action at a distance it is easy to appreciate why quantum non-locality was not acceptable to him. Einstein along with Podolsky and Rosen (EPR), in a seminal work in 1935 claimed because, non-local or spooky action at a distance is impossible in physics, quantum mechanics is an incomplete theory. A clear method to look for these quantum 'non-local' correlations was suggested by Bell in 1964 and they have been experimentally established only in recent times. Unfortunately, Einstein's position is not supported by experiment. Einstein disliked pompous claims. According to Asher Peres, 'Podolsky released the contents of the EPR paper to the *New York Times* in a way implying that the authors had found that quantum mechanics was faulty. This infuriated Einstein, who after that no longer spoke with Podolsky'.

Strange are the ways by which applications emerge from basic ideas in science. Einstein's work studying the properties of an atom in a radiation-filled cavity led him to introduce the idea of stimulated emission, paving the way for the discovery of the laser almost fifty years later. The entangled pair introduced by EPR in 1935 has become a resource in lithography, cryptography and communications. Who could have imagined that the most abstract of all, Einstein's gravitation theory is crucial for GPS (global positioning system), which can help rescue a stranded person or guide a bomb to its destination.

It is interesting to compare Einstein with Gandhi, whom he admired a great deal. To quote (pp. 82–83) 'Gandhi, the greatest political genius of our time... gave proof of what sacrifice man is capable of once he has discovered the right path' and again 'Gandhi's development resulted from extraordinary intellectual and moral forces in combination with political ingenuity and a unique situation'. We can find an echo in Einstein, exceptional intelligence combined with extraordinary tenacity and single-minded pursuit of the goal he set himself, his struggle for utmost clarity and his refusal to accept, unlike some of his great contemporaries, that there is any limitation to understanding the ultimate reality.

There is an interesting anecdote. Einstein was putting together some sheets of paper, and had a clip that was bent. He went on to get a pair of pliers to straighten the clip while his collaborator went looking for a new clip, and found one. Meanwhile Einstein had set right the bent clip and said 'when I set myself a task I do not give up'.

In this book, one finds many quotations on philosophical, religious, ethical and other issues as well. Suffice to say Einstein's impact on our understanding of space and time and nature of reality will continue to be deep and profound.

Finally, at a personal level, Einstein in his life seems to have experienced more sorrow than happiness. One may empathize with him, but many will be perplexed by the events surrounding his divorce from his first wife Mileva and complex relations he had with his cousin Elsa, whom he eventually married while he was simultaneously courting her daughter Ilse. All the more so when one realizes all this happened during the period in his life when he created the general theory of relativity, one of the great accomplishments of the human mind.

If I am permitted to use an analogy from statistical physics, a subject that was dear to Einstein, to understand his transition from great to immortal, the physicist in him is the relevant one, the philosopher is a marginal one and his private life is irrelevant.

There is a good bibliography at the end of this book. The great physicist Schwinger's book *Einstein's Legacy* (Scientific American Library, 1986), which gives an extremely lucid account of Einstein's achievements, should have been included. Apparently, Schwinger's work was originally meant to be beamed on the television, but sadly did not get enough sponsorship. Perhaps whatever audio-visual material that is available could be distributed as CD today.

It is entirely superfluous to commend this book – it is difficult to see how anyone will not be interested in it. I hope there will be translations in at least a few Indian languages. When that is done, an appendix consisting of useful websites, documentaries and films on Einstein can be included.

J. PASUPATHY

Centre for High Energy Physics,
Indian Institute of Science,
Bangalore 560 012, India
e-mail: jpcts@cts.iisc.ernet.in

India's Legendary Wootz Steel: An Advanced Material of the Ancient World. Sharada Srinivasan and Srinivasa Ranganathan. National Institute of Advanced Studies, Bangalore and Indian Institute of Science, Bangalore. 2004. 146 pp. Price not mentioned.

