Science and Beyond: Cosmology, Consciousness and Technology in the Indic Traditions. Sangeeta Menon *et al.* (eds). National Institute of Advanced Studies, IISc Campus, Bangalore 560 012. 2003. 338 pp. Price: Rs 350/US$ 35.

The volume represents the proceedings of a symposium held at the National Institute of Advanced Studies, Bangalore, in early January 2003. The motivation behind the symposium was to seek an insight into the question 'Is there anything beyond science?', especially in view of the spectacular success of science during the last three centuries.

Modern science is only about 400 years old. Many things that were considered to be beyond science in the 19th century, or part of science fiction, are parts of respectable science today. Also, counter-intuitive concepts like those in relativity and quantum mechanics have penetrated science, and some of these now lie at the foundations of modern science. The domain of science has been continuously and phenomenally expanding, due to developments in instrumentation, discovery of new and often unexpected facts following painstaking observations, and new concepts. There is no reason to believe that this process will not continue, and that there will remain any domains of man's knowledge and understanding outside the purview of science – considered in its dynamic, evolutionary perspective.

One suspects that behind the title of the symposium and the present volume, there is a lurking feeling that religion, spirituality and consciousness will remain outside the domains accessible to science. Is such a feeling justified? More than half the essays deal with consciousness and spirituality.

Most scientists think that beyond science (and technology) is more science (and technology). They do not think much about the obligations of science – and scientists who embody it – to society. This obligation has ethical dimensions and therefore, there is a tendency among scientists to claim that science is neutral. Modern science places at the disposal of society, powerful tools which have the potential to get rid of poverty, destitution and human indignity around the world. Work in these directions is so little compared to the needs and potentialities. How long does humanity have to tolerate these scourges, with the prevalent thought that they are not a province of science? Does science (and technology intimately related to it) have to stick to this self-imposed boundary to its applicability? Are actions prompted by humanitarian considerations to remain forever beyond the scope of science? On the other hand, research and development having inhuman potential is undertaken by a large fraction of the world's scientists – apparently without any qualms of conscience.

There are, no doubt, some organizations of scientists, like Pugwash, which worry about such issues. But their influence on the scientific community – if there is any such *community* – is negligible.

I recall a Pugwash Conference held at Dagomys in 1988 against the background of the end of the cold war, where possible collaborative projects in S&T between the US and the USSR were being discussed, specially a mega-project in the area of fusion, and a mission to Mars. Someone asked a question as to why scarce resources, including brains, should be spent on such projects, when there were more urgent problems of poverty, hunger and underdevelopment waiting for global action. Weisskopf, a physicist known for his deep societal concerns, got up to reply. Part of his reply was that we have the scientific manpower to do both. But he went on further to say that being human means to find out more about our environment, about nature, about what human intellect is capable of, and that such endeavours which expand the frontiers of human knowledge make us proud to be members of humanity and *make humanity worth saving.*

This reply bothered me, and I had to ask if man had not extended the horizons of his reach far enough over the past few centuries, to show what human intellect was capable of, so that he could take a few decades off from such pursuits and apply his capabilities to the challenges of poverty and underdevelopment, of restoring human dignity all round, which are *challenges of the inner frontier*, of domains which are within reach but yet not accessible? In applying our energies to get rid of these scourges, would we make humanity less worth saving? After all, more people remember Buddha or Jesus than most of the scientists who expanded man's external frontier.

Beyond science, or as an extension of the awareness of its potentialities, combined with a strong moral sense, is the conviction that one can and must change the society in which we live. This conviction shows up in the essays by Devaki Jain, N. R. Narayana Murthy, D. R. Karthikeyan and M. S. Swaminathan in the first section of the volume, entitled 'Science, Technology and Society'. Swaminathan draws attention to the particularly vital role of scientists and technologists in launching an *Ethical Revolution.* Could Pugwash, which he now heads, spearhead such a revolution?

