In the Shadow of The Bomb – Bethe, Oppenheimer, and the Moral Responsibility of the Scientist. S. S. Schweber, Universities Press (India) Ltd, 3-5-819 Hyderguda, Hyderabad 500 029. 2001. 260 pp. Price: Rs 285.

Books about theoretical physicists are by and large a post-World War II phenomenon. Till then, the public paid scant attention to its mathematicians and physicists. With the rare exception of Albert Einstein, other great theoretical physicists, representing some of the finest minds that human evolution has produced, remained unknown even to the larger intelligentsia, let alone the general public. But the situation has changed somewhat because of the massive technological spin-off that has flowed from what started out as highly esoteric ideas in modern physics. These include not only the transistor (which also made possible computers), lasers, nuclear power and medical tools but, sadly, also nuclear weapons (known more popularly, but not quite accurately, as atom bombs). Thanks to the horrifying and dramatic impact atom bombs had in ending World War II, several American and European theoretical physicists involved in the Manhattan Project attained some level of public prominence, enhanced further by the spy hunts during the McCarthy period. Many books have been written over the past 40 years analysing the angst and guilt of nuclear scientists. Today, nerds are still not pop icons, but it is felt that they have to be not merely tolerated, but understood and nurtured. Even movies and plays ('A Beautiful Mind', 'Copenhagen') have become hits, dramatizing what was once considered the dull world of physicists and mathematicians.

Schweber's recent book *In the Shadow of the Bomb* is therefore not the first to be written on the atom bomb and its aftermath. Some of the standard material it contains, such as Oppenheimer's tribulations with his security clearance and his alleged betrayal of his friend Chevalier have been amply described by others. Even the issue of 'the moral responsibility of the scientist' (a part of the book's subtitle) has been dealt with in great depth, as far back for instance as 1958 by Jungk in his *Brighter Than a Thousand Suns* (Penguin Books; Middlesex). The special feature of Schweber's book is its focus on contrasting the manner in which Oppenheimer and Bethe, two of the most important theoretical physicists involved in the Manhattan Project, dealt with moral issues surrounding nuclear weapons and national security.

If you are planning to analyse the psyche of prominent theoretical physicists, it helps not only to have known them personally but also to have experienced first-hand the special joy and pain of doing theoretical physics. Schweber comfortably fulfils these requirements. A learned historian of science today, he had earlier been an active researcher in particle physics and relativistic field theory – frontier areas in pure physics to which most Manhattan Project physicists, including Oppenheimer and Bethe, had returned after World War II. Schweber in fact did his graduate study at Princeton, where Oppenheimer was then the Director of the prestigious Institute for Advanced Study. From there he went on to do his postdoctoral work with Bethe's group at Cornell during the fifties.

Both Oppenheimer and Bethe were known from their early postdoctoral days as exceptionally gifted physicists. But as the years unfolded, Oppenheimer never really fulfilled his individual scientific potential, although he remained right in the thick of things on the frontiers of physics – fully abreast of the latest ideas and formulations. His role in physics grew more akin to that of a highly respected and feared orchestral conductor, as he rode herd over generations of talented physicists, first at Berkeley and later at the Princeton Institute. It was in the realm of science management, as everyone knows, that Oppenheimer went on to play his historic role by directing the Manhattan Project. That the person publicly identified as the 'father of the atom bomb' was later stripped of even his security clearance is the stuff of tragedy, but it made him an even more celebrated public figure.

Bethe, on the other hand, ended up doing a huge body of pioneering research, decade after decade, in practically every branch of physics. He is, at the time of writing, arguably the most revered physicist alive. Although he never became a household name, Bethe also played a role comparable to that of Oppenheimer in the development of nuclear weapons and in formulating public policy related to them. After the Manhattan Project (where he was head of the theoretical physics group) came to an end, Bethe continued as a leading advisor to the US Government on nuclear arms control and development. As Oppenheimer came increasingly under a cloud because of revelations during his security clearance trial and Edward Teller turned far too hawkish, it was Bethe who gradually emerged as the most widely respected expert on both nuclear weapons and nuclear reactors, a patrician figure whose opinion was valued by both doves and hawks alike.

Portions of the book that contrast the personalities and psychology of the two men are very insightful. The author puts his finger right on the button when he quotes Nietzsche's 'universal law' that 'a living thing can only be healthy, strong and productive within a certain horizon . . . on there being a line that divides the visible and clear from the vague and shadowy . . . [otherwise] it will come to an untimely end'. Schweber goes on to say that whereas 'Bethe knew this instinctively, Oppenheimer grasped it only with great difficulty'.

Oppenheimer epitomized the romantic image of a dazzling and charismatic intellectual. He possessed an extraordinarily erudite mind with an appreciation not just of high physics but also of literature, philosophy and poetry. Schweber recalls his famous quote from the *Bhagavad Gita* upon witnessing the first nuclear explosion, 'I am become Death, the destroyer of worlds'. His was a scathing intellect which terrorized seminar speakers, young and old, at the Princeton Institute. By contrast, Bethe had the very opposite of a flamboyant personality. His words were carefully measured, his opinions always moderate. Even when tackling the most esoteric physics problems, his approach was down to earth, emphasizing concrete results over elegant abstractions.