The current publication on India's Wootz steel is a pleasing and timely one on a remarkable material from ancient India. It has continued to fascinate soldiers, artisans and scientists alike from various parts of the world right down to the twenty-first century. It is a result of a partnership between Sharada Srinivasan who has been working for over fifteen years on archaeometallurgy and Srinivasa Ranganathan, a senior metallurgist (who was the Chairman of the Study Group for the metallurgical heritage of India constituted by the Indian National Academy of Engineering). The book has been commissioned by Tata Steel, Jamshedpur who have also supported its publication. As the authors have pointed out correctly, Wootz is an important material in metallurgical history originating from India and there are no books by Indian authors on this subject. They have stated that this book has been '...oriented towards a wider readership inclusive of school and college students'. They have produced a book that has lived up to this objective to a large extent.

The book is divided into ten chapters and it takes the reader through a vast panorama of evolution of materials spanning a period of about thirty centuries. They trace the evolution of materials starting from the stone age and interestingly enough, they have a broad concept of materials which includes not only various metals and alloys, but also silk and diamond. The initial chapters take us through the iron age and then introduce the evolution and spread of swords through the ages in various countries. They then go on to discuss about the role of Wootz and the crucible steel in Indian armoury. This is written in a delightful style, which is easily readable by and large without sacrificing any technical rigour.

The second half of the book starts from the period of the European excitement and studies relating to Wootz from the sixteenth century onwards. It traces in detail the varied studies carried out regarding Wootz steel and the Damascus swords in England, France and Russia

through the twentieth century. It then goes on to continue the narrative about studies carried out in the US through the twentieth century, when the focus of attention moves across the Atlantic. The concluding chapters give us insights into the authors' own interest and work relating to the study of traditional iron smelting and steel-making and places the entire saga of Wootz in the context of the broad perspective of materials science. It is indeed remarkable that the authors have packed so much information of a technical nature into a narrative that can be comprehended by a general reader. Perhaps the only place where the general reader may feel a little lost is in the beginning of the third chapter, where he is suddenly confronted with phase diagrams and discourses on ferrite, cementite, austenite, etc. with no help for the non-technical reader.

The major lacuna in this book, however, is what comes across as a lack of information and material about certain important Indian efforts and studies relating to these areas over the last fifty years or so. I would like to cite a few illustrations regarding this.

There have been a large number of attempts made for the reconstruction and study of traditional Indian iron smelting process as well as the characterization of materials of which we find no mention in this book. For example, as part of the 1961 census operation, the Government of India had undertaken a detailed survey of traditional crafts from various parts of India. A study of indigenous techniques of smelting iron in some selected villages of Orissa was taken up and a detailed report was published in 1967, which even provided the description of the whole process with diagrams of furnaces with various designs[1].

More recently, starting from the late 1980 several efforts have been made to reconstruct and describe the process in many locations such as Bishunpur near Ranchi (which involved scientists from the National Metallurgical Laboratory and IIT, Bombay), reconstruction of furnaces of Agaria tribals in Varanasi as well as Mumbai and reconstructions in Indira Gandhi Rashtriya Manav Sangrahalay (National Museum of Mankind) with participation from metallurgists of RRL, Bhopal, of which even video documentations have been made.

In terms of an overview of the development of traditional steel technology, some important developments do not find a mention. For example, while the production of steel by carburization of wrought iron is widely known and reported, we also have reports from the nineteenth century[2], where the process of making steel that was prevailing in the Salem region by the 'decarburization process' has also been described.

One is left with a feeling that the authors may not be as well acquainted with Indian sources and developments on the matter to the extent that they are in touch with efforts in Europe or the US. For example:

(i) They make mention about the use of lead sulphide as eyeliner in Egypt (p. 15), while this practice has also been prevalent for a long time in India and finds a clear mention in the Siddha and Ayurveda texts.

(ii) Wootz and swords which are the central subject of this book are known to be produced in many locations in South India, but it is not clear if the authors are aware of (or have made efforts to locate) any literature on these subjects in Indian languages and particularly in South Indian languages such as Tamil, Kannada or Telugu. Such literature is indeed known to exist. For example, the Government Oriental Manuscript Library in Chennai has a Telugu manuscript entitled *Khadgalakshana Siromani* dealing with swords[3]. Similarly, references to swords are also found in Sanskrit texts such as *Brihat Samhita*[4]. Recently there have been publications regarding information found in various Sanskrit texts even on a specialized topic like *Musa* or crucibles[5].

