Keshavkant and Naithani have shown that chilling is one of the principal causes of die-back in sal seedlings. This can be reduced by 20% by placing the seedlings in the greenhouse during winter. There are three papers dealing with seedling growth in response to various treatments and spacing in avenue trees. The contribution by Mani *et al.* discusses the role of seed source identification and seed pelletization methods to enhance 'elite seedling production' in *Acacia nilotica*. That pelleted seeds perform well under stressed conditions is useful information for agroforestry and social forestry.

The book is neatly produced. Inclusion of species index and author index has enhanced its utility. Concept papers and reviews by experts in this publication would be useful to foresters, planters, nurserymen, biotechnologists, physiologists, conservationists, NGOs and policy makers. It is hoped that unlike other conference proceedings, that merely sit on a library shelf, this book will stimulate decision-makers in the forestry sector to wake up and put into practice at least some of the major suggestions made by the experts.

H. Y. MOHAN RAM

Department of Environmental Biology,
University of Delhi South Campus,
Benito Juarez Road,
New Delhi 110 021, India

Microbes Minerals and Environment. K. A. Natarajan. Geological Survey of India, A.M.S.E. Wing, 'Vasudha Bhavan', Kumaraswamy Layout, Bangalore 560 078, India. 1998. 162 pp. Price: Rs 200/US $ 15.00.

Microbes Minerals and Environment is a useful monograph generated from interdisciplinary studies pertaining to ore-forming processes, bio-leaching methods and environmental protection. Technology development today is critically dependent on the synergistic working of scientists from diverse fields. This book is proof of the success resulting from such an effort under the umbrella of IGCP Project-357 Organic and Mineral deposits.

The book contains twelve chapters, which could have been reduced to eight or less with greater elaboration of each chapter. The more general aspects of biotechnology pertaining to minerals and their recovery are covered in chapters 1–3. Specifically, these chapters deal with biomineralization and geomicrobiology (chapter 1), biomineral beneficiation (chapter 2), and biotechnological aspects of metal extraction and leaching bacteria (chapter 3). Chapters 4–6 cover applications of biotechnology, e.g. biohydrometallurgy and bioleaching to specific minerals such as metal sulphides and ores containing copper, uranium and gold. In particular, integrated biotechnological methods of gold ore processing are nicely presented in chapter 5. Chapter 10 deals with biofouling, biodeterioration and biocorrosion of metals, metal alloys and concrete, which is especially relevant in the Indian context in view of prevailing climatic factors. Chapter 11 focuses on recent development and future trends in biomineral technology, while the last chapter concentrates on the Indian scenario which is still in its infancy. Nevertheless, the efforts of a few companies are laudable.

This is a useful college-level book which will be especially beneficial to those who seek to broaden their awareness of biotechnological applications in the above areas and perhaps even work in future on such applied research problems. As emphasized, the treatment of subject matter is rather sketchy and readers will have to refer to primary sources of material for better appreciation of the techniques involved. The editing of the book could have been done better and a more in-depth literature survey would also have been helpful. However, given the increasing role of biology in conventional chemical and metallurgical processes, this book is a timely introduction for popularization of the subject. No doubt, such technologies will be on the rise with future research breakthroughs, heightened awareness of the environment and growing numbers of practitioners of the subject.

S. MISHRA
P. K. GHOSH

Central Salt and Marine Chemicals Research Institute,
Gijubhai Badheka Marg,
Bhavnagar 364 002, India
e-mail: salt@csir.res.in

PERSONAL NEWS

Abraham Pais: Physicist and biographer (1918–2000)

An obituary

As the saying goes, 'geography is about maps, while biography is about chaps'. Abraham Pais who died in Copenhagen on 31 July 2000 was not only an award-winning physicist, but also one of the best-known biographers of outstanding physicists. It was Sir Peter Swinnerton-Dyer, a one-time Head of the University Grants Commission in the UK who once pointed out that, 'most scientists reach a moment at which they know they will never have another worthwhile idea'. Once the optimum period is over, the laws of diminishing returns begin to operate, and a sensible scientist should have the courage to change direction. This is precisely what Abraham Pais did when he switched in his later years from scientific research to chronicling the lives of some of the brilliant physicists and the greatest breakthroughs in physics in the 20th century. It was while he was working at the Institute of Advanced Study in Princeton that Abraham Pais got to know Einstein personally during the last nine years of Einstein's life. In his excellent biography of Einstein entitled, *Subtle is the Lord* (1982), Abraham Pais opens a window into the life and mind of the greatest scientist of our century. Today it is recognized as the most outstanding and authoritative biography of the great man. It won the American Book Award.