To anyone who has interacted with the individuals in this book, Schweber's assessment and analysis of their personalities will ring true. I narrowly missed getting to know Oppenheimer. (He succumbed to cancer just a few months before I joined the Institute for Advanced Study in 1967). But prior to that I had the great good fortune of having closely worked with Bethe during the early sixties, first as his Ph D student and later as his co-author and junior colleague on the Cornell faculty. Most of what Schweber says about Bethe accords with my own experience. So do his descriptions of Phil Morrison and of Bob

Wilson, who later went on from Cornell to build the world's largest particle accelerator near Chicago.

Sometimes, characters in a book can wrest the initiative away from the author and shade it in different colour. Perhaps Schweber did not intend it that way, but the two people who emerge as the most heroic characters in the book turn out to be neither Bethe nor Oppenheimer, the former a far too well-centred realist and the latter, a victim of his own moral compromises. It seems to me that the true heroes are two secondary actors in this drama, Bernard Peters and Philip Morrison. I personally found the section of the book dealing with their stories during the McCarthy era the most touching. Peters, a remarkably courageous man who escaped from a Nazi prison camp and crossed the Alps on a bicycle, later worked as a longshoreman in San Francisco before being discovered by Oppenheimer for his physics talents. This very same mentor later described Peters to the House Un-American Activities Committee variously as an intemperate person, 'quite Red' and one who favours 'direct action' – a loaded phrase during the McCarthy period, implying an unconstitutional overthrow of the US government. All this resulted in Peters almost losing his job and eventually having to leave the US. America's loss turned out to be India's gain as Peters then spent several very productive years at our own TIFR.

Philip Morrison was another remarkable person of the times, a brilliant physicist, a scintillating lecturer and among other things, one of the first Americans to walk through the rubble of Hiroshima. I remember sitting riveted in my chair in his classes at Cornell, hanging on to his every word as Morrison, unfazed by a longstanding physical handicap, dominated the classroom with his completely original and inimitable exposition of Statistical Mechanics. He too faced problems with his job at Cornell because of his past links and sympathies with the communists. His letters in response to the President of Cornell during that crisis are models of ethical precision and among the truly inspirational portions of Schweber's book.

This book understandably limits itself to American and European nuclear physicists. But the 'moral responsibility of the scientist' is a far more universal concept. We have much to ponder in our own country about the moral posture of our scientists. This is not just because we too have gone nuclear. The larger issue (of which the ethics of bomb-making is only one example) is whether our scientists guard sufficiently zealously the values of independent thought and intellectual honesty essential for any form of ethical introspection. In our traditional culture, high academics – the Acharyas and Gurus – are also expected to act as the conscience keepers of society by advising and guiding both their students and their rulers equally fearlessly. One hopes our scientists still view themselves more as such academics rather than as briefcase-toting, jet-setting executives who, for a few crore rupees of grant money, feel no qualms about abandoning their critical faculties.

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There is need, no doubt, to digest the flood of research but when they are too many, it makes it difficult to keep track of even reviews. This is particularly so with a proliferation of review journals, including proceedings of conferences, assorted edited volumes and reviews of limited scope. *Annual Reviews* have traditionally avoided being so and have covered areas comprehensively and with invariably outstanding authors. The effort that has gone into the production of *Annual Review of Neuroscience Volume 24* is underscored by the fact that the team responsible for the contents was set-up in 1998. The canvas is broad; molecular, cellular and systems neuroscience and when you have multiple models and modalities it makes the effort daunting. The editors have achieved a great synthesis and produced a volume of incomparable value.

Not too long ago neuroscience meant behaviour studies, chemistry of the brain, physiology and anatomy. It is possibly still that, but at a vastly different level of detail and understanding. The literature on behaviour used to be replete with measurements of dubious value, the anecdotal and the birdwatcher's variety. It did not help much with the understanding of the making and working of the brain. When do you learn about the working of an instrument? When you completely design and make it or when it fails and you trouble shoot and over several failures and all possible such you have a fair idea, if you are analytical and arrived at solutions not the style of 'Thuppariyum Shambu'. Evolution has gone ahead and designed brains over a few billion years and so we are left with an option, equivalent of turning on and turning off switches one at a time and retracing connectivity. This is what the tools of behaviour genetics and pharmacology have done and that which now molecular and cell biology is extending with unprecedented analytical vigour. Behaviour is a reflection of the response of cells to the environment it finds itself in. Genetics has turned this around to a precise and analytical area with even complex behaviour like learning and memory now amenable to analysis at all levels. Tools of genetic analysis are the mainstay of about half of the reviews in this volume.

The concluding piece on 'Flies, genes and learning' by Waddell and Quinn in this volume highlights the successes of a quarter century of research with *Drosophila* learning mutants. Flies can learn, remember and forget. Interestingly, while genetics has confirmed some classical models on learning, it has produced some remarkable new insights. Two distinct forms of long-term memory were demonstrated in flies; an unexpected relationship between learning and addictive drug response was also shown. Recent work in Tim Tully's laboratory at Cold Spring Harbor using genetic and molecular tools unique to *Drosophila* has been able to dissociate centres of memory formation and recall. While I was reviewing this volume, there were reports that the molecular machinery controlling addiction has been unravelled in fly mutants at Mani Ramaswami's laboratory at University of Arizona. These reflect the trend in neuro-