(iii) It is also rather unfortunate to see that some vague stories and rumours about processes in ancient India have been mentioned casually in the book without any efforts to ascertain them. For example, the authors state that some gruesome methods of quenching steel are also known. The Tamil *Sangam* text, *Tolkappiyam* dating to the prechristian era mentions 'quenching of sword in slave's stomach' (p. 40). I have heard this kind of statement doing the rounds, but this was the first time that I have heard it attributed to this specific text. Subsequently, I have looked hard at several dictionaries, commentaries and concordances of *Tolkappiyam* and consulted two leading scholars on the subject – there appears to be nothing bearing even a remote resemblance to this story. One surely feels that the first Indian book on this important subject should deal with something like this more carefully.

While the book is indeed focused on the subject of Wootz, the authors have correctly placed it in a much wider context of materials science in India. In this connection I should also mention that there are at least a couple of other dimensions of this subject that do not find a mention in this book, which are highly relevant in terms of its meaning today. The first aspect is the interesting possibilities arising out of the well-known property of high corrosion resistance of Indian iron. While the authors have correctly taken note of the remarkable properties of the Delhi iron pillar, in this connection what is perhaps not highlighted (or even widely known) is the fact that traditional Indian iron in general is known to have high corrosion resistance properties. For example, in 1963 the National Metallurgical Laboratory held an international symposium on the Delhi iron pillar. In one of the papers presented during the symposium[6], the authors compared from the point of view of corrosion resistance the iron of the Delhi pillar, steel produced by the modern process and the iron being produced at that time by tribals using traditional technology. They concluded that tribal iron was superior to the blast furnace iron from the point of view of corrosion resistance. This should indeed be considered as quite remarkable and a study worth pursuing just on these grounds. It has been estimated that the national losses due to corrosion may be of the order of Rs 10,000 crores every year!

The second aspect of this subject is the role of *Viswakarmas*, a traditional community of artisans of India who work with various kinds of materials, including metals and alloys. There is a stupendous number and spread of these artisans throughout the country, who are even today playing an important role in the area of materials science. Some of the outstanding specimens of metals, stones, sculpture and architecture through the ages and right down to this century are products of this community. However, it is a tragedy of our times that our technical institutions and education, training and research relating to materials science has developed in a way that has no particular place for or ways to involve or encourage this community. In fact, when the Indian Industrial Commission of 1916 held a se-

ries of hearings, there was a moving and prophetic testimony rendered by the Secretary of the Viswakarma Mahajan Conference Committee, who stated that while the artisans were '…the industrial backbone of the country, they were not going to be the beneficiaries of the new policy regarding technical schools'. He observed that most of the manual workers were not educated and lacking exclusive literary training, were ineligible for technical scholarships. Citing the 1911 Census Report on the 'complete disassociation with the intellectual class in the country from its industries', he remarked that 'the mistake lay in the very first steps taken', viz. in the selection of students to go to foreign countries for training from communities other than the industrial or artisan classes, who possess the initial aptitude for manual labour which a university graduate of any other class despised as derogation of his caste dignity or literary merit[7]. Sadly, it appears that this divide continues even today. While the authors have taken note of activities of bladesmiths of USA, no interaction seems to exist with the Viswakarma community of our own country.

On the whole, the book is well produced and beautifully illustrated, with nice photographs and artwork. The text is by and large free from typographical errors, barring some stray instances (spelling of *Arthasastra* on p. 15, the name of Verhoeven misspelt on p. 64, etc.). Greater care could have been exercised in a few cases. While describing Figure 17, the authors state that the picture contains '…a touch of pathos conveyed by the playing of the harp', while the figure shows what seems to be a *Tambura*, and certainly not a harp. It is also a little painful to see what is today widely recognized and accepted as India's first war of independence of 1857 being described as the 'Indian mutiny'.

