

A Life in Science. C. N. R. Rao. Penguin Random House India Pvt Ltd, 7th Floor, Infinity Tower C, DLF Cyber City, Gurgaon 122 002, Haryana. 2016. xii + 216 pages. Price: Rs 499.

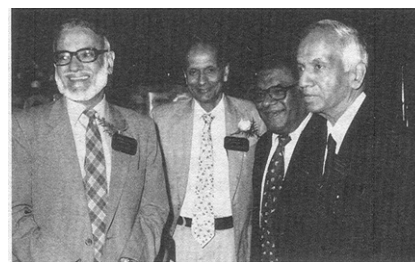
India is fortunate to possess a reasonably well-developed infrastructure for science education and research, despite being less developed economically compared to the Western world. The tradition of modern science received significant boost in the early years of the twentieth century with the foundation of centres of learning like Indian Institute of Science (IISc) in Bengaluru, Banaras Hindu University (BHU) and many others in different parts of the country. The planning for scientific research in various fields had begun in decades preceding the political freedom in August 1947. This resulted in higher education and research in emerging areas being accorded high priority soon after the independence with Prime Minister Jawaharlal Nehru fully backing these efforts. Such overall positive atmosphere for scientific research, despite scarcity of resources and other problems, helped nurture talent and shape academicians, scientists and science administrators of future. C. N. R. Rao is one of the products of this process. Rao's life journey makes a fascinating story – from the time of his first visit to IISc in 1945 as a school kid to his becoming director of the same institute decades later and playing the role of a science advisor and policy planner at the national level. The book under review – is an interesting account of Rao's professional and personal life. It complements his first autobiography – *Climbing the Limitless Ladder: A Life in Chemistry* – published in 2010.

The book is an autobiography, but it has been written in a different style. It begins with autobiographical accounts of six well-known scientists primarily highlighting why and how they took to science. The scientists included in this chapter are Paul J. Crutzen, Vitaly L. Ginzburg, Walter Kohn, Jean-Marie Lehn, Abdus Salam and Myriam P. Sazhik. These accounts have been reproduced from an earlier published collection titled *Hundred Reasons to be a Scientist* (Abdus Salam International Centre for Theoretical Physics, Trieste, 2004). In the second chapter, 'What is science all about', Rao has reflected on some of the fundamental questions about science, such as the role of experimental science, freedom in science, science and utility, scientific temper and so on. This discourse is peppered with relevant quotes of famous scientists and has been contextualized for Indian conditions. For instance, Rao says that scientific temper is essential for tackling problems of the society and life itself, more so in countries having disadvantages arising from superstitions and obscurantism. The problem in India, however, is that 'many scientists do not have a scientific attitude', Rao says quoting a friend of his. As regards facilities for scientific research, Rao supports Patrick Blackett's view that 'a first rate laboratory is one where even mediocre scientists produce outstanding work'. He also argues forcefully for academic freedom for scientists. He notes, rather, alarmingly: 'I am not sure whether Faraday, Rutherford and Raman would be happy to do science in the present circumstances'. It would have been great if the author had chosen to elaborate on this statement.

The first two chapters serve as a nice backdrop for the life story of Rao told in the next four chapters. They are neatly arranged focusing on his early years; trials and tribulations of a young researcher; years of growth as a scientist and science administrator and planner; and experience of doing science after 60. The chapter on his early days should serve as an inspirational story for students interested in taking up science. From his story, it is clear that young minds need a trigger or stimulus to get interested in science in their formative years. Rao was fortunate to have been born and schooled in a city which had great tradition in education and science. His first visit to IISc as a school kid and

an encounter with none other than C. V. Raman there kindled his interest in science. On the suggestion from one of his lecturers at the Central College, where he did his B Sc, Rao decided to pursue post-graduation at BHU mainly because doing research was integral part of the course there. The very first year of M Sc resulted in his first paper – co-authored with his professor – that got published in *Agra University Journal of Research* in 1954. After a brief stint as a research scholar at IIT Kharagpur, Rao went to Purdue University for his Ph.D. He wanted to work with Linus Pauling on molecular structure, but Pauling suggested to Rao to work under one of his former students at Purdue.

