C. V. Sundaram (1929–2008)

C. V. Sundaram, distinguished metallurgist and former Director, Indira Gandhi Centre for Atomic Research (IGCAR), Kalpakkam, passed away in the early hours of 15 August 2008 at Chennai. The scientific community in India in general, and the materials community in particular has lost an eminent nuclear metallurgist, a great mentor, a passionate leader and a wonderful human being.

Sundaram was born on 7 November 1929 in Ottappalam, Kerala. He had early interest in science because of his father, who was a dedicated mathematics teacher and a disciplined and simple person. Sundaram did his initial schooling at P.S. High School, Chennai. His eminence in academic pursuit was evident right from childhood. Sundaram obtained his B Sc (Hons) in chemistry, with a first rank, from Presidency College, Chennai. He then joined the Indian Institute of Science (IISc), Bangalore for his metallurgy degree under the guidance of Brahm Prakash, who was then the Department Head of the Metallurgy. Brahm Prakash was an inspiring teacher, who left a lasting professional and personal impression on Sundaram. Thus, started Sundaram's distinguished and life-long association with the Department of Atomic Energy (DAE).

After completion of the course at IISc, Sundaram joined the Metallurgy Division, Bhabha Atomic Research Centre (BARC), Trombay, along with Brahm Prakash to establish rare metals technology in India. After thorough grounding in nuclear metallurgy and rare-earth metal extraction, Sundaram rose to head the Extractive Metallurgy Section till 1975 and was Head, Metallurgy Division till 1982. Sundaram, led the R&D programme for scaling the laboratory processes to industrial-scale production of rare metals. During his illustrious scientific career at BARC, Sundaram was a major architect in ushering an era of production of rare, reactive and refractory metals, such as zirconium, beryllium, titanium and tantalum, utilizing indigenous resources and expertise, with important consequences for the indigenous atomic energy programme. He nurtured young scientists and engineers to carry out extensive research and development work on extractive metallurgy of rare metals based on metallothermic reduction of oxides and halides, and vacuum processing. This led to the development of a process for the production of nuclear-grade, hafnium-free, zirconium sponge based on magnesium reduction of zirconium tetrachloride, and pilot plants for niobium and tantalum metal products at Nuclear Fuel Complex, Hyderabad. Process development for the

production of titanium sponge by magnesium and sodium reduction of titanium tetra chloride was mastered under his guidance, which resulted in establishing the titanium sponge process at Defence Metallurgical Research Laboratory, Hyderabad. Another major contribution in the production of rare materials was the successful development and production of beryllium metal starting from Indian Beryl for space and nuclear applications. During his tenure at BARC, Sundaram's influence extended beyond metallurgy to other disciplines ranging from condensed matter physics to chemical engineering.

In 1982, Sundaram took over the leadership of the Fast Breeder Reactor Programme at Kalpakkam as the Director of the Reactor Research Centre (RRC). RRC (which was later named as IGCAR), at that time, was at a crucial stage of the final steps of the construction of the Fast Breeder Test Reactor (FBTR). Through his dedication, hard work and inspiring leadership, Sundaram led the team of scientists and engineers in IGCAR towards the successful criticality of FBTR in October 1985. He laid the foundation and blueprint for various research programmes in metallurgy and materials science, chemical and engineering sciences. He steered the activities of the Centre at a crucial stage in a synergistic manner, so as to fulfil the mandate in terms of the research and development of the 500 MWe Prototype Fast Breeder Reactor, which is currently under construction at Kalpakkam. He provided the much needed momentum in conducting research on several aspects of materials development and characterization, sodium technology, reprocessing of spent fuel and safety analysis of reactor components. Subsequent to his retirement from the DAE in 1989, Sundaram served as a consultant to the Nuclear Fuel Complex, and subsequently as a Homi Bhabha Visiting Professor at the National Institute of Advanced Studies, Bangalore till July 2001.

The foresight and imagination of Sundaram in the planning and organization, and his dedicated efforts in the successive stages of the nuclear programme development over the decades, have paid rich dividends in the form of a strong and comprehensive base that we now have in rare and refractory metals processing and fast breeder reactor technologies in India. Based on his immense all-round contributions to the DAE, in 1996 Sundaram was commissioned to write the 'History of Atomic Energy Programme in India for the period 1948–1998'. The then Prime Minister of India, Shri Atal Bihari Vajpayee released the book *Atomic Energy in India – 50 years* on 10 August 1998, to mark the Golden Jubilee of the Indian Atomic Energy Commission. The comprehensive compilation co-authored by Sundaram, L. V. Krishnan and T. S. Iyengar has been widely acclaimed. Sundaram took this assignment with enthusiasm and sincerity, interviewed all the stalwarts, looked through early records in the DAE, and produced a comprehensive book.