Ramanath Cowsik suggests that we need an additional axiom apart from those of science, e.g. one that supports 'positive evolution' (love of humanity, non violence, etc.), to lead to the creation of a supra-science that bridges the gap between science and spirituality! Certainly, a change in the ethos of science is needed – an ethos in which even a Homi Bhabha is supposed to have given up physics when he started building TIFR and AEC in his later life!

Anindya Sinha deals with a different ethical issue, related to human cloning. Roddam Narasimha has an interesting discussion on the role of private and public knowledge in determining action. He makes the point that all human action depends on a fusion of private and public knowledge, and 'to that extent remains currently and seems likely to remain, outside even the frantically expanding sphere of science'.

In the next section, 'Indic Traditions', Rajiv Malhotra has a thought-provoking essay, wherein he raises the question as to whether Indian *Adhyatmic Vidya*, based on faith in an inherent and infinite human potential, is an empirical science, and if so, could it be reconciled with historically *unique* revelations by God, through prophets or his Son, as is the belief in Abrahamic religions (Judaism, Christianity, Islam). One wishes that Charles Townes (whose essay comes in a later section), who asserts that science and religion must be parallel and must interact, and that religion and science are more similar than we normally think, had been able to devote some space to a discussion of the problem of historicity vs ahistoricity raised by Malhotra.

Ashok Kumar Jain has a piece on the scientific content in the exploration of the spiritual world in the Jain tradition. He asserts that spiritual quests of ascetics/mystics are nothing short of scientific explorations of the beyond. He does not, however, deal with the question of how the findings of such quests are to be vali-

dated. On the other hand, he states that experiential knowledge counts more than intellectual knowledge. Other essays in this section are as follows: Sharada Srinivasan makes the point that aesthetic experience lies beyond science; R. L. Kapur discusses the spiritual practices of sanyasis; and S. Settar emphasizes the centrality of plurality and collective wisdom in the Indic tradition.

The next section on 'Consciousness' begins with an article by Roger Penrose, wherein he argues that it is necessary to have a scientific theory of consciousness, if *science – or some extended discipline going beyond what we mean by science today* – is to be able to say something deep and non-obvious about morality. This is followed by a long article by K. Ramakrishna Rao, who starts by pointing out that the concept of consciousness remains 'clouded'. The Western and Eastern perspectives of consciousness parallel the scientific and spiritual traditions. The Western approach focuses on the *knowing* aspect of consciousness, while in the Eastern approach, the emphasis is on the *being* aspect and consciousness is sharply distinguished from the mind. Rao argues that the two perspectives are complementary rather than conflicting. In the next article, N. Kumar raises what he calls the central problem of free will – as to the consistency of its interaction with the will-free world of physics, the two being subject to different rules of procedure.

Sangeetha Menon points out that *the question* about consciousness is of 'how physical, discrete, quantitative processes give rise to non-physical, unitary, subjective experience'. One wishes that there was some reference to the 'Astonishing Hypothesis' of Francis Crick. George Ellis is concerned about how the stored information in the human genome (only about 45,000 genes) controls the brain development by itself. P. G. Vaidya makes the hypothesis of a meta-entity called the super conscious, which would reside in a matrix that consists of a large number of individuals; this also points a way to the possibility of an emergent super-soul, he says.

In the next section, entitled 'Cosmology and Biology', Vidyanand Nanjundaiah looks at evolutionary antecedents for science, and concludes that their study suggests that there is nothing beyond science. C. S. Unnikrishnan draws attention to the role played in physical theories by unobservables, e.g. by dark energy in cosmology. He also makes the point that rational enquiry within the domain of science is perhaps the *ultimate spiritual quest.* Bruno Guideroni makes a case for the Anthropic Principle, based on fine-tuning in the universe. Jean Staune goes further and proposes a 'Super strong Anthropic Principle'. He also formulates experiments aimed at discovering if there is design in the universe.

