to science, his foresightedness and utter disregard of personal comforts in the pursuit of his chosen vocation will long remain an inspiration and example."

Subodh Mahanti

Birbal Sahni

BirbalSahni (14 November 1891 – 10 April 1949) is regarded as the founder of palaeobotanical research in India. Palaeobotany is the branch of science that is concerned with the study of plants through geological time, as revealed by their fossil remains. Sahni's research covered almost all aspects of palaeobotany in India. He was a founder member of the Indian Botanical Society and founded the Institute of Palaeobotany in Lucknow. This was renamed as Birbal Sahni Institute of Palaeobotany after his death.

Birbal Sahni was born at Bhera, a small trading town in the Sahpur District. This is now part of West Punjab in Pakistan. Sahni's family came to Bhera from Dera Ismail Khan and finally moved to Lahore. He was the third child of his parents, Ruchi Ram Sahni and Iswari Devi.

Ruchi Ram Sahni was an eminent professor of chemistry of the Lahore Government College. He played a pioneering role in popularising science in Punjab and a self-made man. He was a scientist, an innovator, an enthusiastic educationist, a fierce patriot, and a devoted social worker. He was an independent thinker with progressive ideas and encouraged his children to think and act according to their own judgments. Birbal Sahni imbibed the spirit of nationalism and rational outlook from his father.

Sahni had his early education first at the Mission School and then at the Central Model School in Lahore. After completing his school education, Sahni joined the Government College, Lahore. His teacher of botany, Professor Shiv Ram Kashyap, a well-known bryologist (specialist in mosses), influenced him to take up the study of botany as his career. After his graduation from Punjab University in 1911, Sahni proceeded to England

for higher studies. In England, Sahni studied at the Emmanuel College at Cambridge. He passed the Natural Science Tripos in 1915. Around the same time he also obtained a BSc degree of London University. In 1919, he received the degree of Doctor of Science (DSc) from London University for his researches on fossil plants. His research supervisor was Albert Charles Seward, an internationally acclaimed palaeobotanist. Sahni's knowledge of Indian plants was recognised early. While he was still a student in Cambridge, Sahni was asked to revise the widely used Lawson's textbook of botany to suit the requirements of students of botany in India. The revised textbook became a widely read book both in colleges and universities. From England Sahni went to Germany, where he worked for a brief period under Karl Ritter von Goebel, a well-known plant morphologist in Munich.

Sahni returned to India in 1919. After spending brief periods at Banaras Hindu University and Punjab University, he joined the newly created Botany Department of Lucknow University in 1921 as its first Professor and Head. In 1943 when the University of Lucknow commenced classes in geology, Sahni served as Professor of Geology as well. Soon after joining, Sahni made the Department of Botany an active centre of teaching and research. He inspired generations of young botanists throughout his long teaching career at the University. His concern for his students was proverbial.

To quote one of his students, T.S. Sadasivan: "To his students he was an ideal to be emulated, he was loved and respected. A nationalist to the core, his personality attracted attention of the entire scientific community. He never sought anything from anyone. In fact, he was sought for his wise counsel both by administrators and academics. A man of taste, everything about him was clear and as was his attire. Simple and elegant, he was clad in hand-spun, hand woven khadi. All this added to his charm. Even after forty years of his passing away, we, the students of this enchanting *Guru* have nothing but fond memories of the many years we were privileged to spend with such a person."

Sahni's research contributions in palaeobotany covered many areas. In fact his researches touched every aspect of palaeobotany in India. Amongst a large number of fossil plants described by him from Rajmahal Hills of Bihar, was his most remarkable discovery of a new group of fossil gymnosperms, to which he gave the name "Pentoxylae". Sahni was greatly interested in archaeology and he published a number of papers in this field. His work on the "Technique of casting coins in ancient India" set a new standard in archaeological research in India. It won him the Nelson Wright Medal of the Numismatic Society of India in 1945. He was also interested in all kinds of geological problems.

In fact, Sahni had acquired thorough knowledge in geology. He believed palaeobotanical researches divorced from geological background would lead nowhere and the former should be done in relation to the geological and geographical conditions

under which the plants lived and perished. He himself made important contributions to geological studies. He threw considerable light on problems like the age of the Deccan Traps, the Saline Series, and the timing of the Himalayan uplift.

Sahni was elected President of the Geology Section of the Indian Science Congress in 1926. In those days to become a sectional president of the Indian Science Congress meant a great honour and recognition in India. He had a long association with the Geological Survey of India. It is interesting to note how he first came in contact with the GSI. The GSI sent some Indian fossil collection to A.C. Seward for his comments. However, Seward declined to undertake the study with the suggestion that the study should be undertaken by his student BirbalSahni. In 1920, Sahni, jointly with Professor Seward, brought out the *Revision of Indian Gondwana Plants*.

In September 1939, a Committee of Palaeobotanists working in India was formed with Sahni as its Convener. Its objective was 'to coordinate the research work done on palaeobotany in India and to issue periodic reports'. The Committee brought out its first report, "Palaeobotany in India" in 1943. The Committee of Palaeobotanists established a Palaeobotanical Society in May 1946 with a nucleus of funds, immovable property, books and fossil collection donated by Sahni and his wife for the promotion of research in palaeobotany. One of the objectives of the Society was to create a research institute forpalaeobotany. On 10 September 1946 the Governing Body of the Palaeobotanical Society established the proposed institute. Initially the institute started functioning in a room in the Department of Botany of Lucknow University. In September 1948, the Palaeobotanical Society received 3.5 acres (1.42 hectares) of land from the Government of Uttar Pradesh for the proposed institute.

The foundation stone of the building of the institute was laid by Pandit Jawaharlal Nehru, India's first Prime Minister, on 3 April 1949. Pandit Nehru said on the occasion: "I used to attend Professor Seward's lectures in botany and I also learnt some geology at Cambridge. This is one of the reasons for my interest in today's proceedings. But the real cause of my interest is that Professor Sahni symbolises in him the kind of scientist that every scientist should be. He has devoted his life with all the energy at his command to his research and most assuredly, he will continue to do so. This quality in a man concerning his work exercises tremendous influence on others. A man who pursues his work in such a devoted manner follows the right path; his work is good; the man is good."

Sahni was an inspiring teacher. He believed that to be a good teacher one has to be a good researcher. He was very fond of music and could play the sitar and the violin. He also showed his talent in drawing and clay-modelling. Sahni died within a week of the inauguration of the institute by Nehru. After his sudden death the Governing Body

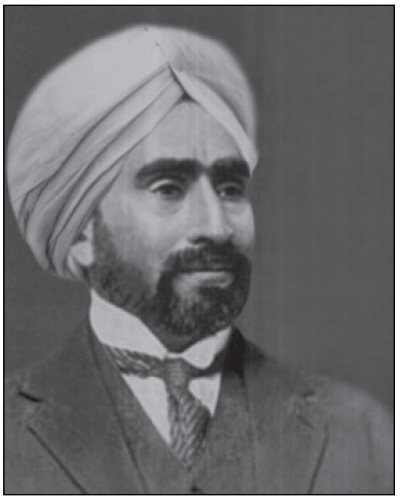
of the Palaeobotanical Society authorised his wife, Sabitri Sahni, to serve as Director of the Institute. She was also authorised to look after the duties of the President of the Palaeobotanical Society. She worked hard to realise her husband's dreams. She managed the institute in its formative years. The institute owes a lot to her courage against heavy odds. In November 1969, the Palaeobotanical Society divested its possession of the institute and it came under the Department of Science and Technology, Government of India. The same year the institute was renamed BirbalSahni Institute of Palaeobotany in honour of its founder.

Mulk Raj Sahni, brother of BirbalSahni narrates his experience thus. "I accompanied him on most of these Himalayan excursions and recall the thrill that we experienced when a plant new to the collection or an orchid or a rare species of epiphyte was discovered; he climbed sometimes at some risk, or helped me with a perch to capture it. This passion for outdoor life and trekking was acquired from father, who, himself an inveterate hiker, carried out traverses on foot across the Himalayas and invariably took Birbal along with him."

Speaking about his uncle, Prof. Ashok Sahni, nephew of BirbalSahni says, "It is interesting to note that when Birbal's father was working in Ernest Rutherford's laboratory at Manchester in 1914, it was the young Birbal who helped him to take photographs and do other incidental work during his summer vacations, although at the time Birbal himself was taking Part II of the Natural Science Tripos. He gained many academic distinctions in high school standing first in Sanskrit, the love of which endured till the very end of his life."

Sahni was elected a Fellow of the Geological Society of Great Britain. He was the Vice President of the Palaeobotany Sections of the 5th and 6th International Botanical Congresses held at Cambridge and Amsterdam in 1930 and 1935, respectively. In 1936, Sahni was elected Fellow of the Royal Society. He was the first Indian botanist to be elected by the Royal Society. Sahni was the General President of the Indian Science Congress (1940). He was twice the President of the National Academy of Science, India, Allahabad. He was elected an Honorary President of the International Botanical Congress held at Stockholm in 1950. However, his untimely death prevented him from going to Stockholm to attend the Congress. He left his footprints not on 'sands of time but on geological time-scale'. The Indian Postal Department has issued several postage stamps on the works of Sahni and one of the species on which he worked has been named as *Birbalsahniadivyadarshanii* in his honour.

Subodh Mahanti



Ruchi Ram Sahni

The name of Ruchi Ram Sahni (5 April 1863 – 3 June 1948) may not be familiar to people as well as the Indian scientific community, but work done by him at the turn of the twentieth century in popularising science will always be remembered. Sahni was a pioneering educationist, scientist and science communicator, who worked for science even under most difficult conditions. He belonged to the first generation of scientists who laid the foundation of modern science in India and ushered in scientific renaissance in Punjab. He was the father of renowned palaeobotanistBirbalSahni.

Despite serious odds, he went to school and then passed BA from Lahore's Government College in 1884, securing the top position in Punjab University. His father was a businessman but suffered heavy loss as a ship-load of goods sank in river Indus. His father used to pay village teacher –*Pandahji*– four *annas* in cash for every multiplication table Ruchi Ram learnt by heart and could recite fluently, without halting. This was in addition to the usual fee of a certain quantity of *atta* and jaggery pupils used to pay him. Sahni also had to spend some time with a shopkeeper so that he could apply the multiplication tables and arithmetic he had learnt. "The object of putting me to this work probably was to make me realise the value of what I had learnt in actual day-to-day transactions. The tables were not merely memory exercises. They had great practical application of their own and a mistake in their application may mean serious loss in business. The calculations had to be made quickly and correctly," Sahni recalled in his memoir.

Sahni's first job was with the Meteorology Department at Calcutta (now Kolkata), from where he moved to Shimla, which was the headquarters of the Meteorology Department. He used to prepare daily and monthly weather reports, and also delivered popular science lectures on weather forecasting. The post he occupied in the weather

office was traditionally reserved for Europeans, and he had to face criticism of Europeans in the media for even small errors in daily weather reports. After leaving the Meteorology Department, Sahni had a brief stint of teaching in Lahore. He was a perfectionist-teacher. He used to perform all the experiments which he had to show to his class a week in advance. He would repeat every experiment thrice and would do them again if there was any discrepancy. He used to arrange lecture and experiment table in advance, including minor details like keeping a matchbox in every table. Science books in the Government College library were inadequate. So, Sahni used to spend a minimum Rs 15 every month to buy books on physics and chemistry and place them in the college library. This he did throughout his teaching career. Sahni was the first Indian to become a science professor at the Government College Lahore, where he served for 31 years from 1887 to 1918.

