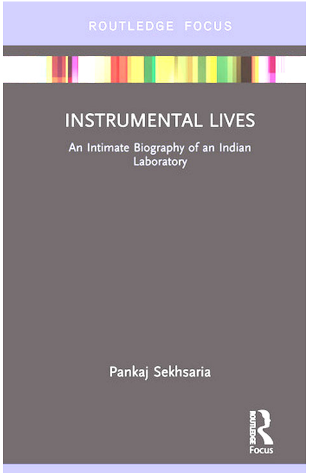

Instrumental Lives: An Intimate Biography of an Indian Laboratory. Pankaj Sekhsaria. Routledge, 2 Park Square, Milton Park, Abingdon, Oxon OX 14 4RN, and 52 Vanderbilt Avenue, New York, NY 10017. Published in 2019. Reprinted in 2020. xxii + 126 pages. Price: Rs 695.

It gave me great pleasure to read the Book *Instrumental lives – An intimate biography of an Indian laboratory* by Pankaj Sekhsaria. Sekhsaria takes the case history of the development of many versions of scanning probe microscope by C. V. Dharmadhikari and his students in the University of Pune over a period of nearly two decades, using innovative solutions with locally available materials. With these microscopes, they produced a significant body of research in nano-science published in peer-reviewed journals. This book touches on a number of points dear to my heart.

First, I have great admiration for Dharmadhikari and his students for this sustained effort over two decades in developing successfully such a complicated instrument for their use in studying surfaces of materials in the nano-scale. People, especially the youth of this country aspiring for a scientific career, should be made aware of this stupendous effort.

Why did Dharmadhikari embark on such an effort and succeed? I can think of the following reasons in decreasing order of importance: (i) the indomitable thirst for doing meaningful research in the newly emerging area of nano-science, coupled with a strong will to succeed, and a freely roving mind to look for local solutions for difficult technical problems; (ii) the strong culture of instrument building in Pune University nurtured by M. R. Bhide and V. G. Bhide; (iii) the availability of local technical expertise in Pune, and (iv) paucity of funds for research. These points are made in the book, though not in this order.

When I joined the Indian Institute of Science in Bangalore for research in the 1950s, the funding for research was very limited, and it was not possible to get foreign exchange for importing equipment. In these conditions, Suryan and his students built NMR instruments for research, and brought out a considerable volume of acclaimed research. Venkatasubramanian built a mass spectrometer for age determination of rocks and minerals. This at a time when the transistor was not invented, and the vacuum industry in India was non-existent. These are in my opinion great achievements which have gone unnoticed. I am sure there are many such achievements from other institutions, of which I am not aware.

However, as the funding for research improved and import restrictions were eased, this culture of developing instruments locally vanished, except in a few places. With the burgeoning number of universities, and the setting up of the CSIR and DAE institutions, the universities were depleted of talented faculty and adequate funds. Competition for employment became severe. The number of publications became a metric for judging a scientist's worth for appointments and promotions. The quality of the publications could not be measured by the administration, and so the number became important. In these circumstances, instrument development became a casualty. Young scientists would rather get quick publishable results using imported equipment than waste years of effort in developing instruments, as such efforts were not considered worthy of reward. There is a general tendency in the country to rate theoretical knowledge superior to practical skill. May be, this tradition is a part of our glorious heritage. But, the net result is a complete decline of hands-on skill at every level. For scientific and technological advancement, both theoretical knowledge and practical skill are necessary and essential. Many of these points find mention in the book.

Questions have been raised about basic and applied scientific research. At this time, the emphasis is on applied research in the policy formulations of the government. I think this distinction is not important. What matters is the quality of research, be it applied or basic. Another question often raised is the social relevance of scientific research. So far as it means that scientific research should benefit society, no one can disagree. However, often results in basic research find applications after several years. I may mention the discovery of superconductivity in 1911, and the applications of superconductivity after several decades, in the form of superconducting magnets which are used extensively in MRI instruments. So, basic research is as important as applied research as long as both are of good quality. A scientist in basic research should keep his eyes open for the possibility of application of his results.

One criticism against Dharmadhikari is that he did not make an effort to commercialize his instrument, but continued to develop improved prototypes of the same. I think the solutions used by Dharmadhikari in his prototypes might not have been suitable for commercial exploitation. In commercial equipment one looks for satisfactory performance in repeated uses over a long period of time, even if the instrument is used by a minimally trained person. For a person who developed the instrument in the laboratory, fault finding and repair would be easy. But, in the hands of an untrained person this will not be the case. Making the instrument fool proof would have taken many more years of effort. One cannot find fault with Dharmadhikari for desiring to obtain new research results, rather than spend years of effort in commercializing his equipment.