The fine-tuning of the universe is again taken up by Charles Townes in the next long section, entitled 'Science and the Spiritual Quest'. Townes asserts that our universe is 'so special that it could only have been intelligently designed'. He does not go on to discuss questions like: Who was the designer? Would the finely tuned parameters and the laws not have to be known before starting to design? Or would they emerge alongside the design? In that case, would one not be right in saying that there is no design except in the process? M. L. Bhaumik also makes observations about the emergence of consciousness as a natural consequence of the unique features of the universe, and this leads him to a discussion of the Anthropic Principle. The reviewer would prefer to go with the spirit of the poetic Creation Hymn in Rigveda, quoted by Karan Singh in his Inaugural Address: 'The Gods are later than the world's production. Who knows then when it first came into being?'

Swami Bodhananda Saraswati expresses his belief that science and spirituality are two aspects of the same phenomenon. He also asserts that the question of immortality brings scientists and spiritualists together.

B. V. Sreekantan points out that the quest for ultimate reality is progressing with an increasing trend towards unification at the end of extreme reductionism. He also points out that to come to the present stage of recognition of oneness behind certain aspects of diversity, several transcendences had to be made in fundamental concepts like space, time, causality, matter, energy, fields, etc.

Sunder Sarukkai has an interesting piece on boundaries. He points out that science resists, as a methodological principle, any attempts to draw boundaries from within. He claims that to understand the boundaries of science, it must be placed against the background of religion, and therefore *science and religion are in Gestalt with each other.* He also asserts that the inability of science to incorporate quality has serious consequences: foremost of which is the inability to understand human existence in terms of quality and not in terms of quantity alone.

Jane Goodall argues that animals have consciousness – something that has been traditionally accepted by Indians for long.

Thomas Odhiambo provides an interesting glimpse into the importance of community connectedness in the African view; also of connectedness of humans with Nature and God, which has bearing on the African world-view *vis-à-vis* science. There is no particular point of demarcation between the natural and the supernatural. Reality goes beyond the arbitrary duality of science and spirituality.

M. G. Narasimhan is concerned about the tension between knowledge and ignorance and asks: where do we go from here – towards the cutting edge of knowledge or towards the cutting edge of ignorance? And whither scientific progress?

It is perhaps in the nature of the area dealt with by the book that many authors tend to have mystical overtones or make statements that can perhaps only have largely a subjective meaning: e.g. that science is finite, religion is infinite (Sarukkai); scientific and religious quests are similar (Townes); that they are converging (Bhaumik). What is the meaning of the statement that the ultimate truth is one? Does oneness in the *Upanishads* and oneness in physics refer to the same entity?

Philip Clayton observes that new habits of the mind are required for a scientist to explore the possible connections between science and spirituality, for here the self plays a role as an inner compass, which is unfamiliar to most practising scientists. And philosophers and religious scholars have important methodological lessons to learn from the way that scientists approach their work.

Scientists themselves have to curb their enthusiasm when talking of ancient insights. Sreekantan mentions that the ancient insights on reality are based on revelations to certain gifted individuals in a higher mental state and adds that in these higher states reality is said to be perceived in its pristine character with all the multiplicity merging into one. It is not clear that this concept of ultimate reality has anything to do with the ultimate reality which the scientists seek. Further, while science is part of verifiable and refutable public knowledge, whatever insight is obtained by an 'arrived' seeker of spiritual truth, seems to be personal knowledge that cannot be shared with others.

As Clayton observes, let there be wedding of science and spirituality, but let it begin with real partners, with all their faults and blemishes – but also with their real strengths.

The most significant outcome from reading this stimulating book would be for serious scientists to gain a feeling that there are bigger questions about science than the ones they love to tackle in the laboratories – but one has to approach them with customary caution and scepticism.

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Graphic Discovery – A Trout in the Milk and Other Visual Adventures. Howard Wainer. Princeton University Press, 41 William Street, Princeton, NJ 08450, USA. 2005. 192 pp. Price: US$ 18.95.