Prof. Ashok Sahni, grandson of Ruchi Ram Sahni, describes his grandfather in these words: "Ruchi Ram Sahni was a man of many facets: scientist, writer and philosopher, industrialist, science populariser, nationalist and historian. There were several moments in his life when his actions and words would have inspired his contemporaries to follow his example. Here I talk of just two examples, the first when he was about 21 years of age and still studying for a Masters degree in Physics and Chemistry at Presidency College in Kolkata in 1885 and the second, when as a 51-year-old middle aged academic teaching Chemistry in Government College, Lahore, he left to work in 1914 at the University of Manchester's Physics Laboratory of Sir Ernest Rutherford where some of the greatest minds had assembled to unravel the structure of the atom. Several of these scientists would go on to get Nobel Prizes!

In 1885, Ruchi Ram set up his own institute called the 'Panjab Science Institute' to popularize science, along with his Government College colleague Prof. J. C. Oman. So great was the demand of the general public, traders, students and the population at large to hear lectures on topics such as soap bubbles, electricity, magnetism, smokes: poisonous and non-poisonous, and, how does the telegraph wire speak, that audiences drawn from mainly the rural areas and the lay public readily gave the princely sum of one anna to two annas to hear the talks and filled the lecture halls to see the magic lantern presentations!

"Appointed the first Indian meteorologist at Shimla, twenty-one-year-old Ruchi Ram took it upon himself in the absence of his senior officers to declare an emergency about an approaching cyclonic storm (the False Point megacyclone) in the Bay of Bengal in September 1885, believed to be one of the severest to take place, thereby saving many lives by his advance warning. Today, very few would have been given the responsibility or have the confidence in their own ability to make such an independent and important announcement.

"As a researcher in Manchester, he published two papers communicated by E. Rutherford himself in 1915 and 1917. One of these was one of the earliest records of alpha particles on photofilms. In this endeavour he was probably helped by his son Birbal who had been studying in Cambridge University before the arrival of his father and who was a great photographer from an early age."

Sahni left for Germany in 1914 to carry out research in radioactivity, but before he could settle down World War I broke out and he escaped to England. There he worked with Lord Rutherford and also collaborated with Niels Bohr, and published research papers on scattering of alpha particles in photographic emulsion with Rutherford. Sahni founded the Punjab Science Institute (PSI), along with his professor J.C. Oman from Lahore and was its joint secretary. PSI was engaged in spreading science through popular science lectures with "lantern slides" and actual demonstrations. Sahni's lectures became a great hit with common people. Sahni developed his own innovative techniques for making "lantern slides". For instance, instead of smoking glass plates on candle flame he would dip glass plates in thin solution of gum and let them dry in the Sun. This would make the surface of glass slides a little rough on which one could trace figures, maps or data.

The themes of Sahni's popular science lectures covered everyday subjects like soap-making, water quality, pure and impure air, electricity, cyclones, electroplating, glass-making, etc. Such lectures were organised in towns and villages during festivals and fairs to attract huge crowds. The demand for popular science lectures of Sahni from different towns of Punjab grew over time, and sometimes a small fee of one *anna* used to be charged. For coining Indian names for machines and instruments, he would often ask his audience to suggest names. At times, Sahni discussed latest discoveries in popular lectures, such as X-rays, Edison's phonograph and wireless telegraphy. These lectures, accompanied with demonstrations, enthused people a great deal and generated curiosity and questions. Using Punjabi as a vehicle to communicate scientific ideas was a great success.

At PSI, Sahni also developed a workshop to make apparatus and instruments for demonstration and for conducting experiments. He used all his personal savings of Rs 1,500 to establish the workshop. In order to generate funds for salaries of *mistries* and carpenters, Sahni set up a lock-making department in the workshop to make locks and safes on a commercial basis. This became a success, and the institute could generate a profit of Rs 100 a month after paying Rs 1 per piece commission to *mistries* for making locks. Soon a lathe machine was added to the workshop, and within a few years the workshop could make a range of scientific apparatus.

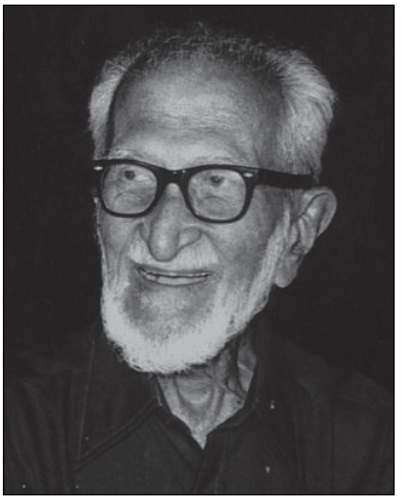
The idea of the workshop had emanated from Sahni's experience that schools and colleges had no labs and all the equipment had to be imported at a prohibitive cost. He

often gifted science equipment to schools or sold at cost price to promote experimental skills among students and teachers. The workshop later started manufacturing scientific equipment of high precision with lathe machines. Sahni also used to buy old scientific instruments being auctioned in Bombay (now Mumbai) while he went there on work. Soon the Inspector of Schools, Punjab, started placing orders of scientific instruments from Sahni's workshop. He also started participating in exhibitions on scientific instruments and orders started flowing from outside Punjab as well. At one such event in Kolkata, J.C. Bose was the judge and he awarded the gold medal to Sahni's workshop.

The personality of Sahni was multi-faceted. Besides being a science teacher and educationist, he was involved in the region's social, cultural, political and industrial life. Science historians believe that his decision to become a crusader of scientific awareness was a result of his involvement with *BrahmoSamaj*of which he was an active member.

Sahni's contribution to modern science in India is unique and unparalleled. Though his research career was short-lived, he devoted his entire life for popularisation of science and improvement of science teaching in schools and colleges. This way he helped shape several generations of scientists and science students. Among them was Shanti SwarupBhatnagar, founder of the Council of Scientific and Industrial Research and one of the leading builders of scientific institutions in independent India. Sahni was instrumental in getting a scholarship for Bhatnagar from Dayal Singh College Trust for his studies abroad. Through his work and deeds, Sahni demonstrated how resource constraints can be overcome through sheer dedication, hard work and innovative ways of doing science. He bought science books for college libraries using his own money. He invested all his savings in the workshop to make scientific instruments. Then he started making locks and safes so that more funds could be generated to sustain work on scientific instruments. All these are innovative ways to deal with shortcomings and lack of government support. Sahni was convinced that teaching of science was not complete or meaningful without proper scientific instruments in schools and colleges. His work on science popularisation remains the hallmark of his career as an educationist and science communicator. The present day scientific community could take a lesson or two from Sahni in spreading scientific literacy among common people and in motivating young boys and girls to take up science as career.

Dinesh C. Sharma



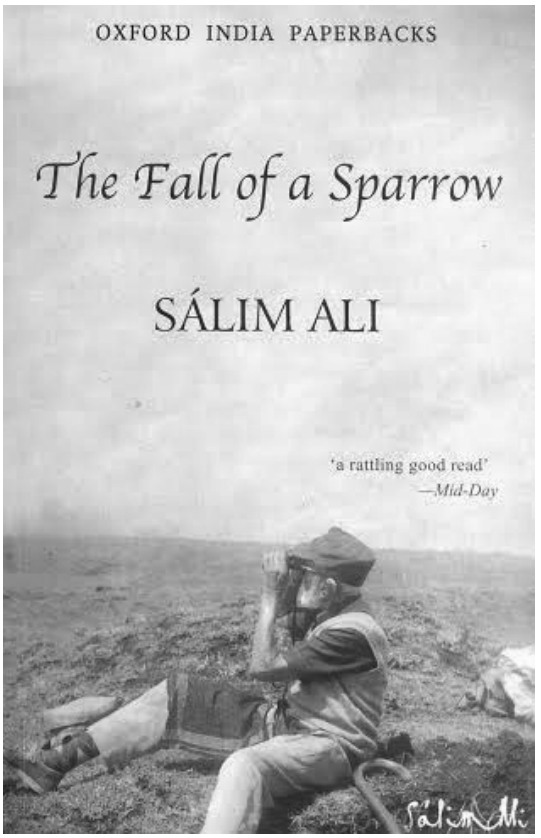
Salim Ali

Salim Ali (12 November 1896 – 20 June 1987) is aptly known as the Bird Man of India based on his pioneering bird surveys across the country. His efforts are commendable especially because this field of scientific pursuit was quite nebulous at the time his interests on the field set in.

Salim Ali's profound understanding of bird life and related fragile eco-systems inspired the conservation ethos and leadership in him. He persuaded Prime Minister Jawaharlal Nehru to declare Bharatpur, a nesting site for thousands of migratory birds every year, as a nature reserve in the 1950s. In later decades he was deeply concerned over shrinking wetlands in the sanctuary and increase in grazing by cattle. It was at Salim Ali's advice that the Silent Valley – a unique ecosystem in Kerala – was declared as a protected area. Plans to develop hydroelectric power there were accordingly shelved. These inclusive and holistic conservation approaches go beyond knowledge creation. He was also the key figure behind the Bombay Natural History Society (BHNS) after 1947 and used his personal influence to garner government support for the organisation.

Salim Ali was born into a wealthy merchant family in Bombay (now Mumbai) and did not flinch from hard work. He learnt all about birds on his own, using such basic tools as binoculars and just a note book. He defined "Bird books" as the reference used by bird watchers during field trips. Interestingly Salim Ali learnt his first lesson in bird behaviour literally through 'hit and trial' just through keen observation. J.B.S. Haldane, British biologist who had made India his home, praised Salim Ali for his capacity to do the most meaningful scientific research with literally his bare hands holding a pair of binoculars.

He used to observe sparrows and other birds that flocked the large house, his uncle possessed. He grew up in this house following the early death of both his parents. One day he saw a female sparrow sitting on eggs in a nest, while a male sparrow stood guard outside. Using his air gun, he shot down the male sparrow. The next day he found another male sparrow on the guard duty. He shot down this one too. This way he shot 7-8 male sparrows. He wrote about this as follows at ten years of age in his notebook: "The cock sparrow perched on the nail near the entrance to the hole while the female sat inside on the eggs. I ambushed them from behind a stabled carriage and shot the male. In a very short while the female acquired another male who also sat 'on guard' on the nail outside. I shot this male also, and again in no time the female had a male in attendance. In the next seven days, I shot eight male sparrows from this perch; each time the female seemed to have another male in waiting who immediately stepped into the gap of the deceased husband." This minute observation and noting of a young child was behind the tenacity he consistently exhibited over the next seven decades as he grew as the leading ornithologist. Interestingly he published this observation later in a scientific journal.



Salim Ali's early days were also a period when bird watching was at best a pastime activity for a handful of the British in India. Some of them were serious scholars too. A.O. Hume, the British civil servant who founded the Indian National Congress, was a well-regarded ornithologist and had published books on birds of the Indian subcontinent. Hume edited the journal *Stray Feathers* over 1872 to 1888, which published reports about bird sightings from all over the country. Hume's collection included 60,000 bird skins, nests and eggs. Another incident that shaped Salim Ali's future as an ornithologist also happened in his childhood. One day he shot a sparrow with a yellow streak below its neck. He took it to his uncle who could not explain the streak and so proceeded to the Bombay Natural History Society. He was at first almost flustered by the dominant English atmosphere within the institution. His tenacity dominated as he went on further with the dead sparrow in his hands to interact with the Englishman, W.S. Millard then the Honorary Secretary of

the Society. Millard's two-fold response inspired the young Salim Ali. The dead bird was identified as Yellow-throated sparrow. He was also introduced to the vast collection of stuffed birds in the society office. This kindled the young boy's interest in ornithology.

He studied zoology at the St. Xavier's College, Mumbai, but dropped midway to look after the family's metal and timber trade in Burma (now Myanmar). He continued his bird-watching activity while in Tavoy, an island near Rangoon (now Yangon). As business did not interest him, he returned to biology. After working for a while as a guide in the Prince of Wales Museum in Mumbai, he went to Germany and trained under Prof. Erwin Stresemann at the Zoological Museum of Berlin.

