Foreword

I am delighted to see that *Current Science* is bringing out a special section on Dr Vikram Sarabhai on the eve of his birth centenary year. I find no better way to describe the personality of this great Indian than to reproduce what Prof. C. N. R. Rao says about him in his concluding paragraph as a part of his tribute in this issue: 'Vikram Sarabhai was one of the most cultured persons that I have known. He was educated in the true sense. His wife Mrinalini was a great classical dancer and ran a dance academy. I consider myself lucky to have known a person as sophisticated, as *suave*, as human and as charming, as Vikram Sarabhai. I have not met anyone like Vikram Sarabhai in my dealings with the scientific community. There was only one Vikram Sarabhai.'

Vikram Ambalal Sarabhai was born on 12 August 1919 in an illustrious family, well known for its social prominence and wealth, in business and in philanthropy. His parents were professionally prominent with his father Ambalal Sarabhai being a pioneer in textile industry and his mother Sarla Devi being a social activist. Sarabhai's early schooling was patterned on the model of a Montessori education, with the idea of imparting knowledge towards stimulating in the pupil its love and pursuit. The early childhood environment of Sarabhai was one where he came in contact with such dignitaries as Mahatma Gandhi, Annie Besant, Rabindranath Tagore, Maulana Azad, Sarojini Naidu, J. C. Bose, C. V. Raman, Pandit Madan Mohan Malaviya, Sardar Vallabhai Patel and Pandit Nehru among many others. This in turn had a unique and positive impact on young Sarabhai. After the completion of formal school education from R. C. High School of Ahmedabad, he continued his interests to pursue Science and Mathematics in higher education at Gujarat College. Following this, in 1940, he got an opportunity to study and complete his Tripos in Physics and Mathematics at St Johns College of Cambridge. He continued his post-graduate studies in Cambridge when the World War II broke out. In view of this, Sarabhai returned to India to work with Sir C. V. Raman at Indian Institute of Science for which Raman got a special permission from Cambridge to ensure continuity of his research work. He could thus, return back to Cambridge and complete his Ph D in Cosmic Rays working on the Doctoral thesis 'Cosmic ray investigation – experiments with gamma rays' under Prof. Robert Millikan. The thesis itself was evaluated by Prof. P. M. S. Blackett. Working with three Nobel laureates in his early phase of academic career could have had a remarkable influence in Sarabhai's later professional life with its multiple dimensions. During a visit to India just before completing his Ph D, Sarabhai met Mrinalini at Bangalore through contacts developed during meetings where arts and culture were the focus of discussion and in which he had deep interest. Upon the completion of his Ph D they finally got married in Chennai. Soon the family became four, with the birth of Karthikeya and Mallika, both of whom in the later years repeated the qualities of their parents with their brilliance both academically and professionally. The country honoured the entire family with *Padma* Awards.

Coming from a family of industrialists, Sarabhai was a part of the family management team to oversee the functioning of the different business establishments. He gave up his business responsibilities when he took over the major task of creating and managing India's space programme.

In the period after Sarabhai returned to India with a Ph D from Cambridge, in order to pursue his interest in Cosmic rays and interplanetary medium, he set up Physical Research Laboratory, Ahmedabad in 1948. This laboratory had two major areas of research, one relating to the study of cosmic ray time variations under the direct supervision of Sarabhai and the other relating to atmospheric and ionospheric studies under the overall guidance of Prof. K. R. Ramanathan. Sarabhai and his students made seminal contributions to the understanding of the interplanetary medium using cosmic rays as a sounding probe. He and his team set up such major observational facilities as Giger Muller Counter telescopes, plastic scintillator telescopes and neutron monitors. In the process of analysing the data from these instruments he and his students established that cosmic ray anisotropy is something that originates beyond the atmosphere and the geomagnetic field, discovery of the 22-year-old variation of solar magnetic field as well as detection of 27-day modulation of cosmic ray intensity on Earth due to solar rotation.