One of the reasons Rao chose to go to University of California, Berkeley for postdoctoral research was liberal environment of California. In Purdue, as Rao has revealed in the book, he faced racial discrimination. He was not served in a bar just outside the university campus because of skin colour. At a bus station in Kentucky, he was asked to go to other side of a coffee counter where blacks were served. In Salt Lake City, he was denied a room in a hotel despite having reservation, and was asked to go to local YMCA instead. Rao encountered a different set of problems upon his return to India to join IISc as a lecturer in the Department of Inorganic and Physical Chemistry. The department lacked both funds and equipment for research. Other departments which had basic equipment like infrared spectrometer refused to allow him access. Rao's efforts of promoting research thinking among students through evening seminars was not taken kindly by his seniors. The institute did not have certain journals which he needed for writing a book on UV-visible spectroscopy of organic molecules. He



C. N. R. Rao, M. G. K. Menon and S. Ramaseshan with S. Chandrasekhar at the golden jubilee meeting of the Indian Academy of Sciences (1984).

had to travel to Pune to access these journals at the National Chemical Laboratory. His colleagues thought of the book idea as 'a joke'. His stint as head of the chemistry department at IIT Kanpur eased the matters as he had necessary equipment and chemicals brought there as part of the Kanpur Indo-American Programme (KIAP). Only in 1977, Rao says he had reasonable facilities for research at IISc – 18 years after beginning independent career in research. Rao's experience in his early career may well resonate with many young researchers even today though our research institutes are much better funded.

The work of Indian scientists interested in new areas of science often gets hampered due to lack of equipment and other facilities. This is what happened with Rao who had been working on lanthanum copper oxide since the 1970s and had shown that it was anti-ferromagnetic. This material came into prominence with the sensational discovery of high temperature superconductivity in 1986. Rao says that he had not measured properties of lanthanum copper oxide compositions at liquid helium temperatures due to paucity of facilities. Undeterred by this, Rao continued vigorously in this area, resulting in his group making first liquid nitrogen superconductor independently in 1987. Bell Labs in the US and Peking University in China had prepared this compound at the same time. The book describes the dramatic way Rao first came to know about the superconductivity discovery in the middle of a conference from a visiting scientist. Those days scientists still depended on printed journals and the postal system to learn about latest developments in science. Another new area of research pursued by Rao by the turn of the century is carbon nanotubes and graphene which the book describes in some detail.

Given wide ranging activities Rao has been engaged since the mid-1980s when he became director of IISc, people have often wondered how he managed to handle multiple tasks in science administration and planning as well as research. Rao has answered this question in the book. He says he had consciously decided to continue laboratory work despite any other responsibility he would hold by dividing time between his office and laboratory work. He continued to balance research and his other responsibilities while he was director of IISc, founder-

director of the Jawaharlal Nehru Centre for Advanced Scientific Research, President of science academies and other professional bodies, and scientific advisor to successive prime ministers. This should serve as an example to our science-administrators and academic leaders who often give up research while shouldering other responsibilities like directorship of institutes. Rao particularly enjoys working with young students. He says that his research showed a marked improvement after 60 and flourished further after the age of 70. Even crossing the 80-mark, Rao is not tired. He says 'I would love to be a Ph D student in the US, and perhaps start publishing again'. Such zest for science is indeed rare and praiseworthy.

The book is important not only as personal reminiscences of a leading figure of Indian science, but adds an important chapter to rather small body of literature on history of science in the post-independent era. Hopefully Rao's book would not only be inspirational for young researchers, scientists and science administrators, but would also prod other senior scientists to pen their experiences for the benefit of present and future generations interested in science in some way.

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Biomedical engineering (also called bio-engineering) generally refers to the utilization of engineering concepts to study biology and develop new technologies for use in medical practice. Based on this definition, research in biomedical engineering tends to be extremely diverse and providing an overview of all the major developments in a single volume

is next to impossible. The editors of this volume of Annual Reviews have done a remarkable job in understanding this problem and concentrate on providing an in-depth overview of a few emerging areas in biomedical engineering. The 16 review articles broadly focus on 7 topics: drug development and delivery; imaging; immuno-engineering; systems and computational methods in medicine; mechanics of tissues; micro-scale technologies for biological and medical application; and tissue engineering.

Therapeutic formulations (drugs) are one of the pillars of today's healthcare systems. Developing new drug entities and devising methods to deliver them effectively to the site of disease are significant areas of research in their own right, but they also form an important component of biomedical engineering. Biomedical engineering tools and approaches such as computational techniques, reverse-engineering and rational-design have significantly aided in drug discovery. Two articles comprehensively review these approaches for the development of new molecular entities, with one focusing on drugs that bind to atypical regions of membrane proteins and another on creating polypeptides and peptide-assemblies with catalytic function. Another review provides a realistic perspective on drug delivery and targeting. Although the importance of drug-targeting in diseases ranging from infections to cancer cannot be denied, the practical aspects of delivering drugs to diseased cells in the body have been challenging. A majority of drug targeting strategies, at least the ones that have been successful in laboratory experiments, employ the use of small molecules or peptides or antibodies that target specific cell surface proteins (receptors). However, these receptors may not be expressed only on diseased cells. Basic biological studies to identify receptors or other molecular entities that are specifically present only in diseased cells would be of tremendous help in developing new targeting strategies.

The old adage 'seeing is believing' applies to biology and medicine too. Numerous advances in biology have been the result of new and improved visualization tools. Further progress in these fields requires the enhancement of imaging modalities. A fundamental research area in biomedical engineering has been the development of new imaging tech-