In 1930, Salim Ali moved to Kihim a coastal village near Mumbai. He studied breeding biology of baya birds in the village and its vicinity. This effort generated newer insights about bird life that fetched him recognition as a world class ornithologist. He studied the flamingos of the Rann of Kutch in depth, and conducted regional bird surveys of Hyderabad, Travancore, Cochin, Afghanistan, KailashManasarovar (China), Kutch, Mysore, Goa, Sikkim, Bhutan, and Arunachal Pradesh. He showed that several species of the waterfowl migrated all the way to Siberia. He wrote several meticulously researched books, beginning in 1941 with *The Book of Indian Birds*. His last bird book, the *Field Guide to the Birds of Eastern Himalaya* was published in 1977.

Migration of birds across the world was a mystery he tried to resolve. In those early days of studies on migration, rings were tagged around legs of birds to help sight them. Salim Ali devised a method to catch such birds. He placed a net of hair from horsetail in front of a mirror in his lawn. When a grey wagtail came it spotted itself in the mirror, tried to attack it, and got entangled. It was then easy to place an identity ring around its ring and release it. Later on, the Bombay Natural History Society, with which Salim Ali had a lifelong association, developed a programme to trap migratory birds in nets to ring them and let go. The ring used to carry a serial number and legend 'Inform BNHS'. This project helped generate new knowledge about behaviour or migration patterns over the years. It was due to Salim Ali that study of birds was included in academic curriculum in Indian universities. He also emphasised on so-called practical aspects of bird watching – some birds may prove to be pests on agricultural crops while others could help eco – system services. He termed this perspective 'economic ornithology' and convinced the Planning Commission to introduce this subject in agriculture universities across the country. At BNHS, he also initiated research about birds as aviation hazard.

J.C. Daniel, colleague of Salim Ali at Bombay Natural History Society, Mumbai wrote in his memoir, "A great and admirable lesson that one learned working with Salim Ali was in the gravity and care necessary in the handling of money, especially public funds. The accountability not only to the donor but also to oneself, that it must be frugally spent and made to give the maximum benefit was imprinted firmly in the minds of all his scientist and students.

"A man with a fine natural modesty, he was humane, selfless, sensible and with a lively sense of humour. Above all, he had what Gandhiji also had and which the Arabs call "Baraka", the quality of being able to bestow blessing or benediction."

Salim Ali had to overcome several odds on personal and professional fronts to pursue his interests in ornithology. He was married early to England-educated Tehmina. She was fond of nature and outdoor life; accompanied him to Yangon; went with him on expeditions and lived in camps. Tehmina died early when Salim Ali was all of only 43. For the next four decades, Salim's sister Kumoo and brother-in-law Hassan Ali gave him a home and looked after all his needs so that he could pursue his interest on birds. After the death of Kumoo and Hassan Ali, their daughter Laeeq and her husband ZafarFutehally – both birdwatchers – took care of Salim Ali till his death in 1987. His scientific research and publications were supported by the BNHS, where he served as Honorary Secretary for many years. He was conferred the Padma Bhushan in 1958 and the Padma Vibhushan in 1976, the third and second highest civilian honours, respectively by the Government of India.

Dinesh C. Sharma

Vikram Ambalal Sarabhai

Vikram Ambalal Sarabhai (12 August 1919 – 30 December 1971) was a cosmic ray and Indian space scientist widely regarded as the father of India's space programme. Thanks to Sarabhai's vision, India today has a well-established and robust space programme with capability to develop, design, fabricate and launch a range of satellites including inter-planetary missions. It has taken nearly half a century for India to reach this position.

This journey was full of hope, ambition, determination, hard work, and of course, hurdles and disappointments. Sarabhai began doing science in an age and time when scientific infrastructure was not fully developed for modern science in India. Scientific research was restricted to a few universities and institutes of higher learning like the Indian Institute of Science in Bangalore (now Bengaluru), besides a handful of industrial research laboratories established to boost war effort of the British. Though born in a wealthy and influential industrial family, Sarabhai was more attracted towards science rather than business and manufacturing. He took his Tripos in physical sciences from the Cambridge University and was deeply interested in cosmic rays – stream of energetic particles reaching the Earth from outer space. In their journey from outer space to Earth, cosmic rays are subjected to solar radiation as well as atmosphere and magnetism of the Earth. Sarabhai was keen to study these changes in cosmic rays. After returning from Cambridge, he did his research for some time at the central meteorological station of the India Meteorological Department in Poona (now Pune), and also trekked to high altitudes in Kashmir to study cosmic rays. He went back to Cambridge to pursue doctoral research and finally returned to India in 1947.

The Late Mrinalini Sarabhai, wife of Vikram Sarabhai is quoted as saying, "He treated all human beings with respect and understanding, whether it was the prime minister in Delhi or a mali in the garden.

"One night on the second floor of his apartment building in Mumbai, Vikram suddenly got up and went to the window talking incoherently about his work. I woke at once, rushed to him, talking gently, patting and soothing him like a child. I brought him back to bed. This instance shows passion and dedication of Vikram towards his work."

Speaking about his father, Mallika Sarabhai, daughter of Vikram Sarabhai, is quoted as saying, "I have realised that a lot of the attitudes he brought into parenting spilled over into the climate he created in his work. He believed in individuals taking responsibility for their work and their action. His attitude towards my solving my own maths problems was very similar to his expectations of his managers in business, and his scientists in the space research programme. He refused to command. He would help people decide by making them probe and question, and might suggest ways of thinking. This led to a horizontal style of management in his science and business institutions, and in our homes."

In order to pursue research in cosmic rays, Sarabhai conceived the idea of a research institute and named it Physical Research Laboratory (PRL). To establish a research institute when the country was in turmoil and on throes of attaining political freedom was indeed a tall order. Sarabhai's contemporary and scientist-friend, HomiJehangirBhabha, had already established the Tata Institute of Fundamental Research (TIFR) in Bombay (now Mumbai) in 1945. The first task was to find a place to locate PRL. Sarabhai decided to convert his ancestral home, *The Retreat*, in Ahmedabad in Gujarat (then part of the Bombay presidency) into research laboratory. This was significant because it was in this house that a young Sarabhai's interest in science was kindled. The house had a workshop with lathes and drills, which were used by Sarabhai – with help from technical staff – to make toy trains. As a child, Sarabhai had the benefit of exposure to the best minds in politics, science, arts and culture. Among the visitors at *The Retreat* were Rabindranath Tagore (who wrote the recommendation letter for Sarabhai's admission to Cambridge), Nobel laureate Sir C V Raman, Jagadish Chandra Bose, and a galaxy of political leaders including Motilal Nehru, C.F. Andews, Sardar Patel, Mohammed Ali Jinnah, Jawaharlal Nehru, and S Radhakrishnan. This exposure perhaps contributed to the shaping of Sarabhai as a well-rounded personality.

After operating for a few months from *The Retreat*, PRL moved to another modest building in the M.G. Science College. The facilities in this location were meagre. For instance, an asbestos sheet placed on two empty wooden boxes served as table for staff, while Sarabhai's 'room' was in a passage. Yet, PRL could attract young students and researchers interested in cosmic ray research. They used to cook their food on hotplates, while working in their labs. Many of them used to work as demonstrators in local colleges during day and work at PRL during night. The scholarship amount that PRL could offer was very low.

For study of properties of cosmic rays and upper atmosphere, Sarabhai and researchers needed instruments. Sarabhai himself designed an apparatus consisting of Geiger counters to take hourly readings of separate cosmic ray intensities. His students fabricated a series of Geiger counter telescopes using 45-cm-long cylinders and lead plates. They also developed own formats for taking readings. The power supply in M.G. Science College was erratic and the building had profusion of pigeons which would often perch on instruments, disturbing their calibration. Sarabhai initiated setting up of a high-altitude station at Kodaikanal in 1949 in addition to one already in Gulmarg in Kashmir, and a sea-level station at Thiruvananthapuram in 1954. By this time, PRL had its own campus in Ahmedabad and was getting support from the Department of Atomic Energy (DAE) too.

The space age officially began with the launch of Sputnik 1 on 4 October 1957, opening new possibilities for humanity. A year later, the International Council of Scientific Unions (ICSU) established the Committee of Space Research (COSPAR), which organised the first space science symposium at Nice in France in January 1960. It was during this conference that Sarabhai met his peers from other nations, including founder of the French space programme. These developments encouraged HomiBhabha to propose to the government to include space research in the mandate of DAE. He then established an Indian National Committee for Space Research (INCOSPAR) and made Sarabhai its head. One of the first projects of this committee was to launch a sounding rocket from Indian soil.

The selection of a fishing village Thumba in Kerala was a long and arduous exercise. The village was selected since it was found to be an ideal location for launching sounding rockets. Thumba was a unique choice because of its proximity to the geomagnetic equator. INCOSPAR pioneered studies on the phenomenon of equatorial electro jet, a narrow belt of electrons moving west to east above the magnetic equator. The height at which this current flows, is beyond the reach of balloons with instruments and too low for satellites. The best way to study the phenomenon is to launch rockets with instruments to collect data.

Sarabhai, along with Bhabha, visited the site only to find that the village had no infrastructure facilities at all, except an old Catholic church. The St Mary Magadelene's Church served working space for scientists while the bishop's house was converted into office. A nearby cattle shed was also used to do preparatory work for the launch of the two-stage Nike-Apache sounding rocket which had come from America. Rocket parts were transported on cycles as it was the only means of communication in the village. The first rocket to be launched from the Indian soil for exploring space was a small American-made Nike-Apache sounding rocket, which lifted off from the newly built launching pad at Thumba on 21 November 1963.

The primary objective of this flight was to measure atmospheric winds, temperature, diffusion and turbulence by photographing the trail of the ejected sodium. In 1965, the United Nations recognised the Thumba launching range as an international facility for launching sounding rockets for peaceful purposes.

In 1968, the Thumba Equatorial Rocket Launching Station (TERLS) was dedicated to the United Nations.Subsequently, the Space Science and Technology Centre was established in Veli Hills in 1965, which gave birth the Indian Space Research Organisation (ISRO) in 1969 – first as part of DAE and then under the Department of Space. The church in Thumba now serves as a space museum.

Another important space-related project initiated by Sarabhai in 1967 was an experimental satellite communication earth station in Ahmedabad. This reflected Sarabhai's thinking about application of space science and technology for national development and the people's welfare. He believed that India need not wait for its own satellites to begin application development and that foreign satellites could be used in the initial stages. Before trying out a full-fledged satellite system, he thought of some controlled experiments to prove the efficacy of television medium for national development. That's how a television programme on agricultural information to farmers 'KrishiDarshan' was started, which received good response. All India Radio and Indian Agriculture Research Institute were key partners in this experiment. Then Sarabhai started working on Satellite Instruction Television Experiment (SITE), which fructified much after his death. It proved to be the world's first experiment in direct broadcasting – a precursor to Direct to Home (DTH) television broadcasting.

The humble beginnings and growth of PRL from an institute operating in residential premises to a national space research body should indeed serve as an inspiration for students and scientists. Many of the researchers who worked at PRL for compensations as low as Rs 100 a month later rose to become national science leaders like U.R. Rao and A.P.J. Abdul Kalam. Vikram Sarabhai was a great institution builder, founding a host of academic, scientific and research institutions from scratch and limited resources. His biggest capital was brilliant minds. Sarabhai received the Shanti Swarup Bhatnagar Medal awarded by ISNA in 1962. The nation honoured him awarding Padma Bhushan in 1966 and Padma Vibhushan (posthumously) in 1972.