By 1960s, the world having seen satellites of Soviet Union and USA being orbited around Earth was getting ready for a new era of space exploration. The Indian National Committee for Space Research (INCoSPAR) was set up by the Government with its headquarters at Physical Research Laboratory and Sarabhai being its first Chairman. The first contours of India's space endeavour were drawn up at this time through the meetings of INCoSPAR under the visionary leadership of Sarabhai. One of the first tasks was to setup a rocket launching station at Thumba close to the geomagnetic equator (TERLS). The first rocket from TERLS was launched on 21 November 1963. Many aspects of atmospheric and ionospheric scientific investigations above geomagnetic equator were facilitated in the subsequent years through a number of rocket launchings including the French, American and Soviet rockets and also instruments from these countries among others. Around this time, Sarabhai also initiated establishing Space Science and Technology Centre (SSTC), in the outskirts of Thiruvananthapuram, now known as Vikram Sarabhai Space Centre (VSSC),

charged with the responsibility of developments of rockets and satellite technologies.

As a part of the first steps towards establishing India's space programme, Sarabhai undertook several initiatives with the policy of indigenization, licensed production and also technology transfer arrangements. Among the many initiatives that the initial part of the space programme witnessed under Sarabhai, some of the more prominent ones include licensed production of the French Sounding Rockets Centaur, finalization and initiation of the work on India's first launch vehicle SLV-3, preparation for undertaking satellite communications at experimental level by an agreement with NASA to loan their ATS-F satellite for the conduct of Satellite Instructional Television Experiment (SITE) – one of the largest sociological experiment ever planned and executed with high technology, and establishment of a unique Developmental Educational Communication Unit (DECU) at Ahmedabad to produce appropriate software for a variety of developmental themes like health, agriculture, family planning, environment and such other areas. As a part of a long term strategy, Sarabhai also initiated studies on a satellite system INSAT for national television, broadcasting and telephony applications. Recognizing the importance of satellite-based remote sensing from space for timely and precise resource management, an agreement was signed with US to receive the imagery data from the first American remote sensing satellite Landsat. The necessary ground systems for the reception, analysis and interpretation of data as well as its utilization by the various user agencies like those related to agriculture, environment, water resources, land use and land cover planning, wasteland mapping, etc. were also initiated. One of the other major steps that Sarabhai took before passing away in 1971 was to discuss with the then Soviet Union about the possibility of launching an Indian satellite with the help of a Soviet Rocket. The first thoughts in this direction were shared between Vikram Sarabhai and the then Soviet Ambassador, which subsequently gave birth to the Aryabhata project.

Sarabhai took over the leadership of Atomic Energy Commission (AEC) as its Chairman, after the untimely demise of Dr Homi J. Bhabha in 1966. In continuing the vision of Homi Bhabha, Sarabhai provided exceptional leadership in spite of his disposition of possessing peaceful frame of mind and therefore very much against coercion in signing the non-proliferation treaty. As Chairman AEC, Vikram Sarabhai took the bold step of starting the fast breeder reactor at Kalpakkam, a far-sighted decision. He also established the variable energy cyclotron project at Kolkata and the heavy water plant at Baroda. Further, as a part of giving vital inputs to the agricultural field, Sarabhai planned a joint venture between Department of Atomic Energy (DAE) and Indian Council of Agriculture Research (ICAR) to set up a nuclear centre for agriculture, to bring together the resources and support of nuclear scientists and agricultural scientists. Under Sarabhai's supervision, the first school run by the Atomic Energy Education Society started functioning in 1969.

At the time Sarabhai took over DAE, there were several management issues arising from running a large diversified programme. Among the notable initiatives that he set in motion includes setting up of a programme analysis group in the department to help in the process of policy formulation. This was a very active group which with time went through several transformations. The present nuclear control and planning wing is in a sense carrying out similar functions to the earlier Sarabhai's set up.