There must be a close collaboration between industrial research and research in a university laboratory, so that developments in the laboratory can be transferred successfully and made into a commercial venture. Such collaboration is developing slowly in our country now. Narayan Khedkar of the Mechanical Engineering Department, IIT Bombay, successfully developed a Stirling cycle liquid nitrogen plant in the late 1980s. This plant was built using locally available materials and technical skills. This project was funded by the DST, and I was the Chairman of the PAC on Cryogenics of DST at that time, and was monitoring the project. This machine was producing liquid nitrogen for many years in IIT Bombay. At that time, Philips had the monopoly on such Stirling cycle plants. We tried to involve a public sector organization to produce this plant commercially. We were asked how many such plants will sell in India. When the organization learnt that the demand will be only for a few plants a year, it withdrew, and the efforts at commercial exploitation fell through. Patil, a student of Dharmadhikari, makes this very same point in an interview with Sekhsaria. The interest of industry is in making profit. The interest of a scientist in a laboratory is different. Unlike in USA, it is difficult for a scientist to start an industry in India in High Tech instruments for which the demand will be low.

The author deals extensively with the definition of Jugaad and compares it with similar practices in other countries. As long as Jugaad is taken to mean innovative use of local materials and skills in the field of science and technology, it is to be welcomed. In scientific laboratories all over the world involved in cutting edge developments, some form of Jugaad is practiced. The author also points out that Jugaad, by its very nature, is not amenable to standardization. So, it is likely to be of less importance if one is interested in the commercial exploitation of such practice.

There is considerable discussion in this book, on the Science, Technology and Innovation Policy of 2013, and the Indian Technology Vision 2035 document. These policies state that development in science and technology should aim at benefiting society at large. But, in drafting the details of the policy, the common man is treated only as a beneficiary, and not as an active participant in determining the priorities. There is merit in this comment. However, the common man in India, as elsewhere in the world, is not sufficiently acquainted with science and technology to make an effective contribution. Of course, there are activists who claim to speak for the common man. Their views need to be taken into account in determining the priorities. But, it is better to leave the task of detailing the measures to be taken, and monitoring the progress, to experts. This is my view. But there could be valid arguments for other contradictory opinions. We view the western model of progress and development as the sine qua non in policy matters. I agree with the author that we should tune this concept to the local conditions and the traditional knowledge that we possess.

In the concluding chapter, the author laments on how all the equipment developed by Dharmadhikari was consigned to the scrap, after the Professor retired. The suggestion that such equipment should be preserved in a museum in the concerned institution to showcase its heritage is an appropriate one.

This book was written as a part of the doctoral work of the author and there are many references to the work of other social scientists on Science, Technology and Society. So, there is much jargon which social scientists use, in this book. Not being trained in such jargon, I found it difficult to understand the meaning of many words. This is not a shortcoming in the book. It is my own shortcoming, not having the felicity to understand jargon which is unfamiliar. In conclusion I found this book well written and informative.

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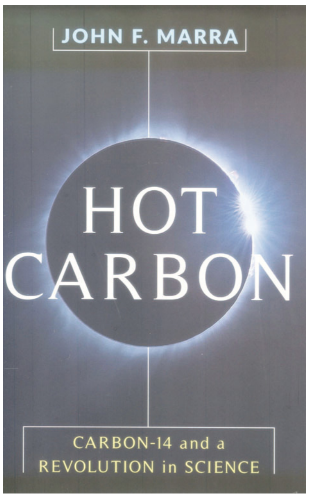

Hot Carbon: Carbon-14 and a Revolution in Science. John F. Marra. Columbia University Press, New York. 2019. xiv + 264 pages. Price: US$ 35.00/£30.00.

Carbon is the fourth most abundant element in the universe and is the building block of life on earth. It is the most important element and forms essential compounds for living beings. Biological processes play a key role in the global carbon cycle by first converting atmospheric carbon dioxide to the simple organic matter which then supports energy requirements of the non-photosynthetic organisms on the earth. This process stays at the base of the food web both on land and sea. Evaluating the mechanism and accurate estimation of photosynthesis is crucial to understand not only the amount of energy prepared by autotrophs but also removal of carbon dioxide from the atmosphere. The rate term is important both in physical and biological processes as the mixing rate determines the amount of nutrients brought to the sea surface and the consumption rate determines how long biology can sustain. It is also important in understanding how climate change brought modifications in the ocean in the past and present and identifying the period of that change to understand potential processes responsible for that.

The invention of radioactive carbon-14 brought revolutionary opportunities to understand the physiology of the plants not only to estimate how much primary production occurs in the ocean but also the mechanisms of photosynthesis such as Calvin–Bensen–Baasham cycle. Carbon-14 is used as a tracer to identify how carbon is fixed by the phytoplankton and kind of organic molecules are formed during this process and how many flashes of light are required to release oxygen. Carbon-14, along with oxygen-18 isotopes, helped identify the released oxygen during photosynthesis. Calvin and his group identified formation of phosphoglyceric acid (PGA) as a first product of photosynthesis after carbon dioxide is taken up and it was a well debated topic in the early 1940s. None of the working of Calvin cycle and identifying the PGA as first product could have been possible without having a long-lived radioactive isotope of carbon, carbon-14. Marra narrated the complete story by explaining the contribution of individuals in understanding physiology of phytoplankton through the incorporation of carbon-14 tracer into their body (as CO_2) and separate the products through paper chromatography and measuring their radioactivity.

Carbon-14 is an excellent dating tool to identify the period of the changes occurred in the climate in the past and the only way to put ‘time’ into the global ocean circulation models. Since carbon-14