Dinesh C. Sharma

Tiruvenkata Rajendra Seshadri

TiruvenkataRajendraSeshadri (3 February 1900 – 27 September 1975) was an organic chemist who contributed immensely to the field of natural products chemistry. Popularly known as T.R. Seshadri, he had a special interest in flower pigments such as flavonoids and anthocyanins and studied flowers from places as far apart as Ranikhet, Hyderabad, and Darjeeling. One of his papers also studied red sandalwood obtained from Burma. He also had a clear sense of nomenclature, as is evident in his naming of a brownish-red, crystalline pigment in the flowers of *Buteafrondosa* as Palasitrin, after the Indian name of the tree, *Palas*. He had an eye for every single detail and combined analytical approaches to research and, late in his career, supplemented them with spectroscopic methods. His career spanned almost half a century during which he established two world-class schools of natural products chemistry in Andhra University and Delhi University.

Seshadri was born in Kulitaiai, a small town near Tiruchirappalli, or Trichy, in the erstwhile Madras Presidency (now Tamil Nadu). After completing his schooling in the temple towns of Srirangam and Trichy, he moved to Presidency College, Madras (now Chennai) in 1917 to study BSc honours in chemistry. He had inspiring teachers of chemistry like P.A. NarayanaIyer, who implanted in him a passion for the subject. With a merit scholarship and support from Ramakrishna Mission by admitting him to its Students' Home, Seshadri could complete graduation in 1920. It is said, "The dedication, sense of duty and spiritual ideals in the Students' Home that he imbibed shaped his life, as seen later in his career at Delhi University".

After completing his MSc from the University of Madras in 1922, he served in Presidency College during 1921-1927. His interest in research arose early, as is evident from the fact that he worked in the laboratory of his teacher B.B. Dey immediately after

finishing his Master's course, instead of searching for a job, which was the norm in those days. In 1927 he won an overseas scholarship to study new anti-malarials and synthesise plant pigments called anthocyanins with Sir Robert Robinson's group at the University of Manchester in UK. After obtaining a doctorate degree there in 1929, he learned organic microanalysis with Nobel laureate Fritz Pregl and studied the alkaloid 'retrorsine' with G. Barger at the University of Glasgow.

On returning to India in 1930, Seshadri served as a research officer at Madras University and the Government College of Agriculture, Coimbatore till 1934. In 1934, he joined Andhra University, Waltair, as Reader and Head of the Department of Chemistry, and became a professor three years later. He and his students worked hard and established an active research school that received international recognition as a prime centre of research on flavonoids and related compounds. During World War II, Waltair campus had to be evacuated: the laboratories were dismantled and converted to a military hospital. The University departments moved, first to Guntur in 1942 and then to Presidency College, Chennai and the laboratories of the Madras University during the academic years 1943 to 1946. Thereafter Andhra University shifted back to Waltair and reconstructing the chemistry laboratories was a great challenge, which Seshadri was able to complete in time. All this while, in the midst of the turmoil of repeated shifting, Seshadri continued to produce high-class research output. Several young people were able to complete their doctorates.

In 1949, on the invitation of the Sir Maurice Gwyer, the then Vice-Chancellor of Delhi University, Seshadri moved to Delhi to join as Head of the Department of Chemistry and organise post-graduate courses and research work. Within a short time, he transformed the Department to one of the most well-known centres in the country for research and established a research school in the chemistry of natural products comparable to the very best anywhere in the world. He received substantial gift of instruments like UV and IR spectrometers from the USA, which helped step up the pace of research. Students from all over the country and in later years from other parts of the world came to work under his guidance. His large research team included postdoctoral scholars from England, France and Germany. His primary area of research was the organic chemistry of natural products, which play an important role in drugs, insecticides and anti-oxidants. His research on hundreds of plants led to the discovery of many new chemical compounds.

Seshadri had a particular interest for floral and animal colouration. His early work centred on the pigments of cotton flowers and the flowers of different species of hibiscus. He could not only elucidate the structures of new compounds isolated from these sources, but also developed new methods of preparing the pigments that have now become routine

in the study of flavonoids and other similar compounds. While at Andhra University, he focussed his attention almost exclusively on the flavonoids. At Delhi University, while building up on the foundations laid at Waltair, he also considerably widened the scope of his investigations and several other types of secondary metabolites, such as the different types of terpenoids, alkaloids, quinonoids and lichen metabolites. In India, he was the first to initiate chemical studies on lichens that included some rare Himalayan species. He not only discovered new compounds in them, but also studied the damage they caused to trees and ways to prevent such damage.

Seshadri developed many reagents and synthetic procedures which he used for elucidation and synthesis of natural products, in particular flavonoids. It is a little-known fact that the technique of O-methylation of phenols using dimethyl sulphate, which is widely used these days, was developed by Seshadri and his students during World War II. At that time, the most commonly used methylating agent was methyl iodide in the presence of silver oxide or silver carbonate. These reagents being expensive, there was a need for cheaper but equally effective substitutes. Seshadri found that calculated quantities of dimethyl sulphate brought about quantitative methylation of phenols in acetone medium in the presence of anhydrous potassium carbonate. He was a prolific researcher. In a career spanning around half a century, he along with his collaborators published more than 1,100 original research papers as well as multiple books on chemistry of natural products. He had trained 160 PhD students.

Sheshadri's dedication to research and his students was legendary. He inspired a large number of young students, setting the pattern of work by his own example. The laboratories were kept open from morning till late in the night, when he was always available for guidance. He not only guided them in research but also helped them in every way including giving financial assistance in times of need. To remain with his students, he is said to have declined the post of the Chairman of the University Grants Commission.

Even after retirement in 1965, Seshadri continued to teach and guide research students and was always available to them. He would sit through every student seminar and critically evaluate the presentation. His research school at Delhi consisted of half a dozen laboratories in three different buildings in which more than 25 students used to work at a time. He had the time and stamina to visit each one of them, at least four times a day, and to spend several minutes with each and every student. His work received wide recognition in India and abroad. He was elected a Fellow of the Royal Society, London, in 1960. In 1963, the Government of India conferred on him the Padma Bhushan. In 1965, the Department of Chemistry of University of Delhi was elevated to the status of a centre for advanced studies in chemistry with Seshadri as the first director.

Prof. Krishna Mishra, research student of Dr. T.R. Seshadri during 1958-1964, recalls her research experience with Prof. Seshadri:"After three months of my joining research my father passed away, leaving the responsibility of looking after my mother and four brothers on me. I wanted to leave research and take up some teaching job but Prof. Seshadri called me and assured me that he was my God father and that I should continue with research. He was very strict and everyone in the department was so scared that when he came out of his room, every one used to rush to their seats. It was like a lion coming out in the jungle. However, I found him very kind hearted and caring. On certain days, he will get me "Rasam" from his home because I looked sick.

"There were three girls working in the department under his supervision, myself, GeetaChakraborty and DarshanRanganathan. Prof. used to tell us that get married to Chemistry, think about Chemistry all the time. His devotion to the subject can be assessed from the fact that he did not attend his daughter's marriage since he was busy in an international conference.

"I cannot forget that day in my life when searching in the library I found that the work I had done in over two years has already been published. I took all my diaries, records and samples, placed them on Professor's table and told him that I am quitting research. Back in my lab, I started crying since my whole world looked crumpled down. I will always remember his words, "If crying can help solve the problem, I will also sit and cry with you". His words that failure in life teaches you to rise and face the problem rather than sit and resent were greatly reassuring. From that time my research work picked up.

"Prof. Seshadri equated research with realizing God. He used to say that research means finding truth. All his research scholars were supposed to attend the lecture on Gospel of Ramakrishna by the head of Ramakrisna mission in Delhi every Sunday morning in Vivekananda Hall of Delhi University. It was usually followed by group discussion by Professor with most of us later in the department. I always keep remembering his words, "Morality and Science go together".

"His love for his students is evident from an anecdote he used to tell us. While he was having dinner after a daylong conference in U.K., the lady sitting next to him asked, "How many children you have?" He spontaneously replied "Twenty six", since there were 26 research scholars working in the department. However, the lady was aghast.

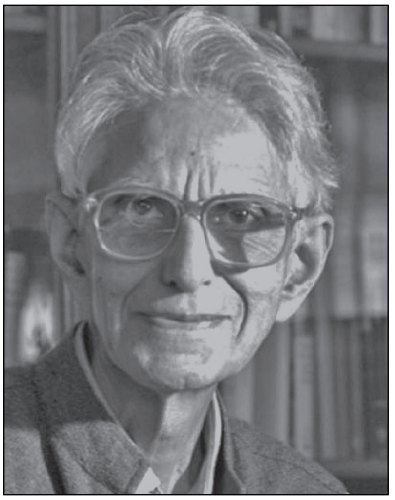
"Working in his research group was a great experience, because we got chance to discuss about our work directly with world renowned scientists like Prof. Robert Robinson, two times Nobel laureate, who was Prof. Seshadri's guru, Prof Alexander Todd, Prof. R.D.

Haworth, Prof. Niels Bohr and many others. Those six years from 1958 to 1964, I worked with him was the best period of my life."

On Seshadri's 60th birthday, his mentor Sir Robert Robinson had to say: "Even if Professor Seshadri were known to me only as an author of original memoirs in chemical journals I would be gratified to have this opportunity to add my tribute to his fertility of ideas, his technical skill in execution and his qualities of energetic drive and wise planning. His original researches have indeed given him worldwide recognition and he is unsurpassed in the experimental survey of the groups of natural products on which he has concentrated his attention. But, to me he is no mere name in the literature; I have enjoyed the inestimable privilege of following his development from the beginning ... We do homage to a most sincere scientist of unassailable integrity, a brilliant and devoted teacher and a most generous friend". The inner satisfaction that came from a life dedicated to the unquenchable pursuit of knowledge and humanism was reflected in the serene personality of Seshadri. As a scientist, humanitarian and a *karmayogi*, he commanded abiding respect and provided enduring inspiration to those who came in contact with him. He believed that science, philosophy and religion, if properly understood were one and the same. He founded the Vedanta Samiti in Delhi University and had a close personal association with the monks of the Ramakrishna Mission, particularly Swami Ranganathananda.

Yet, tragically, Seshadri had to face a lot of hardship late in his life. The new regulations of Delhi University prevented him from receiving honorarium, research scholarships for projects, and funds for carrying on with his research work. He was left without research grants and means of subsistence, which affected his health despite his spiritual strength. He passed away on 27 September 1975. In his tribute to him, Dr. Atma Ram, the then Director-general, CSIR said, "We have in India the example of a scientist like Prof. T. R. Seshadri, being singularly isolated to the extent that he had to undergo considerable suffering and die in penury". But his indomitable spirit continues to guide and inspire the present generation of researchers.

Biman Basu



Obaid Siddiqi

Obaid Siddiqi (7 January 1932 – 26 July 2013) was a celebrated molecular biologist and the Founder-Director of the National Centre for Biological Sciences, Bengaluru, which is part of the Tata Institute of Fundamental Research. He is well known for his pioneering work on taste and smell detection and coding in the brain. He is considered the father of modern Indian biology and the last of the giants of the South Asian science scene. Apart from molecular biology, Obaid's interests ranged from classical music, history, visual arts, to several sports. ObaidSiddiqi's story is the journey of a small-town lad from district Basti in Uttar Pradesh to the hallowed corridors of the Cold Spring Harbor Laboratory and University of Pennsylvania, USA, where he could have chosen to make a name for himself, but decided to come back to India and went on to establish molecular biology in the country. Apart from establishing and running the most prestigious scientific institute in South Asia, he fulfilled his social contract by writing educational books for underprivileged mid-school kids in Hindi for free.

An institution builder, Obaid Sidiqi set up the first Molecular Biology Unit (now the Department of Biological Sciences) and then the National Centre for Biological Sciences of the Tata Institute of Fundamental Research. He was a firm believer that a culture of creativity was vital to long-term institutional success. Born on 7 January 1932, Obaid studied at the Aligarh Muslim University. However, this was the period when India had just become independent and political movements and passion were still strong. Obaid was also sucked into politics. He would have been lost to the world of science had not Dr. Zakir Hussain, who later became the President of India, persuaded him to carry on with his scientific research rather than succumbing to political ambitions. Obaid would forever be thankful and talked about how much he owed Dr. Zakir Hussain for this change of course.