During the time when Sarabhai was Chairman AEC between 1966 and 1971 and at the same time Chairman of Indian Space Research Organisation (ISRO), a profile for decade 1970–1980 was drafted for both atomic energy and space research. Atomic energy went ahead with its plan by starting the implementation, whereas ISRO decided to hold a seminar to consult the stakeholders. A committee was constituted in November 1971. Some of the key people included Prof. P. D. Bhavasar, Prof. P. R. Pisharoty, Prof. E. V. Chitnis and Prof. U. R. Rao. Later on, six study groups were set up in areas of communications, meteorology, Earth resources survey, geodesey, navigation and space sciences; the study groups worked over a period of six months culminating in the August 1972 seminar attended by 201 participants and 78 different organizations. The seminar was presided over by Prof. Satish Dhawan, inaugurated by Shri K. C. Pant, Minister and the keynote address was delivered by Prof. M. G. K. Menon. The outcome of this seminar along with the vision of Sarabhai is the mainstay of ISRO's programmes until recently.

ISRO is currently in the process of executing a mission to place human/humans in space. It is interesting to note the observations of Sarabhai in this context which he made five decades ago as a part of the National Programme of Talk, Series – Exploration of Space 1966 and quote 'There is active debate in the world today on the value of space exploration in the context of the many immediate problems of human existence. Why does man wish to go to the moon when he has sophisticated instruments including television cameras, which can be sent in spacecraft under command and can communicate information from millions of miles. It is because nothing that has been developed with the most sophisticated technology so far approaches anywhere near the capability of man who possesses the facility of receiving information simultaneously from a number of channels to synthesize it to create an image of the environment as a whole. Let us note here that our present-day computers and systems for analysis operate only serially, i.e., taking one bit of information after another. It is unlikely that man will restrain his image to see, to feel and to listen, himself if he can possibly accomplish all these. I do not expect that the debate on the merit or otherwise of putting man into

space would ever be settled. If we are to rely on historical experience, man will surely push ahead with adventures of this type backed by motives which will inevitably be mixed. In India the immediate goals of our space research are modest. We do not expect to send a man to the moon or put elephants, white, pink or black, into orbit round the Earth.'

I cannot close a narration on Sarabhai without highlighting some of his management style. Coming from a family of businessmen and directing complex programmes in science and technologies whose outcomes cannot be predicted with regard to timeframe, finance and other resources, he uniquely brought to bear this duality in him to manage different systems and institutions successfully. I cannot do better justice in this context than to quote from two of his close colleagues who knew him intimately, his methodologies and approaches, i.e. Mr J. R. D. Tata and Dr Kamla Chowdhry and I quote

> 'Like Homi Bhabha, he sought to rid science and technology of the incubus of past practices, static thinking, purposeless controls, and restraints that hamstring development.'
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> – JRD Tata

> 'Vikram, like Bhabha, built institutions around the competence of people. There was no master plan of an organization structure that guided him. The structure evolved depending on how the people grew and developed, the underlying approach being a deep concern for the potentialities of people and their development. An organization based on caring for people gives assurance to individuals to innovate and to respond to situations with creative problem solving – a situation as likely to occur in government settings as in scientific organizations. As long as people know that there is an attitude of caring for them in the leadership of the institution, they can be committed and creative.'
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> – Dr Kamla Chowdhry