When dealing with numerical data, whether from experiments or surveys or computations, we take it for granted that we are likely to benefit from analysing the data graphically. In fact, nowadays, graphical analysis is almost made a fetish of in contemporary pedagogy. It therefore came as a surprise to me to learn that graphing of data is an invention just about two and half centuries old. Wainer forcefully emphasizes this by showing in figure 1 of this book, a plot of the christenings in London between 1630 to 1710, the data being taken from a table published by John Arbuthnot in 1710. There is a sharp dip in the data in 1704, when there were no wars or plagues or other epidemics to account for this. If the data had been graphed, Arbuthnot would surely have noticed the unusual datapoint and suspected and corrected the clerical error. But graphing had not yet been invented and the error remained uncorrected.

While a number of people contributed to the discovery of modern graphical display, in Wainer's view, it is William Playfair who should get the major credit. Born in 1759, Playfair was a colourful character who was in turn, among other things, millwright, engineer, draftsman, accountant, inventor, economist, land speculator, convict, blackmailer and journalist. A remarkable man of passion, ambition and industry, Playfair was also a bit of a rogue and scoundrel. A man of considerable practical inventiveness, he took out several patents and made a number of improvements to existing machinery. He also recorded his inventiveness; on his arrival in Germany in 1793 he wrote:

> 'When I was in Germany, I was surprised that in a country where the milk is excellent the butter was little better than common grease without anything, either of the colour or taste that butter possesses. But one day in changing horses where the post master spoke a little French and had a farm, I asked to see the dairy when I found that the milk was kept in deep narrow jars about three feet deep and eight or nine inches wide. The cream that rose to the top was about three inches in depth before it was taken off and though not quite rancid had a disagreeable smell. I advised him to get wide shallow vessels and keep them very clean, but he smiled as if I knew nothing of the business.'

Between 1786 and 1801, Playfair invented or perfected three of the four fundamental types of statistical graphs: the pie chart, the line and bar graphs; the scatterplot did not appear till the middle of the nineteenth century. These inventions were put to good use in producing his influential *Commercial and Political Atlas.* Each chapter begins with a well-produced graph, which is used in the following discussion to highlight some aspect of the revenues, expenditures, debts and commerce of England. It says something about that country, that at that time a man such as Playfair could produce on his own a book of this type and that there was a demand for it. No wonder they were able, within a century, to control so much of the world.

We have all come across instances where a graph provides the evidence for a plausible conclusion, even though the evidence may only be circumstantial. Figure 13.1 of the book shows a graph of young bald eagles per breeding area as a function of the year. The mean line dips to a minimum around 1973, the year that DDT was banned, and then starts to rise again. Even though the evidence is circumstantial, it hard not to connect the sad fate of the eagles to DDT prior to its banning and their remarkable recovery after the 1973 ban. The subtitle of this book comes from a similar story of the middle of the nineteenth century. Apparently, there was a dairymen's strike in New England at that time and there was suspicion that the limited supplies of milk were being watered down for wider distribution. In commenting on the reliability of the evidence being cited, Thoreau wrote in his journal (11 November 1850): 'Sometimes circumstantial evidence can be quite convincing; like when you find a trout in the milk'.

But, Wainer points out that such arguments are not always valid. Take for instance the winning times in the Boston Marathon for men and women. Men have competed since around 1900 and there is clearly a general reduction in the times over the century. Women were first allowed to compete in 1972 and they have been making rapid progress since then. If the data are plotted on the same graph (figure 13.2 in the book) for the period 1900–90, and if linear fits are drawn, one finds that the line for women intersects the one for men around 1996. One might draw the conclusion, as apparently some sports reporters actually did, that women would out perform men by 2000 and that their timings would approach the 2 h mark! Thus, one has to be careful with circumstantial evidence, this time obtained by linear extrapolation.

This is a nice and interesting book with many stories and examples of the uses, misuses and abuses of graphical display. There are twenty-two chapters, most of them being just 4–8 pages long, with fine illustrations, as befits a book on graphical display. The book is not just for teachers or scientists. Like all people who are passionate about their work, Wainer writes so that he can convey his love for his subject to all readers. If the book is left on your coffee table, it is quite likely that at least some of your visitors will pick it up and browse through it. On the other hand, if you teach students or are interested in science or in history, you will certainly benefit from reading this well-written book.

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