After his degree at the Aligarh Muslim University, Obaid started his career as a lecturer at AMU. His inclination towards the field of molecular biology made him work on mapping of rust-resistance genes in wheat at the Indian Agricultural Research Institute (IARI) in New Delhi. One day, however, a hailstorm destroyed his crop and he wasted no time in deciding that he should move away from this path and explore the possibilities of venturing into genetics. Obaid wrote to Guido Pontecorvo, Professor of Genetics at Glasgow, UK, who would later go on to win the Nobel Prize. Impressed with Obaid's intelligence and persistence, Pontecorvo immediately took young Obaid under his wings. Obaid did his PhD under Pontecorvo in microbial genetics. He mapped the fine structure of the *pabA* gene of *Aspergillus* by examining intragenic recombination and suggesting that this could be polarised. This work is a classic, with Obaid as the soleauthor of the papers, and eventually also contributed to Guido Pontecorvo's Nobel winning work.

In 1961, Obaid Siddiqi moved to the University of Pennsylvania in USA to carry out postdoctoral research with Alan Garen. Together they discovered the suppressors of "nonsense" mutations that led to the discovery of "nonsense" codons, the stop signals in the genetic code. His work there also led to the first exploration of the genetic basis of taste and smell. During this time, the term Molecular Biology had just been coined. Obaid had the fortune of working with some of the best star scientists in this field during his stay abroad. These connections would come in handy when Obaid took upon himself the mantle of an institution builder and brought these eminent scientists to India and also linked his young Indian scientists to the best in the field the world over.

At the height of his career in 1962, when Obaid could have easily set up a lab in the United States, he took the first opportunity handed to him to head back to India for establishing molecular biology in India. HomiBhabha had been looking to begin molecular biology at the Tata Institute of Fundamental Research. It so happened that Leo Szilard once ran into Alan Garen who talked to him about Obaid Siddiqi. After a brief meeting with Obaid, Szilard wrote to Homi Bhabha suggesting to him that Obaid was the right candidate to head any venture into molecular biology. He also enclosed Alan Garen's and Guido Pontecorvo's recommendation letter.

Homi Bhabha wasted no time in writing to Pandit Jawaharlal Nehru, suggesting that Obaid be offered a position in TIFR. Even though the TIFR faculty was against starting of a molecular biology unit because they felt TIFR was a place meant for the pure physics and mathematics, Bhabha did not back off from the offer he had made to Obaid.

Obaid joined the TIFR in 1962 to set up the Molecular Biology Unit. He recruited top-class scientists and very soon put the TIFR's molecular biology group on the world map of genetics. He established a small but strong bacterial genetics group. The group's work on de-linking DNA transfer, DNA replication and recombination in bacteria, was widely

recognised. In the 1970s, Obaid's work with Seymour Benzer, the father of neurogenetics, brought in a new aspect – using genetics to understand the nervous system and behaviour. The unit's pioneering work on neurogenetics of the fruit fly, Drosophila, opened up the prospects of an integrated genetic and neurobiological investigation of chemosensory perception. Led by Obaid, the unit did path-breaking work in neuroscience that is still remembered today.

While engrossed in all this research work and also motivating his team of researchers by example, Obaid was also developing a vision of – and soon founded – the National Centre for Biological Sciences (NCBS). In 1984, the Planning Commission agreed to fund a centre for fundamental research in biological sciences. Located in Bengaluru, its programme was to be broad-based, dealing with all levels of biology: cell biology, development of animals and plants, brain research, behaviour, ecology andtheoretical biology.*Siddiqi was the Director of NCBS from its inception until February 1997.*

A man who shunned publicity, Obaid's humility was legendary and he refused to chase awards. Those who knew him remember him for his refusal to compromise on quality and principles and resort to shortcuts. He would work hard to persuade bureaucrats to change their view and if they did not he waited for their successor. "They will all retire," he would say. There were honours aplenty for Professor ObaidSiddiqi. He is one of a few non-US citizens inducted as a Fellow of the US National Academy of Sciences. He was a visiting Professor at the Massachusetts Institute of Technology and Gosney Fellow and twice Sherman Fairchild Distinguished Scholar at the California Institute of Technology. He was a life Member of Clare Hall, Cambridge University; President of the Indian Academy of Sciences, Fellow of the Indian National Science Academy, the National Science Academy, the Royal Society of London, the Third World Academy of Sciences Trieste, and Foreign Associate of the U.S. National Academy of Sciences, Washington.

Siddiqi also received the Shanti Swaroop Bhatnagar Prize, The Aryabhat Medal, the Indian National Science Academy Jubilee Medal, the Goyal Prize, the Birla SmarakKosh Award for Biological Sciences, Bhasin Award, GM Modi Innovative Science and Technology Award, the B.C. Roy Award for Biomedical Research, and the Indian civil honours Padma Bhushan and Padma Vibhushan. The Aligarh Muslim University, Banaras Hindu University and JamiaHamdard conferred on him honorary DSc degrees. He was a true nationalist. Sukant Khurana, who worked under Prof. ObaidSiddiqi, remembers quote poet Kaifi Azmi that, even though he was born in enslaved British India and had to live through a divided subcontinent, he would love to die in a united, truly secular and a socialist one.

Hasan Jawaid Khan

Radhanath Sikdar

Radhanath Sikdar was an Indian mathematician and surveyor best known for measuring the height of Mount Everest. George Everest, after whom the peak is named, described Radhanath Sikdar (Sickdhar) in these words, "*...hardy, energetic young man, ready to undergo any fatigue, and acquire a practical knowledge of all parts of his profession. There are a few of my instruments that he cannot manage; and none of my computations of which he is not thoroughly master. He can not only apply formulate but investigate them.*"

Radhanath was the eldest of two sons and three daughters born to Tituram Sikdar of Jorasanko, Calcutta (now Kolkata). The family that had once enjoyed power and prestige had fallen on hard times. Radhanath was known for his sturdy physique, fearless nature and a surprisingly open mind. He did not hesitate to take to task young British lads who were rude to the women of his neighbourhood. Radhanath's father ensured that his sons received proper education that would enable them to get good jobs. Radhanath received his primary education initially in a village *pathsala* and later at the school called *firangi* Kamal Basu's school because Kamal Basu was a convert to Christianity. At age thirteen Radhanath entered of the Hindu College, Calcutta (now Presidency University, Kolkata) where his life was transformed by the fiery social reformer Henry Vivian Derozio. As an enlightened Derozian, he was opposed to child marriage and refused to marry the eight-year-old girl his mother had chosen for him. Radhanath was known to be devoted to his mother and it is believed that he never entered into marriage because he wanted to atone for having disagreed with his mother.

Both Radhanath and Srinath received scholarships. Radhanath was awarded a scholarship of Rs.16 in the First Class. He used most of the money to buy books while Srinath's scholarship was used to sustain the family. Recognising that Radhanath was a

maths wizard and a child prodigy, Dr. John Tyler, his mathematics tutor, took him under his wings. He introduced Radhanath to Newton's *Principia Mathematica* and thus catalysed his interest in physics. Radhanath gained mastery over English, Sanskrit, and Philosophy as well. He also learnt some Greek and Latin. He studied Euclid's *Elements*, Windhouse's *Analytical Geometry and Astronomy*, Lagrange's Theorem, and Jephson's Fluxion–seminal works that consolidated his hold over the subject. While still a student, he published a new method for drawing common tangent to two circles in *Gleanings in Science* (Vol. III, 1831). The Editor commented, "*The solution is altogether his own discovery, and I have not altered a word in his composition*."

However, although a brilliant student, Radhanath did not complete his studies. After spending seven years and ten months in Hindu College, he joined the 'Great Trigonometric Survey of India' (GTS) on 19 December 1831 at an initial salary of Rs. 40. His name had been suggested by Dr. Tyler and he was the first Indian to join the Survey; a herculean attempt to carry out geodetic survey of India. However, it became clear that his mathematical abilities far outstripped those of his colleagues. He was soon appointed as Sub-assistant to GTS. In 1832 he joined the then Surveyor General, Sir George Everest to begin work in the Dehradun region. Radhanath was promoted to the post of Chief Computer in Survey of India in1851. The term "computer" in the context of a post may seem odd now, but in those days it merely meant that the person was computing numbers. Radhanath Sikdar served as one of the land surveyors in the Dehradun circle for 20 years.

Andrew Waugh, who succeeded Sir George Everest as Surveyor General in 1843, asked Radhanath to devise a formula for calculating the heights of the peaks of the Himalaya. From a distance of 150 miles (about 242 km), Radhanath collected necessary data for his work from six different locations. He realised that atmospheric refraction affected the readings and developed methods for making the necessary corrections. However, it was not till 1856 that Peak XV was announced as "most probably" the highest mountain in the world with a height of 29,002 feet (8,840 metres). In 1865, Peak XV was finally named Mount Everest by the Royal Geographical Society upon a recommendation by Andrew Waugh.

By then, Radhanath Sikdar had been transferred to Kolkata. So, in 1851, in addition to his service to GTS, he took up responsibilities as the Superintendent of the Meteorological Department. He introduced many novel innovations that stood the test of time for decades. He had realised that the thermal expansion of the metallic scale attached to the barometer, as well as the dilation of the mercury inside the instrument, affected barometric readings. So he devised a formula for conversion of barometric readings taken at different temperatures to 32 degrees Fahrenheit (0 degree Celsius). The formulae used in Europe were unknown to him. Undeterred, he devised these formulae on his own. His research paper was published in the *Journal of Asiatic Society of Bengal* in 1852, wherein he presented

his formula. As a mark of recognition of his mathematical ability, he was elected a member of Bavarian branch of the famous 'Philosophical Society' of Germany. He was the first Indian to achieve this honour.

Radhanath Sikdar retired from active service in 1862. Subsequently, he became involved in various philanthropic activities. With his friend Peary Chand Mitra (1814-1883) he jointly edited a monthly magazine (*masikpatrika*) meant primarily for women. Thus, he may have been one of the early pioneers of popular science writing. In the closing years of his life, Radhanath worked as a mathematics teacher at the General Assembly Institution, (now, Scottish Church College), Kolkata.

Radhanath Sikdar passed away on 17 May 1870 in Chandannagore town, West Bengal; where his grave may still be seen. The unkindest cut came after he passed away. Radhanath Sikdar's contribution to the preparation of the Manual of Surveying for India (Eds. Capt. H. L. Thullier and Capt. F. Smyth) had been duly acknowledged in the preface to the first and second editions. However, this acknowledgement was omitted in the third edition that came out in September 1875. The colonial rulers had decided to delete the name of a deceased native from the publication; they knew the dead man could not protest. This did not go un-noticed by the media. In 1876, the paper *Friend of India* called it, "robbery of the dead".

In the obituary published in the *Hindu Patriot* he was described as: "...a remarkable man ... many good qualities." The Department of Posts, Government of India, issued a postal stamp on 27 June 2004, commemorating the establishment of the Great Trigonometric Survey in Chennai. The stamp features Radhanath Sikdar and Nain Singh, two significant contributors. A tablet has been erected in the National Library, Kolkata in memory of Radhanath Sikdar.

Sikdar's achievements cannot be understood unless one realises the tremendous hurdles he overcame with such apparent ease. India in the early nineteenth century was not an easy country to traverse carrying large yet sensitive equipment. It has been calculated that the average length of a side of the triangulation was almost 50 km, the maximum being almost 100km. The instruments were huge and cumbersome too. Imagine trying to establish a clear line of sight in densely forested regions where attacks from wild animals could not be ruled out; or fording raging rivers carrying the instruments. Yet Radhanath did all this and more. Faced with the need to devise formulae for accurate readings, he drew on his expertise to meet the intellectual challenges. In an age when India was an enslaved nation, Radhanath Sikdar did not just discipline the unruly British elements but also stood shoulder to shoulder with the British scientists and forced them to acknowledge him as their peer.

