

BOOKS & ARTS

Born to greatness?

Staking a claim in history for one of the driving forces behind quantum mechanics.

The End of the Certain World: The Life and Science of Max Born

by Nancy Thorndike Greenspan
Basic Books: 2005. 320 pp. \$26.95

Kurt Gottfried

Max Born was one of the founding fathers of quantum mechanics — indeed, he coined its name even before his assistant, Werner Heisenberg, gave birth to the theory with a breakthrough paper in the summer of 1925. But Born never received the recognition he so richly deserved, a gap that this book should help to fill.

Born was the professor of theoretical physics in Göttingen from 1921 until his dismissal by the Nazis in 1933. In those days that meant he could really shape the content and quality of the research programme. This he did superbly, assembling a group of brilliant youngsters and focusing them on atomic physics.

By 1925, Born had already realized that the puzzles posed by atomic spectra should be attacked by focusing on transition probabilities. He had also reached the seminal view that the theory should concentrate on what is in principle observable, and not on classical but unobservable constructs, such as electronic orbits, which figured prominently in the 'old quantum theory'. These insights were essential conceptual ingredients in Heisenberg's paper, which first set out, albeit in a skeletal and rather opaque form, the algebraic scheme of the nascent theory. It was Born who recognized that this scheme was matrix algebra. And it was Born who first wrote down the commutation rule, which specifies by how much xp differs from px , where x and p are the matrices corresponding to the coordinate and momentum of a particle. This equation is the key to the mathematical structure of quantum mechanics, and was engraved on Born's tombstone at his request.

Before the end of 1925, Born, Heisenberg and Pascual Jordan had developed these first steps at amazing speed into an almost complete theory — as had the incredibly gifted Cambridge student Paul Dirac working independently in splendid isolation. By 1933, Nobel prizes had been given to Heisenberg and Dirac, and also to Erwin Schrödinger, whose equivalent wave-mechanical formulation only began to appear in January 1926. But Born was left out. More unfair still, Niels Bohr and



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Overlooked: while his colleagues quickly won Nobel prizes, Max Born received little recognition.

Heisenberg subsequently gave him little recognition for his role in developing the widely accepted interpretation of quantum mechanics. Finally, in 1954, long after Born had been forced to leave Germany for Britain, he did receive a Nobel prize.

The prize recognized, at long last, Born's discovery of the statistical interpretation of the wave function. He was the first to recognize the profound departure from classical concepts of causality that quantum mechanics implies. In particular, he recognized that although the Schrödinger equation describes a continuous and causal evolution, it nevertheless makes only statistical predictions about observable events. This was before Heisenberg's discovery of the uncertainty principle and Bohr's formulation of complementarity, the essential ingredients in the Copenhagen interpretation. Bohr, Heisenberg and their entourage did not properly acknowledge this fact for a very long time.

In *The End of the Certain World*, Nancy Thorndike Greenspan paints a rich picture of the social, political and intellectual scene in which Born rose to the academic stratosphere from his birth in 1882 into a prosperous Jewish family. He was not a wunderkind. On the contrary, at the age at which the prodigies Dirac, Heisenberg and Wolfgang Pauli had

become legendary scientists, Born had only earned his doctorate in applied mathematics with a thesis on an unexciting topic, and was yet to realize that cutting-edge theoretical physics would be his forte.

As the book recounts, the German physics community took a long time to recognize the talents of this creative and productive man — quite why has been something of a mystery. The intellectual calibre of the cast that populates the book during the early years of Born's career is stunning to a degree that is not adequately recognized or explained, except in the case of Einstein. Born was a modest man of exceptional but not overwhelming intellectual power (unlike the ever-present David Hilbert), and would have had good reason to be intimidated. He was in a similar position to an outstanding Florentine artist whose work remains well known to this day, but who had to make his way in the company of Michelangelo and Leonardo da Vinci. Born compensated for whatever handicap he felt by becoming something of a workaholic, which over time helped him to master an enormous range of physics and produce a prodigious quantity of research papers and splendid texts — from the elementary to his classic treatise on optics.

As the book explains, Born did not have an easy youth psychologically. As a mature man

he was often not sturdy enough, physically and mentally, to handle the load that he imposed on himself. This was compounded by his sometimes shaky marriage to a fragile and not always faithful woman. That he produced so much despite all this is remarkable. The portrait that emerges is of a refined intellectual of the highest ethical standards, unwilling or unable to advocate effectively on his own behalf — even accepting his wife's demand that their children should not attend the Nobel ceremonies. Although he was a refugee from Nazi Germany, he was profoundly disturbed to see his beloved pure physics spawning nuclear weapons in the hands of some of his most talented students: Robert Oppenheimer, Edward Teller, Victor Weisskopf and the spy Klaus Fuchs.

