dinated to the mind. Nobody accepts Aristotle's line on people these days, but most of us still follow his reasoning when it comes to beasts. The question at issue today is just how stupid a natural slave has to be before the Aristotelean arguments kick in. In this eloquent and disturbing book, the literary scholar Dale Peterson and the primatologist Jane Goodall argue that chimpanzees and other apes are too smart and too human to qualify as natural slaves and that we should stop treating them as such.

The book's governing metaphor is the figure of Caliban in Shakespeare's *Tempest*, who like the chimpanzee straddles the boundary between people and beasts. The authors begin their report on Caliban's present condition with an evocative description of the complex social lives and technical skills of chimpanzees in the wild. This idyllic prelude is followed by a grim account of the advancing destruction of chimpanzee habitat as the African forests recede and the animals, soils, and groundwater vanish with them. The book then descends into a 200-page simian Inferno, reporting and documenting cases and patterns of death, degradation, and misery visited upon chimpanzees that have fallen into human hands and been converted into butcher's meat, impossible pets, squalid nightclub performers, or cunning and dangerous lab animals interminably shut away behind bolted doors and "Biohazard" signs.

Goodall (whose prose in this book is distinguishable from Peterson's by its different typeface) holds out hope that chimpanzees can be protected, both as species and as individuals, by instituting new international laws, new chimpanzee sanctuaries, more effective and humane captive breeding programs, and aid programs that will promote "responsible development that will help the people of Africa escape the grip of poverty." More controversially, she urges an expanded Golden Rule on the scientific research community: whatever you would not do to a human being to gain knowledge, refrain likewise from doing to a chimpanzee.

Researchers who use apes in their work will undoubtedly reject this plea on the grounds that a chimpanzee's life is not worth as much as a human being's. Peterson and Goodall would probably agree. The same underlying belief, that the value of an animal's life depends in some sense on how humanlike it is, is implicit in Peterson's own suggestion (p. 244) that researchers should help preserve chimpanzees by using rhesus monkeys instead whenever they can. But this possible point of agreement does not take us very far toward solving the practical problem of weighing animal life against scientific knowledge in deciding when a piece of research is likely to be too trivial or fruitless to warrant the suffering and death of a chimpanzee, or a dozen macaques, or a thousand mice. Indignation is the mother of moral invention; and perhaps some reader of this book will be sufficiently outraged to ponder this question and come up with some useful answers. All scientists would do well to think about these issues—and to consider the possibility that there may just be something wrong somewhere with the whole theory and practice of natural slavery.

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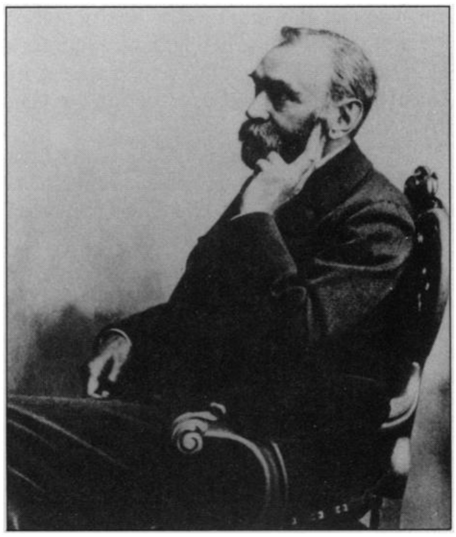
Chemical Entrepreneur

Alfred Nobel. A Biography. KENNE FANT. Arcade, New York, 1993. x, 342 pp. + plates. $24.95. Translated from the Swedish edition (Stockholm, 1991) by Marianne Ruuth.

Nitro compounds contain a grouping of atoms made up of two oxygens and one nitrogen. The credit for their commercial importance belongs not to the chemists who established their properties but to those who overcame the problems of practical application. This happened in the 1860s when nitro compounds became the basis of the new technologies of synthetic dyestuffs and explosives. The latter, in the form of the unstable liquid nitroglycerine, accelerated railroad construction, increased the output of mines and quarries, and gave a new and terrifying dimension to warfare. The harnessing of nitroglycerine as dynamite was the triumph of the Swedish inventor Alfred Nobel. By careful control of his patents, mainly through licensing arrangements with companies (later dominated by the Nobel Dynamite Trust Company and a second multinational corporation) that were set up to exploit his inventions, as well as through other industrial activities, Nobel left a fortune that serves to reward achievements in science, medicine, and literature and "the best work for the brotherhood of nations" (the Nobel Peace Prize).