Sukanya Datta

Kamala Sohonie

Kamala (Bhagwat) Sohonie (1912 – 1998) was a biochemist and the first Indian woman to earn a PhD degree in any field of science. Her pioneering struggles cracked the thick glass ceiling and made it easier for subsequent women researchers to enter the domain of science.

Kamala was born to NarayanraoBhagwat, a chemist and one of the earliest alumni of the Indian Institute of Science (IISc), Bangalore (now Bengaluru).Her family encouraged her to study science and she took up chemistry and physics at the Bombay Presidency College. Her graduation results were spectacular; she topped the 1933 batch. With such a feather in her academic cap, she assumed she would be welcome at any institution of higher learning of her choosing. Her choice was IISc. Perhaps her father's association with the institute played a role and she wanted to walk in his footsteps; perhaps not. IISc had obvious attractions for the scientifically inclined. Not only did it have the famous Nobel laureate Sir C.V. Raman at its helm but it was undeniably a leading institute that acted like a magnet for scholars. Imagine her shock therefore; when Raman summarily dismissed her application with the words, "I am not going to take any girls in my institute." Few girls in 1933 would have had the gumption to challenge such bias and that too of an icon like Raman. But Kamala was made of sterner stuff. For all that she was soft spoken and a quiet person, she had a spine of steel. She went to Bengaluru to register her protest and to convince Raman to admit her. Her silent *satyagraha*-like protest swayed Raman a little. He capitulated and agreed to admit her on probation, and not as a regular candidate; and that too with other conditions attached. One of the conditions was that she would need to work late hours if necessary. However, the most insulting condition was that her presence should not disturb the male researchers. Kamala accepted the humiliating riders, no doubt telling herself that the end justified the means.

However, her real struggles began after she joined IISc. It was expected that she would work from 5 AM to 10 PM with a mere two-hour break in between. Yet, Kamala doggedly pursued her work and finally after the first year even Raman was won over by her sincerity. He bent enough to allow her to carry out regular research in biochemistry and apparently overcame his bias against women researchers. By her uncompromising commitment to science, Kamala caused a male bastion to fall. Today IISc admits male and female researchers without gender bias. It was at IISc that Kamala met her true mentor Sreenivasayyawhose strict yet affectionate guidance, like the gurus of yore, set her foot firmly on the path of biochemistry. He encouraged her to read the publications of leading scientists and to correspond with them. Kamala carried out research on milk-proteins, pulses and legumes, which had important implications for nutritional practices in colonial India. As early as in 1936, Kamala was one of the global pioneers studying pulse-proteins. Her work earned her the MSc degree from Bombay University.

The quality of her work won alsohera scholarship to Cambridge University in 1937. Interestingly, there were about 60 women scientists at the Biochemistry Department at Cambridge University at that time. Nobel laureate Frederick Hopkins was in charge. Kamala later recounted her experience in these words, "I applied for admission to his (Hopkin's) laboratory), although it was already full. Then, the unexpected happened– a kind scientist already working in the laboratory offered me the daytime use of his bench while he would work at night. Prof. Hopkins accepted this solution and I was admitted to this great laboratory on 18 December 1937–the happiest and proudest day of my life." The kind scientist was Derik Richter with whom she worked for a while. After Richter left she continued her work under Robin Hill. Kamala worked on potatoes and isolated and purified the elusive enzyme cytochrome C. The research carried out by Kamala and Hill is recognised today as, "...the first biochemical study of plant mitochondria." It was one of the most fulfilling periods of her life.

Her PhD thesis was completed in just over a year (14 months) and it was only 40 type-written pages long. Yet, the impact of this slim volume was remarkable. Kamala Bhagwat was awarded two scholarships. The first one was at the Sir William Dunn Institute of Biochemistry at Cambridge University. Here she worked on biological oxidation and reduction reactions with Prof. Hopkins. The second scholarship was an American travelling fellowship and it enabled her to interact with eminent scientists in Europe.

Dr. Kamala Bhagwat returned to India in 1939 and was employed as Professor and later, Head of the newly opened Department of Biochemistry at Lady Hardinge Medical College, New Delhi. However, since most of her colleagues and subordinates were males her experience here was not as enjoyable as those at Cambridge. In 1942 she moved to Coonoor in Madras Province (now Tamil Nadu) where she accepted the post of Assistant

Director of the Nutrition Research Laboratory. Here she carried out research to release vitamins from food-items; studied the destruction of the vitamin B-complex and anti-vitamin factors. Yet the lack of scope for advancement troubled her to the extent that she mulled putting in her papers. In 1947 she married M.V. Sohonie, an actuary by profession, and shifted base to Bombay (now Mumbai).

The move to Mumbaisignalled a new beginning for her and not just in her personal life. The Government of Bombay State (now Maharashtra) had invited applications for the post of Professor of Biochemistry at the newly opened Biochemistry Department at the (Royal) Institute of Science, Mumbai and there was no better candidate than Kamala Sohonie to grace the post. Around 1964, she became the Director of the Institute of Science. There is no doubt that, but for her gender, she would have got the position at least four years before she actually did. Be that as it may, her selection as Director was cause for global rejoicing in the scientific community. Derik Richter, her first guide at Cambridge, noted, "... (she) has made history by being the first lady Director of such a big science institute." Sohonie retired from active service in 1969.

Her tenure at the Institute of Science marked an extremely productive time in her career. She attracted bright students and led by example, introducing them to biochemical/ nutritional research of great significance and relevance to a newly independent nation haunted by malnutrition and hunger. Her group carried out detailed biochemical studies on the three major groups of food items especially those consumed by the rural poor. The group worked on the nutritional aspects of *neera* (sweet toddy or palm nectar), pulses and legume-proteins, palm-jaggery (*gur*), palm molasses, mill residue flour (*balata*), whole paddy flour (*dhanata)* and established their nutritive values. Sohonie found that both *dhanata* and *balata* contained reasonable amounts of calcium, phosphorus and the B vitamins. The fibre content and phytic acid content were quite high compared with those of milled rice. Raw and steamed *dhanata* and *balata* were as easily digested by the digestive enzymes pepsin and trypsin as polished rice and casein (milk solids).

It was her idea that *dhanata* and *balata,* which are usually lost during the milling process, could be used to enhance the nutritional quality of Indian diet because these were quite rich in vitamins, minerals and proteins. She discovered that *neera* contains appreciable amounts of vitamin A and vitamin C in addition to iron. Interestingly, vitamin C contained in *neera*was not destroyed when it was converted to palm jaggery and palm molasses. Thus these products could be used as affordable dietary supplements. N*eera* in the diet of malnourished children and pregnant women significantly improved their overall health. Her group also studied trypsin inhibitors and other compounds which reduce the digestibility of Indian legumes. She advised the Aarey Milk Project on improving the quality of their products.

Sohonie was instrumental in founding the Consumer Guidance Society of India in 1966. This was India's first consumer organisation and it was co-founded by nine women. It began formal product testing in 1977.

Kamala Sohonie's life is a vivid example of the uphill struggle that pioneering women scientists had to constantly face just to carve out an identity for themselves. Her achievements form a formidable bulwark against gender bias. Yet her early encounter with bias scarred her and the scars did not fade with time or fame. She later recalled publicly, "Though Raman was a great scientist, he was verynarrow-minded. I can never forget the way he treated me just because I was a woman. Eventhen, Raman didn't admit me as a regular student. This was a great insult to me. The bias against women was so bad at that time. What can one expect if even a Nobel Laureatebehaves in such a way?"

Sohonie was fortunate to get her family's support every step of the way and considerable appreciation from her peers abroad; yet, in the end it was her own unwavering commitment to science, her devotion to work and her confidence in her abilities that facilitated her climb to the top. Sohonie's story has a bitter-sweet ending. In1998, Dr. Satyavati, the first woman Director General of the Indian Council of Medical Research, New Delhifelicitated Dr. Sohonie who was then 84. Kamala Sohonie collapsed during the ceremony and died shortly afterwards. Virginia Woolf once said, "For most of history, Anonymous was a woman." Pioneering women scientists such as Kamala Sohonie made it their life's work to ensure that Anonymous would henceforth have a name.

Sukanya Datta

Yellapragada Subbarow

YellapragadaSubbarow(12 January 1895 – 9 August 1948) was an Indian biochemist who in his short life made a myriad contributions to biochemistry, pharmacology, microbiology, oncology, and nutritional science. Two years after his death, American author Doron K. Antrim wrote, "*You've probably never heard of Dr. YellapragadaSubbarow. Yet because he lived you may be alive and are well today. Because he lived you may live longer*." What a fabulous and lasting legacy to leave behind. In July 1948, he electrified the world by introducing the antibiotic Aureomycin, the first of the tetracycline antibiotics. It was the first broad-spectrum antibioticthat worked against both gram-positive and gram-negative bacteria. The next month he died peacefully in his sleep; taken by death much before his time and perhaps at the pinnacle of success and the zenith of fame.

YellapragadaSubbarow was born in Bhimavaram, (now in Andhra Pradesh). His father was Jagannatham, a revenue inspector who took early retirement from work due to ill health. His mother was Venkamma. YellapragadaSubbarow had three brothers and three sisters. He was the third child in the family of seven children. Jagannatham's pension was a meagre one; so the family was not affluent nor was life easy. An indication that Subbarow was different from other kids his age was apparent when at age thirteen he left home with the aim of executing his business plan. He had figured out that Varanasi, which was visited by innumerable pilgrims, was the right place to earn money. His idea was to sell bananas to the hungry pilgrims. In today's language he showed entrepreneurial spirit at a young age. However, he was soon traced and brought back home. Subsequently, his mother kept a sharp eye on him and on his education too. Later in life, she would not hesitate to sell her gold ornaments to finance his education. It was her exquisite parenting that guided the steps of her son at two decisive points of his life.

Unfortunately just about five years after his attempt to reach Varanasi, his father passed away; a great shock to the young Subbarow. Although good in mathematics, he had to appear three times to finally qualify in the Matriculation examination. Never a distinguished student, Subbarow received his pre-high school education at Taylor High School, Narasapur and Viresalingam Theistic School, Rajahmundry. He cleared his high school education from Hindu High School, Madras (now Chennai). He passed the Intermediate Examination from Presidency College, Chennai, having studied mathematics, physics and chemistry, English and Telugu. While at Presidency College he had become deeply enamoured of the philosophy guiding the Ramakrishna Mission and wanted to renounce everything and become a *sannyasi*. The monks at the mission told him that he could not be ordained a monk without his mother's permission; something Smt. Venkamma refused to give.

Still wishing to serve suffering humanity, Subbarow then opted to join the Madras Medical College (1915) to become a doctor. His expenses were met by KasturiSuryanarayana Murthy, whose daughter Seshagiri he married in 1919. KasturiSuryanarayana Murthy then loaned him money to further his education. Answering Gandhiji's call for *swaraj*, Subbarow had taken to wearing khadi surgical gowns; a fact that angered M.C. Bradfield, his surgery professor. Perhaps that was the reason he was awarded the lesser certificate of "Licentiate in Medicine and Surgery" (1921) instead of the MBBS degree. This lesser qualification was an impediment to getting a government job. It was at Madras Medical College that his determination not to be a worldly failure became a resolute reality.