The major shortcoming of the book is the almost exclusive reliance on literature and testimonies from the West (including 'travellers tales'), with little attention to Indian language sources. It also appears as if the authors' awareness regarding Indian developments and initiatives in this area may have been confined to published papers in scholarly journals due to which they have missed out on certain rich sources of information and insights from India. One certainly needs to guard against the ethnocentric bias that permeates some of the Western sources. In his landmark publication on Indian science and technology in pre-British India, the doyen of Indian science historians, Dharampal has made deeply perceptive observations on this matter, pointing out how the British Royal Society was also part of such enthnocentric bias[8]. Helenus Scott, in his communication to the Royal Society in 1794, sent them a sample of Wootz and wrote that 'it appears to admit of a harder temper than anything we are acquainted with'. However, when this communication was published by the Royal Society in *Philosophical Transactions*, the article quoted his letter as '…admits of a harder temper than anything known *in that part of India*'. Today the bias may not be so obvious in writings from the West, since the discourse has become much more sophisticated. However, the pitfalls of an exercise with a heavy reliance on only Western sources for Indian technology are quite obvious.

Despite some of the shortcomings, the book is undoubtedly a significant achievement. It marks a new phase in our studies on this important material from ancient India. There is no doubt that future work on this subject can get strengthened and enriched considerably by also drawing inspiration from not only Indian source material, but also our traditional metal workers and artisans, who are still the carriers of this tradition in a significant sense. The book certainly deserves a place in every collection about the history of metallurgy and in the library of anyone who is interested in the history of science and technology in India.

1. Ahmed, M., *Census of India 1961*, vol. XII, Part VII-A, Govt of India, 1967.
2. Holland, T. H., *Rec. Geol. Surv. India*, 1892, **XXV**, 136–159.
3. Venkat Rao, N. (ed.), *Khadgalakshana Siromani* (of Navanappa of Pudukottai), Government Oriental Manuscripts Library, Madras, 1950.
4. Ramakrishna Bhat, M., *Varahamihira's Brhat Samhita* (with English translation; in two volumes), Motilal Banarsidas Pvt Ltd, New Delhi, Reprint, 1997.
5. Deshpande, V. J., *Indian J. Hist. Sci.*, 1996, **31**, 359–373.
6. Lahiri, A. K., Banerjee, T. and Nijhawan, B. R. N., *Natl. Metall. Lab. Tech. J.*, 1963, **1**, 46–54.
7. Shiv Visvanathan, *Organizing for Science: The Marking of an Industrial Research Laboratory*, Oxford University Press, New Delhi, 1985. Contains detailed discussions on the Indian Industrial Commission of 1916 and the testimonies recorded (in seven volumes); see p. 51 for the quoted testimony.
8. Dharampal, *Indian Science and Technology in the Eighteenth Century: Some Contemporary European Accounts*, Biblia Impex, New Delhi, 1971, p. 42.

A. V. BALASUBRAMANIAN

Centre for Indian Knowledge Systems,
30, Gandhi Mandapam Road,
Kotturpuram,
Chennai 600 085, India
e-mail: balu@ciks.org

***Heliothis/Helicoverpa* Management: Emerging Trends and Strategy for Future Research.** Hari C. Sharma (ed.). Oxford and IBH Publishing Company Pvt Ltd, New Delhi. 2005. 469 pp. Price not mentioned.

This unique volume highlights the diverse management strategies against the cotton bollworm *Helicoverpa/Heliothis*, whose adaptations to exploit transient habitats created by the intensification of agriculture, have made them major pests causing huge economic losses worldwide, including the semi-arid tropics, USA, Canada, Australia and South America. Their high mobility, polyphagy, high reproductive rate, ability to diapause and development of high level of resistance, are contributory factors towards the pest status. This book therefore is a timely publication presenting diverse positive strategies currently in use against *Helicoverpa armigera* in India and *Helicoverpa zea* and *Helicoverpa virescens* in other countries. The volume comprises 24 chapters written by specialists across the globe on diverse facets of bollworm biology, bioecology and management strategies involving a combination of strategies for the traditional cultural management, biological and chemical control and genetic engineering.

Host plant resistance has received more emphasis on the physical and chemical mechanisms of resistance as well as utilization of wild relatives of crops for resistance. Of particular interest are the chapters on the development of transgenic crops for resistance, resistance to *Bt* and insecticide resistance management strategies. Recent trends of research have been well discussed, especially molecular