Kenne Fant's reconstruction of Nobel's life is achieved mainly through the use of contemporary accounts, some by people whose contact with the inventor-industrialist was only fleeting, analysis of a manuscript of Nobel's play *Nemesis*, and correspondence with his mistress, Sofie Hess. The play and accounts of Nobel's early desire (quickly stifled by his father) to become a writer show him to be the perfect example of the frustrated and sensitive artist who achieves great success as an industrialist.



Alfred Nobel. [© The Nobel Foundation]

Nobel was born into poverty brought about by the bankruptcy of his father, a prolific inventor and innovative builder who suffered a series of financial disasters in Stockholm. Nobel Senior had more luck in St. Petersburg, where he manufactured munitions for the Russian army. In the meantime, Alfred received a grounding in chemistry, which was put to good use when the family returned to Stockholm, though not before a fatal explosion killed his brother and four other people. During 1865–66, Alfred overcame the problems of detonation and safe transportation of nitroglycerine with his dynamite. Its promotion was a matter of clever showmanship, especially demonstrations before military authorities and the media of Europe and North America. He was particularly concerned to use the publicity to show that a spate of fatal accidents associated with it had been caused by carelessness. Once the product was accepted Nobel turned to international partnership arrangements, sometimes with individuals that he should not have trusted in the first place.

Nobel's business links with his brothers eventually extended his interests to the oilfields of Baku. There were disagreements, moments of great personal difficulty with family members, and several financial calamities.

The correspondence with Sofie Hess, some of which is included in the volume, provides, more than anything else, a vivid impression of his hectic life, with continuous travel to and fro across Europe, experimentation and trials, negotiations with lawyers over patent litigation (especially for smokeless powder), and changes of direction in mid-course as a business matter or family tragedy interrupted his itinerary. The dark side of the relationship with Hess is exposed. It is apparent that Nobel kept her out of sight because (however much he may have required her sexual favors) he could not accept her lack of education. Hess's financial demands were matched by Nobel's insensitive condemnation of her background.

Increasingly, Nobel had to contend with a hostile press, which often labeled him a merchant of death. Despite his close friendship with Bertha von Suttner and great sympathy with her peace movement, which no doubt influenced the formulation of his testament, Nobel was hardly a pacifist. He firmly believed that weapons of mass destruction, such as those he worked on, would be the ultimate deterrent, to the extent that in 1890 he wrote: "On the day when two armies will be able to annihilate each other in one second all civilized nations will recoil from war in horror and disband their forces."

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Quantum Mysteries

The Quantum Theory of Motion. An Account of the de Broglie–Bohm Causal Interpretation of Quantum Mechanics. PETER R. HOLLAND. Cambridge University Press, New York, 1993. xx, 598 pp., illus. $120 or £70.

How can electrons behave sometimes like particles and sometimes like waves? How does an atom know, when it passes through one slit of a double-slit apparatus, that the other slit is also open, so that it should behave so as to contribute to an interference pattern? How does a radioactive atom know when to decay? How can electrons tunnel across classically forbidden regions? How can Schrödinger's cat be simultaneously dead and alive—but only until we look at it and find that it is one or the other?