1921 probably shaped Subbarow's life in ways more than one. Sprue– a tropical disease characterised by malabsorption of food leading to impaired digestion, anaemia and a lingering death – affected all three brothers. It killed Purushottam and Krishnamurthy in 1921. Subbarow narrowly escaped death thanks to Ayurveda. His appointment as Lecturer in Anatomy and Physiology at Madras Ayurvedic College was perhaps a reflection of his desire to explore the ancient science of Ayurveda and is evident in his efforts "to place the innumerable Indian herbs on a standardised basis so that they will be of use to practitioners of all systems of medicine..." However, that was not to be and he decided to branch out to allopathy instead. Again, an obstacle in the form of his interest in Ayurveda raised its head as an impediment. Richard Strong, Dean of the School of Tropical Medicine at Harvard University advised him to continue his studies in India. It was not till 1923 that Subbarow's sustained efforts met with success.

He was promised financial aid by charitable organisations and his father-in-law raised additional funds. Yet, Subbarow reached the shores on USA travelling on the deck of a ship because he did not have money to buy tickets for a proper berth. He left behind

his pregnant wife whom he would never see again. In the early days, resource constraints forced Subbarow to support himself by doing odd jobs that included cleaning the bedpans of patients.

His short-lived son, whose face he never saw, was born in April 1924. Two months later, Subbarow earned his Diploma in Tropical Medicine and entered Harvard Medical School for Ph.D. in Biochemistry–a degree he would receive in 1930. In the interim period, Subbarow and Cyrus Hartwell Fiske developed a rapid colorimetric method to estimate inorganic phosphorus, organic phosphorus, organic phosphates and lipoid phosphorus in blood and urine. He also discovered the role of phosphocreatine (1927) and adenosine triphosphate (ATP) in muscular activity (1929). These were such seminal discoveries that by 1930 these had entered textbooks. By the next decade his fame was such that he was chosen as Associate Director of Research, Lederle Laboratories in USA. In 1942, Gramicidin, the first-ever antibiotic from Subbarow's laboratory, was cleared for use in first-aid dressings. His work at Lederle Laboratories had also resulted in the discovery of Polymyxin– widely used in cattle-feed. In 1942, he became the Director of Research at Lederle.

In 1945, the world took notice when he announced the isolation and synthesis of folic acid, a compound that could treat a variety of anaemias and other disorders. Two years later he unveiled Hetrazan (diethylcarbamazine, DEC). It was a cure for filariasis/ elephantiasis. In April 1948, he announced that Aminopterin, the 4-amino derivative of folic acid that he had discovered, could be used to treat several types of cancer, including childhood leukaemia. The closely related compound Methotrexate was simultaneously marketed by Lederle Laboratories during this time.Soon, it began to be used to treat not just cancer, but rheumatoid arthritis and psoriasis too. The conquest of cancer was his 'magnificent obsession.' He set up the first cancer research unit in any American pharmaceutical company and supervised a screening programme. His interest in folic antagonists as anti-cancer agents catalysed the field of chemotherapy. Dr. YellapragadaSubbarow spent his fruitful years working in USA although he remained an Indian till his last day. The Government of India released a commemorative stamp in his honour in 1995; his 100th birth anniversary. A fungus was named *Subbaromycessplendens* in his honour by American Cyanamid.

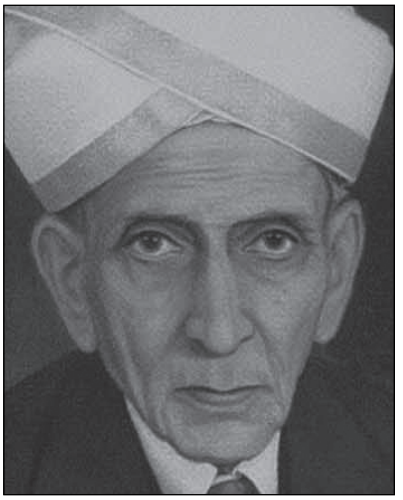
His life shows interesting evolution. From a student disinterested in school education to a young man drawn to renunciation, he evolved to realise his potential as someone whose actions would serve humanity long after he was gone. Often he paid the price for his beliefs and each time he rose above the circumstances; perhaps even compromised with them. As a child, he chose to abandon his family because of grinding poverty hoping to earn riches through business. He chose to enter a marriage of convenience with the younger daughter of his benefactor because the age difference of 12/13 years between him

and his wife meant he could delay starting a family. For 25 years he lived in USA, never once returning or even attempting to bring his wife over. In her later years, Sheshagiri is reported to have come to terms with the sacrifice she was forced to make for the benefit of humanity. However, Subbarowhonoured the promise he had made to her father-in-law, his benefactor. He returned the loaned amount and more at a time when the family was under financial duress. It is said that behind every successful man there is a strong woman. In the life of Dr. Yellapragada Subbarow, there were two: his ever-vigilant mother and his self-effacing wife. Self-effacement was a trait that characterised Dr. Subbarow too. About him it has been said, "*He was invariably in the audience when a colleague or a collaborator, pushed by him to the limelight, took the bow as each fruit of research directed by SubbaRow was revealed to the public. He never granted interviews to the press. He never made the rounds of the academics which apportion accolades among the achievers. He never went on lecture tours.*"

However, with single-minded sense of purpose, a steely determination and armed with superb intellect he achieved his ambition ...something he had articulated when his mother had had him apprehended enroute Varanasi. "*I must win a name in the world. Then only would life be worthwhile. ...*" It was to leave his mark on the world; to leave behind worthwhile legacy. He paid the price by sacrificing the joys of family. He struggled in an alien land. But his resolve did not waver; his efforts did not cease. When he died the obituaries celebrated his life in glowing terms such as: "A legend during his lifetime."

"Little known biochemical prodigy.""A man truly deserving of the highest accolades including, perhaps, a Nobel Prize." Today too, a hundred and twenty years after his birth, everyday thousands who have gained a new lease of life thanks to the fruits of his research have reason to be grateful to this Indian whose name they may not know.

Sukanya Datta



Mokshagundam Visvesvaraya

Mokshagundam Visvesvaraya (15 September 1860 – 14 April 1962) was an engineer par excellence who played a key role as the architect of modern India. He was a great scholar who also served as Diwan of Mysore (1912-1918). He was the chief engineer; Krishna Raja Sagar dam and the chief designer of the flood protection system for Hyderabad. He was instrumental in developing a system to protect Visakhapatnam port from erosion. In view of his multi-faceted contributions, he can perhaps only be summed up as a "nation builder." Diwan Bahadur Sir Arcot Ramaswamy Mudaliar described him as " *....one of the greatest patriots of India, belonging to no party, adopting no slogans, attached to no shibboleths but dedicated to the uplift of his countrymen.*" In independent India, his birthday is celebrated as Engineer's Day.

Mokshagundam Visvesvaraya was born to Sanskrit scholar Mokshagundam Srinivasa Sastry and Venkatalakshammain village Muddenahalli, Kolar District, Mysore State (now Karnataka). The couple had four sons and two daughters. Mokshagundam Visvesvaraya was the second son. He lost his father when he was just fifteen. By then he had completed his lower secondary education from Chickballapur Middle and High School. He then moved to Bangalore (now Bengaluru) to live under the guardianship of his maternal uncle H. Ramaiah. He was admitted to Wesleyan Mission High School in 1875.

In 1881, he completed BA (with distinction) from Central College, Bengaluru. Charles Waters, the Principal of Central College soon came to appreciate the academic acumen of his student and asked him to coach other students. He remembered Visvesvaraya all his life and bequeathed his gold cuff-links for him. Water's widow came to India to hand him the gift from his erstwhile teacher; a gift Visvesvaraya treasured all his life along with the dictionary given to him by Waters. During his graduation studies, Visvesvaraya's financial

situation was quite precarious and he took to tutoring the children of Shri Muddaiah, Minister to the Maharaja of Mysore. He had to walk long distances to juggle his duties as a tutor and his duties as a student. This habit stayed with him life-long. The Government of Mysore provided scholarships to brilliant students who could use it to study subjects outside the state, because facilities to study that subject were not available in the state. This scholarship enabled Visvesvaraya to take admission in the College of Science, Poona (now Pune) to study engineering. In 1883, he stood first in the final engineering examination and was awarded the James Berkley gold medal. His specialisation was civil engineering. As was the policy in those days, his examination rank secured him a job under the Government of Bombay. In 1884, he joined as Assistant Engineer in the Public Works Department, Government of Bombay and served there till 1908. His first assignment was the construction of a syphon on the Panjra river at village Dararti. Since this work was carried out when the monsoon season was at its peak, the work involved flooded rivers and travelling on horseback in torrential rain. Yet, the work was completed on time and impeccably so.

Following successful clearing of a departmental examination, Visvesvaraya was posted to Poona and then to Sukkur, Sindh. He was involved in the construction of roads and buildings, water supply projects, sanitation projects, and irrigation projects; all of which he meticulously executed. He devised a new irrigation system called the Block System. Visvesvaraya's innovativeness resulted in the design of automatic steel gates to increase storage level in dams and stop wastage of water. First used at a dam near Poona, the design of the Automatic Sluice Gate was patented by him. These gates worked so well that these were installed at the Tigra Dam in Gwalior and the Krishna Raja Sagara Dam in Mysore. He foresaw the importance of using reservoirs for flood control. Till then, reservoirs had been used only for irrigation and power generation. His recommendations fructified as the Hirakud Dam. His interventions tamed the River Mahanadi and reduced the floods in Orissa (now Odisha). In 1906, he went to Port of Aden to set up drinking water and drainage systems. In recognition of his contributions, he was awarded the Kaiser-i-Hind medal.

On 15 April 1909, Visvesvaraya joined as Chief Engineer of Hyderabad; only after explicit assurance from the Maharaja and the Diwan of Mysore State that he would be given full freedom to carry out his plans for the development in the State. This is an interesting clause because he had embarked on a personal tour of foreign countries, including Japan, Canada, America, Russia and parts of Europe. The idea was to study engineering and irrigation interventions implemented by these developed nations and to use them in India. He was particularly interested in the Ford automobile factory in Detroit, USA and on his return; he submitted a "practical scheme for the establishment of an automobile industry in India." In Hyderabad, taming the River Musi was his first test. However, just before he

could join, he was convinced to accept the post of Chief Engineer of Mysore State on 15 November 1909. He had the satisfaction of knowing that his plans for saving Hyderabad from the vagaries of floods would be implemented to the letter. He returned repeatedly in 1922 and in 1930 to Hyderabad and even compiled a report on the implementation of his plans.

For three years Visvesvaraya served as Chief Engineer. Then he became the Diwan of Mysore. His assessment of the situation he inherited and the steps he took to mitigate things are best summed up in his own words. He referred to "*Low level of education, lack of initiative, ambition and power of organization, lack of capacity for planning amongst the leader, low economic condition and absence of any effort on a planned basis for improvements and developments. My one aim therefore was, to plan, promote and encourage developments chiefly in education, industries, commerce and public works to encourage the people to work well, earn well and live well.*" And truly, his touch galvanized sectors such as education, agriculture, power, irrigation, social welfare, transport and industry to name just a few. He even introduced reforms in the political and administrative systems. He initiated the Mysore Economic Conference and served as Chairman.

His focus was on agriculture, industries, commerce, and education– lynchpins of societal transformations. He stressed the need of education as away to overcome backwardness. He introduced compulsory primary education and arranged for educational grants for backward communities. He introduced short-term courses in Kannada for the benefit of fringe-farmers and for small shop-keepers who were educated in elementary account-keeping, banking, and commercial geography. Schemes were prepared for imparting general instruction in civics, duties and responsibilities of the citizens, business and social ethics. An agricultural school was opened in Hebbal, near Bengaluru, in 1913. His touch was extended to the higher reaches of scientific education too; he facilitated the setting up of the prestigious Indian Institute of Science in Bengaluru. He also facilitated women's education and even introduced special hostels for them. His goal was simple. He did not want a village to have a single illiterate family and a family to have an illiterate member. He emphasised the need to learn modern skills. In July 1916, the University of Mysore opened its portals making Mysore the first Indian princely state to have a University of its own.