While drawing up an overall framework for this special section on Sarabhai, we had to carefully select the names of authors who could understand and therefore contribute to the rich legacy of Vikram Sarabhai spread over many dimensions of national and international endeavours. Mr Aravamudan, Former Director of Satish Dhawan Space Centre and subsequently of U. R. Rao Satellite centre in his article 'Vikram Sarabhai – His vision of India as a space power and its fulfilment' has highlighted his eventful association with Sarabhai from the inception of ISRO to the last moments before Sarabhai's passing away. Aravamudan has worked with Sarabhai closely on many ISRO programmes, particularly on launch vehicles and satellite missions, besides the related applications. Mr Pramod Kale, Former Director of Space Applications Centre and later Director VSSC had also a long association with Sarabhai, especially in defining ISRO's early versions of INSAT systems and also contributing several ideas related to configurational studies of the multipurpose INSAT systems and dealing with major satellite manufacturers in USA. In his article 'Vikram Sarabhai – Visionary motivator' Kale recalls Sarabhai's deep commitment to get the best out of his colleagues. In a sense, he treats Sarabhai as his teacher and mentor. Dr Abhijit Sen, one of the pioneers in plasma fusion research has provided an insightful article 'Sowing the seeds of an Indian fusion programme – an untold legacy of Vikram Sarabhai'. He traces the development of Sarabhai's role in giving an early start to the fusion programme in India through facts and incidents which are not well-known. Dr M. S. Swaminathan has had a wide-ranging role in working with Sarabhai on a variety of programmes that encompassed translating the brainchild of Sarabhai – the use of remote-sensing for agriculture, initiation of Krishi Darshan programme in Doordarshan and use of space for forecasting crop yields. In the field of Atomic Energy, Dr Swaminathan worked with Sarabhai in establishing Nuclear Research Laboratory at Indian Agricultural Research Institute. In his contribution 'Vikram Sarabhai – A scientist's scientist' Dr Swaminathan explains many of these developments where he and Sarabhai worked together. In an article by Dr Karthikeya V. Sarabhai and Mr Padmanabh Joshi 'Vikram Sarabhai – Science in developing countries', the authors have highlighted the several facets of Sarabhai's thinking and unique strategies. They have tried to relate this to the extraordinary ecosystem that Sarabhai experienced in different phases of his life. Prof. Joseph Francombe of University of Cambridge, UK in his article 'Propagating and practising "horizontal control": Vikram Sarabhai, management and American social science' has described Sarabhai as a pioneer of management education in India. He points out that there has been little attempt to examine critically the nature of Sarabhai's thought in this area. In this context, he has argued that Sarabhai's thinking on management converged around one particular set of ideas about the types of organizations (and leadership) required for effective management at the centre of which sat the horizontal control. Further, the author has explored the parallels between Sarabhai's thinking on this and the forms of management education adopted by post-war American social sciences. In a comprehensive article 'Vikram Sarabhai: His vision for the development of atomic energy in India', Dr R. B. Grover and Dr M. R. Srinivasan have highlighted some of the unique contributions of Vikram Sarabhai to the development of Atomic Energy that includes the management strategy to translate Bhabha's visionary ideas into concrete outcomes. Further, they have dealt with some of the special contributions from Sarabhai in areas of heavy water, fast reactors, nuclear fuel, radioisotopes, reprocessing and thermal reactors.

The challenges of technology denials and the way Sarabhai crafted innovative approaches to deal with the same is a matter that has been discussed by the authors authoritatively. In his article 'Vikram A. Sarabhai Community Science Centre', Dr Dilip Surkar outlines the genesis, vision and evolution of this innovative institution, established by Vikram Sarabhai with the purpose to encourage scientific thinking and innovative teaching. The author has identified several areas of implementation and its futuristic directions consistent with the dreams of Sarabhai, who was always concerned about quality of science education in India. Prof. E. V. Chitnis was one of the closest associates of Sarabhai in the formative years of ISRO. In his contribution 'Scientist, businessman, visionary, institution builder', Chitnis has traced his own educational trajectory and how he was inspired with the vision and ideas of Sarabhai. Going beyond his scientific pursuits, Chitnis worked closely with Sarabhai in evolving the technical, managerial and governance elements of the overall supervision of India's space programme. Ms Amrita Shah in her article in *Times of India* 'The man with big ears, and big dreams that took India to the moon', reproduced here, vividly describes Sarabhai's personality, his life, academic interests, professional inclinations and very many personal interest in the areas like arts and crafts, besides, of course, management styles and running of successful businesses. His handling of two major S&T establishments of India and the extraordinary knowledge that he brought to bear from his other areas of activities certainly makes a very enriching reading. I find that the tributes and reminiscences of three eminent authors, Prof. C. N. R. Rao, Prof. Govind Swarup and Prof. Praful D. Bhavasar, stem out of their very personal associations and intimate knowledge of his thinking and working methods. The common thread that runs across their write-ups is the one of highest regard and esteem with which they hold Vikram Sarabhai as a total personality or in other words a true 'Purushotthama'.

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