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.

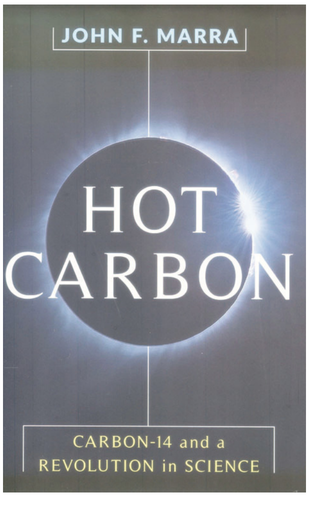
There is considerable discussion in this book, on the Science, Technology and Innovation Policy of 2013, and the Indian Technology Vision 2035 document. These policies state that development in science and technology should aim at benefiting society at large. But, in drafting the details of the policy, 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.

R. SRINIVASAN

Res. 143, V Cross, III Main Road,
Vijayanagar Extension,
Mysuru 570 017, India
e-mail: rsvmys@gmail.com



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 is taken up by the plants/animals and they expel it to the atmosphere through respiration and these two processes are in balance as long as plant/animal is living. Once it dies, carbon-14 in the body remains and disintegrate through radioactive decay at the rate of half in about 5700 years. Hence, it is quite possible to date when the organism is living from the fossil organic matter. Carbon-14 helped significantly to date occurrence of the palaeoceanographic events such as period of Last Glacial Maxima (LGM), Younger Dryas, and Milankovitch cycle and so on. He explained potential corrections required in dating the material due to addition of non-radioactive carbon dioxide through fossil fuels burning that decreased the carbon-14/carbon-12 ratios. In addition, there was a spike in carbon-14 in the atmosphere due to atomic bomb testing which lead to increase in carbon-14/carbon-12 ratio. These momentary enrichment of carbon-14 led to new science in the oceanography to study circulation pattern and water mass movements. So the discovery of the carbon-14 as a long-lived isotope of carbon changed all that and began a revolution in science.

Carbon-14 is a well-utilized tool in several fields of science such as archaeology, geology, meteorology, astronomy, oceanography and climate change research. The application of carbon-14 as a tracer is expanding to new vistas due to revolutionary changes in measurement technology. Small amount of sample is now enough to make the measurement of carbon-14 activity. In the past high quantities of the sample was required to make the measurement of carbon which was time-consuming and pre-process methods were elaborate.

Marra made journey through hydrosphere and biosphere and application of carbon-14 to understand different processes on earth. He captured all the events of carbon-14 from efforts of Martin Kamen and Ruben in early 1990s in the invention of carbon-14 using cyclotrons to its applications in various fields of science. This book gives vast information on invention of carbon-14 to applying the tracer in understanding various processes on earth. This book captures all this and much more, and it is a useful addition to the oceanography literature.

V. V. S. SARMA

CSIR-National Institute of Oceanography, Regional Centre, Visakhapatnam 530 017, India
e-mail: sarmav@nio.org