Sundaram was recipient of several prestigious awards, including the National Metallurgists' Day Award (1970), Platinum Jubilee Distinguished Alumnus Award of Indian Institute of Science (1985), Homi Bhabha Life Time Achievement Award of Indian Nuclear Society (2001) and Life Time Achievement Award from Ministry of Steel and Mines, Government of India (2006). He was fellow of the Indian National Science Academy, Indian National Academy of Engineering, and Indian Academy of Sciences. Sundaram served with distinction as the Chief Editor of the

Transactions of the Indian Institute of Metals. He was also President of the Indian Institute of Metals, and of the Indian Nuclear Society. For his outstanding scientific and technological achievements, the Government of India honoured Sundaram with the Sanjay Gandhi Award for Science and Technology in the field of energy (1985) and Padma Bhushan (1986). He was awarded the honorary degree of Doctor of Science by the Banaras Hindu University and Distinguished Material Scientist Award by the Materials Research Society of India.

Sundaram was a man with a brilliant mind, a man of science with a voracious appetite for knowledge and truth, and an avid reader who felt at home surrounded by a variety of books. His knowledge and scholarship, diligence and patience, temperance and charity, and above all his paramount devotion to duty and virtue have made a lasting impression on all those who came in close contact with him. Sundaram pursued his career as an opportunity to serve the nation using science and in the process found satisfaction. He was profoundly influenced by Homi Jehangir Bhabha, Brahm Prakash and Raja Ramanna. Sundaram was also inspired by the spiritual thinking and simple living of great leaders like Swami Vivekananda and Mahatma Gandhi. He was erudite in Sanskrit and translated *Sivanandalahari* into English published by Bharathiya Vidya Bhavan. He was also known for his deep understanding and ardent love for classical music. Sundaram was a compassionate human being, and an articulate speaker and writer. He was always keen to foster talent and develop new scientific leaders for the future. He had his entire education and training in India, where he also did most of his research. He had genuine pride in things that are Indian and was keen to push forward the frontiers of science and technology in India. In his passing away, India has lost one of her worthy sons, who was a true leader in science and technology and more importantly, a human being par excellence.

Sundaram will be fondly remembered by his family members, peers, collaborators and a large number of colleagues, admirers and friends.

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K. Joseph Thomas (1935–2008)

K. Joseph Thomas was born on 20 March 1935 in Kerala. He obtained his Ph D in botany from Bombay University in 1962, followed by a postdoctoral stint at Prague, Czechoslovakia, working on mass cultivation of algae. Thomas (better known as Joe Thomas to most) joined the Biology and Agriculture Division, Bhabha Atomic Research Centre (BARC), Mumbai in 1966. Here, Joe spent the prime of his research career to make several outstanding and original contributions to cyanobacterial/rhizobial nitrogen fixation research in India.

Using absorption microspectrophotometry, he was the first to show that photosystem II pigments were absent in heterocysts of *Anabaena*. This *in situ* study implicated the mysterious heterocysts as the possible sites for localization of oxygen-sensitive nitrogen fixation in *Anabaena*. He followed this up by demonstrating nitrotetrazolium blue reduction in heterocysts *in vivo*, to establish the required reducing atmosphere inside these specialized cells. Both these discoveries were published in *Nature*. Thomas and his colleagues isolated new cyanobacterial strains from Trombay, devised a new culture medium (cyanophycean medium) for cyanobacteria, and developed methods for their mass cultivation. They also identified physiological and biochemical factors regulating the formation of heterocysts and spores in *Anabaena*, and characterized the response of *Anabaena* strains to UV light.

The first-ever demonstration of conformational changes in nitrogenase *in vivo* came from his laboratory in 1978. Long-term preincubation with acetylene was found to enhance nitrogenase activitiy in several organisms, including cyanobacteria, resulting in over-estimates of their diazotrophic potential. This revelation led to the development of an improved acetylene reduction assay technique for analysis of hundreds of field samples per day. In the late 1970s and early 1980s, Thomas and his colleagues discovered an unusual and novel requirement of sodium for cyanobacterial growth and metabolism. Mechanisms underlying salinity stress tolerance in *Anabaena* were elucidated and the myth behind the well-known reclamation of saline soils using cyanobacteria was unravelled.

Thomas visited the laboratory of C. Peter Wolk, Michigan State University, East Lansing in 1975–76, to pioneer work on ammonia assimilation pathway in cyanobacteria using the short-lived radioisotope, ^{13}N. This outstanding research work established exclusive aerobic fixation of nitrogen in heterocysts, transport of fixed nitrogen to vegetative cells as glutamine and its assimilation there as glutamate. Subsequent to his return to BARC, his laboratory extensively characterized the major ammonia assimilatory enzyme glutamine synthetase from *Anabaena* and from rice, and described its regulation. Thomas also used stable isotope of nitrogen (^{15}N) to obtain reliable estimates of nitrogen fixation by cyanobacterial biofertilizers and their contribution to rice yields. Efficient strains of *Anabaena* and *Nostoc* were de-