Abraham Pais was born into a Jewish family on 19 May 1918 in Amsterdam, Holland. After finishing his schooling in Amsterdam, he went to the University of Utrecht for his post-graduate studies. It was the time of Nazi occupation of Hol-

land, and the persecution of Jews. The Nazis decreed that no Jew could be granted a doctorate after 14 July 1941. Thus, Abraham Pais had to complete his doctorate before the brutal deadline. He received his Ph D with Leon Rosenfeld in Utrecht in 1941, after which he went into hiding to escape the Nazis. He and another friend were involved with the resistance movement concerned with the fate of Jewish orphans after the war. They had written a document about this issue and it was in his friend's pocket when the two were caught by Nazis and sent to prison in Amsterdam. The Gestapo executed his friend for possessing that incriminating document. Pais was among the few lucky prisoners who were not executed but released shortly before VE Day. With the end of World War II, he was able to leave Holland and go to the Niels Bohr Institute in Copenhagen to work with Niels Bohr on the interaction between light and matter. Although Pais described Bohr as a 'divinely boring lecturer', he nevertheless loved working with him. Bohr was another great physicist of our time, whose discovery of the existence of stationary states and of quantum jumps, from his research on the spectrum of hydrogen, paved the way to the formulation of quantum mechanics and to our understanding of the periodic system of elements.

One of the scientists Abraham Pais admired and revered was Paul Dirac – another great physicist and one of the founders of the quantum theory. 'Of all physicists, Dirac has the purest soul', was the assessment by Bohr. Pais was greatly influenced by Dirac and his work. Dirac's book, *The Principles of Quantum Mechanics* motivated him during his graduate years in Holland. He first met Dirac and his Hungarian wife, Margit (sister of Eugene Wigner, Professor of Physics at Princeton University) on a brief visit to their home in Cambridge in January 1946. In September 1946, Pais went to the Institute of Advanced Study in Princeton, hoping to work with Wolfgang Pauli, who was called 'the living conscience of theoretical physics'. But by the time Pais arrived in Princeton, Pauli had already left for Zurich. In the course of his 17-year career at the Institute, Pais got to know many famous scientists, including several Nobel Laureates quite well. During his joint 'talks and walks and wood chopping expeditions' with Dirac, he was able to develop a good grasp of Dirac's views on physics.

Pais did much of his best scientific research at Princeton. It was here that Bohr introduced Pais to Einstein, but Pais found him difficult to understand at first. When he told Einstein about his inability to follow his arguments, the great man invited Pais to accompany him on his lunch-time walks to his house at 112 Mercer Street. This was the beginning of a series of fruitful discussions Pais had in German with Einstein until the latter's death in 1955. Although the main topic of discussion was quantum mechanics and its interpretation, they also talked about things other than physics: politics, the bomb, and the Jewish destiny. The most interesting thing that Pais learnt from these conversations was an insight into who Einstein really was and how he thought. After Einstein's death, his secretary Helen Dukas gave mementos to his friends, and Pais received his last pipe, and the galley proof of the second appendix to the 'Generalized Theory of Gravitation'.

Pais became a US citizen in 1954, and after Einstein's death he began working with the Italian-born American physicist, Oreste Piccioni on subatomic particles. One of the puzzles in particle physics was what holds the neutrons and protons together inside the nucleus. Richard Feynman describes how several experiments were carried out in which 'protons of higher and higher energies were smashed into nuclei'. Although only protons and neutrons were expected to come out, there were so many other particles such as pions, lambdas, sigmas and rhos, that they, in the words of Feynman, 'ran out of the alphabet'. Pais coined the term 'baryon' to denote a type of strongly interacting particle that includes the proton and neutron in the atomic nucleus. Feynman however found the term 'baryon' rather horrible. It was Murray Gell-Mann who came up with the quantum theory of strong interactions, whose 'main actors are particles called "quarks"'. All of the particles made of quarks, according to Feynman, come in two classes: some, like the proton and neutron, are made out of three quarks (which are called baryons); others such as pions, are made of a quark and an anti-quark (and are called mesons). Feynman recognized Pais' contribution and hailed his work with Piccioni as 'one of the greatest achievements of theoretical physics'.

Pais left Princeton in 1963 for Rockefeller University in New York, where he retired as Professor Emeritus. He loved French food and enjoyed smoking Caminante cigars. As a Dutchman, he was well known for his large appetite, and at Princeton, he would regularly eat three sandwiches for lunch. Watching this performance, Dirac once inquired if he always ate the three sandwiches in some order? When Abdus Salam visited Pais at the Institute, he said: 'I have regards for you from Professor Dirac in Cambridge. He wants to know if you still eat three sandwiches for lunch!'.

In 1990 Pais married Ida Nicolaisen, an anthropologist at the University of Copenhagen in Denmark. It was his second marriage. He became extremely relaxed and productive in his writing after he married Ida. His biographical study of Niels Bohr *Niels Bohr's Times, in Physics, Philosophy, and Polity* (1991) was greatly admired by the scientific community. *Einstein Lived Here* came out in 1994. Pais published his autobiography, *A Tale of Two Continents* in 1997. His last book, *The Genius of Science: A Portrait Gallery* (2000) is a collection of twelve essays on American physicists. Abraham Pais was truly a remarkable person. He did to physics what James Boswell did for Samuel Johnson. He radiated love for physics and physicists. He combined a brilliant mind with a sensitive pen in his biographies of physicists. In his passing away, we have lost one of the best physicists of our time and a skilled chronicler of science and scientific breakthroughs. He is survived by his wife and a son from his first marriage.

CHARLES SANTIAPILLAI

Department of Zoology,
University of Peradeniya,
Sri Lanka
e-mail: csanti@slt.lk