Visvesvaraya founded the Deccan Club, Poona; Century Club, and Ladies Club, Bengaluru; and the Cosmopolitan Club in Mysore. He set up the Public Library, Bengaluru. He also wrote a book on Planned Economy for India and Reconstruction of Rural India that predates India's First Five Year Plan. As Diwan of Mysore, he introduced the concept of model villages and model *talukas*. He laid down specific time-bound milestones for the administrators whose reports he personally scrutinized.

Visvesvaraya's democratic outlook was evident in all he did particularly in the way he approached administrative issues. Nothing escaped his notice and he paid equal attention to all problems, be it cleanliness in temple premises, the plight of widows, poverty, untouchability, and social backwardness. Neglected sectors such as hospitality, catering and tourism industry received a fillip because of his actions. Although his stellar contributions as an engineer is the plinth on which his fame rests, he is also known for establishing the Sri Jayachamaraja Silver Jubilee Technological Institute, Bengaluru, and the Bank of Mysore (now State Bank of Mysore). His clarion call was "*industrialise or perish*." He was particularly interested in the industrialisation of agriculture. He even wrote a small booklet entitled *Prosperity through Industry*.

He established the Mysore Iron and Steel Works Ltd., Bhadravathi (now Visvesvaraya Iron & Steel Ltd.,) which was not only the largest State-owned factory in South India but the first in India to have a ferro-silicon plant and electric pig-iron furnaces. Bhadravathi soon earned the epithet "Birmingham of South India." In Mysore state Visvesvaraya established sugar factory, chrome tanning factory, match factory, brick and tile factories, soap factory, wood distillation, and the ferro-silicon industry. He established the Sri Krishnarajendra Mills, the Central Government Weaving Factory, and in an attempt to market artisanal products, set up the Mysore Arts and Crafts Depot in Bengaluru. He began new industries, revived the ailing ones and strengthened those that were thriving. He modernised sericulture, cottage industries and the handicrafts sector. He empowered the Conservator of Forests to carry out research with an eye to utilising the forestry resources (emphasis on sandalwood) to develop forest-based industries. He voluntarily retired as Diwan of Mysore in 1918, but retained a life-long connection with the state often going back and extending much-needed services. He served as one of the Directors of the Tata Iron and Steel Co. for 28 years.

He often said, "*Work, work. Work hard. Hard work does not kill. Worry kills*." His motto was "*It is better to serve like steel than rust and wither away like iron*." And serve he did; almost to the last day of his life. When he passed away aged almost 102 years, the legacy he left behind was enough to ensure immortality. Sir Mokshagundam Visvesvaraya walked with Kings and commoners but without fear or favour. He answered the call of duty with all the resources at his command. Scrupulous, disciplined, meticulous, painstaking, punctilious, impeccably dressed, extraordinarily punctual, the frugal and soft-spoken Sir M.V as he was lovingly known was a legend in his lifetime. His stature has only grown as time passes and his legacy endures. In trying to emulate him we can only use, as a timeless and priceless touchstone, his advice to future generations, "*Remember, your work may be only to sweep a railway crossing, but it is your duty to keep it so clean that no other crossing in the world is as clean as yours.*"

M.S. Nanjundiah, husband of Sir M. Visvesvaraya's grandniece, recollects, "I am married to Shantha, who is the grandniece of Visveswaraya. He called us for lunch. He said what did you do, for example, to block the channel? How did the guide bund work? Were you able to transport all things on time? So it took me almost half an hour at the end of which he was satisfied with the replies I gave him. He patted me on the back and he told me that your work is fine."

Visvesvaraya never sought fame and often insisted that institutes be named not after him but after others. Yet, his work spoke for him and honours and awards followed him. He was appointed a Companion of the Order of the Indian Empire (CIE) in 1911 and created a Knight Commander of the British Indian Empire (KCIE) in 1915 by King George V for his contributions to the public good. In 1955, independent India bestowed on him the highest civilian award of the nation: Bharat Ratna. The Government of India released a memorial stamp in tribute to him in 1960; the year he celebrated his 100th birthday. Many institutions in India today bear his name. Examples include: Visvesvaraya Technological University, Belgaum; University Visvesvaraya College of Engineering, Bengaluru; Sir M. Visvesvaraya Institute of Technology, Bengaluru, and Visvesvaraya National Institute of Technology, Nagpur. The Visvesvaraya Industrial and Technological Museum, Bengaluru is named in his honour. The Visvesvaraya National Memorial Trust has created a memorial at his birthplace Muddenahalli.

Sukanya Datta

D.N. Wadia

DarashawNosherwanWadia (23 October 1883 – 15 June 1969) laid the foundation of geological investigations in India. K.S. Valdiya, an eminent Indian geologist, said: "A giant among geologists, DarashawNosherwanWadia was a great visionary who not only shaped our understanding of the geological making of the Indian subcontinent but also set the national agenda of geological activities when India won freedom." Wadia was born on 23 October 1883 in Surat into a Parsee family in Gujarat. He was greatly influenced by his elder brother, Munchershaw N. Wadia, a well-known educationist and imbibed three important qualities of his life – a strong love for science, devotion to knowledge and a rational outlook.

After completing his school education at the age of 16, Wadia joined the Baroda College, which was then affiliated to Bombay University. From Baroda College Wadia obtained two BSc degrees. His first BSc degree, which he obtained in 1903, was in zoology and botany. His second BSc degree obtained in 1905 was in geology and botany. Wadia's interest in geology was aroused by his teacher at Baroda College, Adarjee M. Masani, a keen naturalist and Professor of Natural History. The geological specimen kept in the Museum of Arts and Science in Baroda greatly helped Wadia in this context.

The Museum was set up under the patronage of the then ruler of the Baroda State, Maharaja SayajiraoGaekwad. In those days Baroda College did not have sufficient facilities for imparting education in geology and therefore whatever Wadia learnt was mostly through self-study. At Baroda College, Wadia was also influenced by AurobindoGhosh, who was then a Professor of English. Aurobindo later turned a mystique, philosopher and saint. In 1905, Wadia was appointed Fellow of the Baroda College. He completed his MSc degree in biology and geology in 1906.

In 1907, Wadia joined the Prince of Wales College in Jammu in Jammu & Kashmir as professor of geology. The Prince of Wales College was later renamed as Mahatma Gandhi College. Wadia served at the Prince of Wales College for 14 years. Besides geology, Wadia also taught English, a testimony of his command over the language. During his service at the college, Wadia spent his vacations in the foothills of the Himalayas to get familiarised with their geology. He also collected minerals, rocks and fossils to aid his teaching at the college and also to solve problems that emerged from his field trips. He used to take his students on adventure trekking and investigative field trips in the Siwalik Hills of the Jammu region. It was in one of these ventures that he discovered a 3-metre-long fossil tusk of an elephantine mammal *Stegedonganesa*, a finding of crucial importance. He undertook research investigations on stratigraphy, structure and palaeontology of Kashmir Himalaya with single-minded devotion. He worked towards identification of broad structural elements of the North-Western Himalaya.

In 1921, Wadia left the Prince of Wales College to join the Geological Survey of India (GSI) as Assistant Superintendent. Wadia was the first Indian without a European degree to be appointed in the GSI. Wadia's appointment in GSI provided him ample opportunities for carrying out investigations on the stratigraphy and tectonics of the North-Western Himalayas. He embarked upon the challenging task of mapping and interpretation of the geology of North-Western Himalayas. He authored about one hundred original research papers, monographs on various topics and the *Records* and *Memoirs* of the Geological Survey of India.

Wadia's work led to the understanding of the geological history of the North-Western Kashmir. He gave a detailed geological account of the Chilas, Astor-Deosai and Hazara districts. Against all difficulties, Wadia succeeded in mapping the geological structure and the rock and mineral composition of the Nanga Parbat and adjoining portions of Chilas in Gilgit district. The basic geological information on the Nanga Parbat gathered by Wadia became the basis for future research on tectonics of the region. Wadia developed his explanation of the 'knee-bend' (or syntaxial turn) of the Himalayan mountain chains around the knot called Nanga Parbat. His explanation differed from the earlier interpretations. Earlier, Edward Suess, the eminent Swiss geologist, had suggested that the bend was a meeting or converging point of two distinct mountain systems, the Himalayas and the Hindukush. Wadia gave a tectonic interpretation for the formation of the knee-bend. Wadia's explanations have been validated by more recent studies in structural analysis, metamorphism and geochronological dating.

Wadia made important contributions on the geological setting and economic minerals of limestone found as island-like mass forms of older rocks amidst young sedimentary rocks in the sub-Himalayan Tertiary belt of Jammu. He prepared detailed geological map

of the Dandili-Devgarh hills in the Kotli area of Jammu region. He discovered the existence of vast reservoir of sulphide ores of copper, nickel, lead and zinc.

In 1928, Wadia discovered a very well-preserved skull of *Actinodon*from *Gangamopteris* beds of Lower Gondwana affinity. The discovery of this skull, which was found in association with fossil primitive fish known as ganoid fish and *pteridospermous*plants, led to the fixing of the age of important geological rock formation in the Kashmir Himalaya to the Permo-Carboniferous time (355-250 million years). Wadia wrote a textbook on geology for Indian students. The book was titled *Geology of India for Students* and it was published by Macmillan in 1919. Before this book was published there was no adequate modern book on the subject. Wadia's book went through six editions and it not only made him a celebrity but it also had a profound influence on generations of students all over the world.

Wadia made significant contribution to the development of soil science in India. He not only pointed out the neglect of soil science in India but also showed the way for its rectification by his own writings. In 1935, Wadia, jointly with M.S. Krishnan and P.N. Mukherjee, published the first soil map of India. It was published by the Geological Survey of India and paved the way for later soil maps. Thus Wadia's work had considerable bearing on agricultural development in the country. He represented in India at the 3rd International Congress of Soil Science held at Oxford, UK in 1935.

While working in Geological Survey of India, Wadia spent his study leave (1926-27) in England studying the vertebrate fossils collected from the Siwalik strata of Potwar and Kashmir and kept in the British Museum. During this period he also visited geological institutions in Germany, Austria and Czechoslovakia and attended a course in Alpine geology at the University of Geneva. In 1937, he attended the International Geological Congress held in Moscow where he presented his famous paper, "Tectonic Relations of the Himalayas with North Indian Foreland."

After his retirement from the Geological Survey of India in 1938, Wadia joined as the Government Mineralogist to the Government of Ceylon (now Sri Lanka). This gave him the opportunity to study the unique geology of an island in a stable continental region. His studies included accurate geological maps of the island and geological investigations concerning water supply, dam-sites and other engineering projects. After returning to India from Sri Lanka he initiated and formulated a mineral policy for the country. In 1963, the Government of India made him the first National Professor in geology.

Dr. K.K. Dhar, colleague of D.N. Wadia, recollects in his memoir:"He had few hobbies besides reading. Always absorbed in his work, he was the very picture of a

savant. An avid reader, he had probity and was able to pick out essentials from the non-essentials and could, therefore, sum up briefly what others would take pages to summarise. He was systematic in work; though a hard task-master, he was considerate to his subordinates, he was alert of mind and eye; sparing in speech, he could make his point in a few chosen words; though of a retiring disposition, he was capable of enjoying a joke. Such are my memories of this eminent man, who was held in high regard by other eminent men, and with whom I had the privilege of working for something like 20 years. From him I drew continued inspiration as, I trust, the coming generation of geologists will also continue to do."

In 1957, Wadia was elected a Fellow of the Royal Society of London in 1957. The Royal Society of Ceylon conferred upon him its Honorary Fellowship for his contributions to geology of Ceylon (now Sri Lanka). He was the President of National Institute of Sciences of India (later renamed as Indian National Science Academy) during 1946-47, General President of Indian Science Congress (1921 and1938), and Inaugural President of Indian Society of Soli Sciences (1949).

Subodh Mahanti

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