Quantum mechanics is undoubtedly our most successful scientific theory. At the same time, it is a bizarre theory, so bizarre that, according to Richard Feynman, a master of quantum calculation, "nobody understands quantum mechanics." The features that primarily contribute to its strangeness are its indeterminism and, even more, its apparent subjectivity, its constant appeal to measurement and to the observer, as codified in Bohr's Copenhagen interpretation. One of the clearest statements on this subjectivity is that of Heisenberg: "The idea of an objective real world whose smallest parts exist objectively in the same sense as stones or trees exist, independently of whether or not we observe them . . . is impossible." The subjectivity and indeterminism of quantum theory have quite naturally been accompanied by the view that quantum particles do not really have trajectories and that, by Heisenberg's uncertainty principle, any talk of such things is meaningless. In their famous textbook on quantum mechanics Landau and Lifshitz declared flatly that the interference effects in the double-slit experiment "can in no way be reconciled with the idea that electrons move in paths." It is true that strong disapproval of this state of affairs was expressed by some prominent physicists, most notably Einstein, who believed that "the essentially statistical character of contemporary quantum theory is solely to be ascribed to the fact that this [theory] operates with an incomplete description of physical systems." Nonetheless, for several decades it was believed by most physicists that the mathematician John von Neumann had proven, with the utmost mathematical rigor, that a return by physics to any sort of fundamental determinism was impossible. For example, according to Max Born, who formulated the now standard statistical interpretation of the wave function, von Neumann had shown that "no concealed parameters can be introduced with the help of which the indeterministic description could be transformed into a deterministic one."

The "proof" of von Neumann and the claims of Born, Landau and Lifshitz, Heisenberg, and Bohr notwithstanding, in 1952 David Bohm, through a refinement of de Broglie's pilot-wave model, succeeded in providing an objective and completely deterministic account of quantum phenomena. This achievement was greeted by most physicists with indifference, if not outright hostility. John Bell, of Bell's inequality fame, was a refreshing exception. Bell expressed his reaction as follows:

> In 1952 I saw the impossible done. It was in papers by David Bohm. Bohm showed explicitly how parameters could indeed be introduced, into nonrelativistic wave mechanics, with the help of which the indeterministic description could be transformed into a deterministic one. More importantly, in my opinion, the subjectivity of the orthodox version, the necessary reference to the "observer," could be eliminated. . . . But why then had Born not told me of this "pilot wave"? If only to point out what was wrong with it? . . . Why is the pilot wave picture ignored in text books? Should it not be taught, not as the only way, but as an antidote to the prevailing complacency? To show us that vagueness, subjectivity, and indeterminism, are not forced on us by experimental facts, but by deliberate theoretical choice? [*Speakable and Unspeakable in Quantum Mechanics* (Cambridge Univ. Press, Cambridge, 1987), p. 160]

The Quantum Theory of Motion is the first book to appear that is devoted solely to a systematic presentation of Bohm's pilot-wave formulation of quantum mechanics, a precise, deterministic, microscopic theory describing a motion of particles under an evolution choreographed by the wave function. Here the reader will find detailed answers to the many questions prompted by quantum theory.

Novel resolutions of the quantum mysteries regularly appear. Most cannot withstand careful scrutiny. It is therefore worth emphasizing that the explanations found in Holland's book are genuine. In particular, they are not evasions, in which the real problems are skirted rather than solved. Moreover, as Holland points out, Bohm's theory is "very much a 'physicist's theory' and indeed puts on a consistent footing the way in which many scientists instinctively think about the world anyway."

One very striking and much discussed implication of quantum theory, that of quantum nonlocality, remains in Bohm's account, not as a mystery but as a natural consequence of the mathematical structure of quantum theory itself. In this sense, while the quantum paradoxes are *eliminated* by Bohm's theory, nonlocality is *explained* by this theory. Holland quite appropriately devotes much attention to quantum nonlocality, delineating how it emerges in the quantum theory of motion.

In fact, one has to do astonishingly little to textbook quantum theory in order to transform it into a theory—Bohm's theory—in which the quantum paradoxes are not merely resolved but are eliminated entirely. This simplicity does not shine forth in Holland's presentation, however, but is often obscured by an elaboration of details. Holland provides detailed computations and descriptions of trajectories, quantum forces, and quantum potentials—a description often involving precessing spins and gyrating rotators—for a large variety of situations. Although these details are interesting and are undoubtedly of some value, pedagogical and otherwise, they are often unnecessary and tend to make it difficult to appreciate the essential point of Bohm's account: that the origin of the quantum paradoxes lies neither in quantum phenomena nor in the quantum formalism that governs these phenomena but rather in the quantum philosophy, expressed in the Copenhagen interpretation of quantum theory, with which the quantum formalism has been encumbered. Almost as soon as one dispenses with this philosophy and instead posits that particles have positions regardless of whether or not they are being observed, one arrives at Bohm's theory, which succeeds in completely accounting for all (nonrelativistic) quantum phenomena while avoiding the