So does this book fill what is a serious gap in the history of twentieth-century physics? In contrast to the other great figures in the quantum revolution, Born's personality has never been described in any depth, and this part of

the gap is filled exceptionally well. As for Born's science, the job is done for the physicist, who can apply well-informed opinions to grade the significance of the people and discoveries described. But other readers would have benefited from an account of Born's work that did a better job of separating the wheat from the chaff.

All the book's readers would have benefited had the editor insisted that we do not need to know the names of all those Alpine hotels the Borns visited, what they ate there, and a barrage of other details. This mass of minutiae often produces a haze that could make it hard for readers to see what is most exceptional and long-lasting among Born's many achievements. Nevertheless, there is no question that any future work on Born will find this book to be an indispensable study of this major figure in one of the most profound transformations in the history of science. ■

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know who Craig was. According to Burkhardt: "Thorpe, supposing Craig was dead, was astonished to learn that Craig was not only alive but in the audience."

The development of ethology has been greatly influenced by the different personalities involved. Nowhere is this shown more clearly than in the relationship between the two key figures in the field, Lorenz and Tinbergen. The characters of these two men could hardly have been more different. Whereas Lorenz was vain, self-centred, an extrovert and a self-styled philosopher, Tinbergen was modest, an introvert and an empiricist. Lorenz characterized himself as a 'farmer', who mainly observed the domesticated birds that he kept around his own house, in contrast to the 'hunter', Tinbergen, who conducted controlled experiments both in the field and in the laboratory. The contrast between the two men became painfully obvious during the Second World War, when Lorenz was a doctor in the German army and Tinbergen was interred in a detention camp for Dutch intellectuals. Burkhardt devotes an entire chapter to Lorenz's conduct during the Nazi regime, and shows that, blinded by ambition, Lorenz did not distance himself from Nazi doctrine. After the war it took some time for the wounds to heal so that the two friends could resume their scientific partnership.

One of Tinbergen's lasting contributions is the identification of the four main problems in animal behaviour: evolution, function, development and causation. Tinbergen has credited British biologist Julian Huxley with identifying three of these as the main problems in biology, to which he merely added development. On reading Burkhardt's account, however, it seems that Tinbergen was being rather generous towards Huxley. "It is from a failure to distinguish between ultimate cause, immediate

Acting on instinct

Patterns of Behavior: Konrad Lorenz, Niko Tinbergen, and the Founding of Ethology
by Richard W. Burkhardt, Jr
University of Chicago Press: 2005. 636 pp.
\$80, £56 (hbk); \$29, £20.50 (pbk)

Johan J. Bolhuis

The Austrian Konrad Lorenz and Dutchman Niko Tinbergen founded ethology, the study of animal behaviour, at the start of the twentieth century. The history of the 'study of instinct', as it was once known, attracts interest from a range of disciplines, and this naturally affects the viewpoint of books on the subject. *Niko's Nature* (Oxford University Press, 2003), for example, a recent biography of Tinbergen, was written by his one-time friend and pupil Hans Kruuk (for a review see *Nature* 427, 293–294; 2004). In contrast, Richard Burkhardt is a historian, not an ethologist, so his book *Patterns of Behavior* is quite different. Nevertheless, it is not a dry factual biography of a scientific discipline, but a fascinating and often entertaining account of the life and work of some of ethology's key figures. Burkhardt has done a tremendous job, meticulously analysing and describing the rise of ethology. He consulted a multitude of written sources and interviewed many of the important players.

Modern history of science is not only about scientific concepts, Burkhardt explains, but is just as much about the social context of the individual scientists — what he likes to call "ethology's ecologies". The term 'ethology' was introduced by the American William Wheeler, and US biologists active around the end of the nineteenth century might have contributed

much more to the development of ethology if they'd had the resources and the intellectual freedom to pursue their empirical studies and develop new ideas. A particularly poignant example of this is the pioneering biologist Wallace Craig, who greatly influenced Lorenz but struggled to make ends meet for most of his life. When the great British ethologist William Thorpe lectured at Harvard in 1951, he paid tribute to his American colleagues Charles Otis Whitman, Wheeler and Craig. Thorpe was surprised that only one or two members of his large audience seemed to

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Up close and personal: Konrad Lorenz liked to observe birds in their natural habitats.