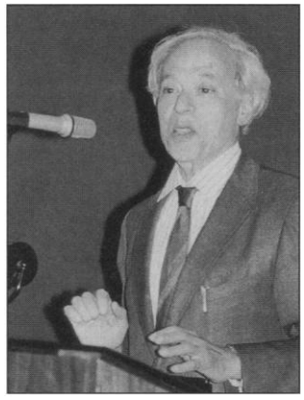
BOOK REVIEWS

Particles and Peregrinations

A Tale of Two Continents. A Physicist's Life in a Turbulent World. ABRAHAM PAIS. Princeton University Press, Princeton, NJ, 1997. xvi, 511 pp. + plates. $35 or £25. ISBN 0-691-01243-1.

For Abraham Pais the 20th century has truly been "the best of times . . . the worst of times." Born to a Sephardic Jewish family in Amsterdam, in one of the most civilized countries in the world, Pais completed his education under the barbaric Nazi occupation. Emerging from his attic hiding place at the end of World War II, he began his professional career at the commencement of the glorious era of elementary particle physics. One of the first of a generation of brilliant theorists who pondered the wealth of experimental discoveries brought forth by the new particle accelerators, Pais made important contributions to the attempt to understand the laws that governed the basic forces of nature. He was witness to the evolution of the field from its inception to the final development, in the mid-'70s, of a comprehensive and successful theory of all the microscopic forces. He then changed fields, and for the last 20 years he has been a prolific historian of modern science, whose biographies of Einstein and Bohr have been much acclaimed.

Pais's account of his own life, *A Tale of Two Continents*, consists of two distinct parts. The first, centered in Holland, describes Pais's coming of age and his experiences during the war. The stories of holocaust survivors are as varied as the survivors themselves. Pais's story, much as does that of Anne Frank, who was in hiding nearby, conveys the mixture of normalcy and terror that characterized the life of those in hiding. There was the time in 1943 when the Gestapo suddenly appeared at the house in which Pais was hiding. Pais hid in the attic wall as the Gestapo searched the attic. After they left, crouched in his narrow hiding place, paralyzed with fear, he heard someone enter the room and begin to read out loud. It was Hans Kramers, Holland's most distinguished theoretical physicist and Pais's mentor, who was visiting when the Gestapo arrived, reading from Bradley's *Lectures on Shakespeare* to calm Pais's nerves.

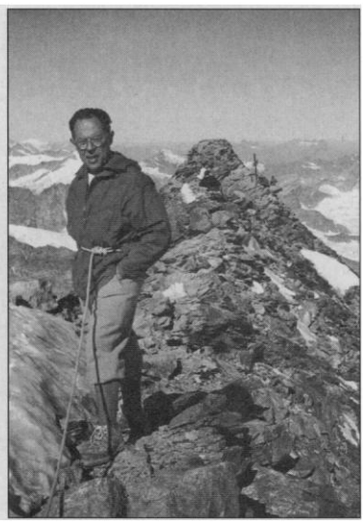


Abraham Pais at a symposium honoring his 70th birthday, Rockefeller University. [From *A Tale of Two Continents*]

In a total of five different hiding places, Pais read novels, studied quantum field theory, exercised prodigiously, and waited for the nightmare to end. By a series of accidents and luck, he managed to avoid capture until almost the end of the war. Arrested by the SS, he escaped death by the courageous action of his good friend Tineke and the help of Kramers. Many of his family and friends were not so lucky. Pais lost 17 members of his family to the death camps, including his only sister and her husband. This part of the book could stand alone as a poignant and engrossing account by a holocaust survivor.

The second half of this book, centered mostly in the United States, describes Pais's coming to America, his career and life here. This is the story of an unusual immigrant, one who fell in love with his adopted country and learned to appreciate baseball, *New Yorker* cartoons, and American humor. It is also the story of his marriages, divorces, and psychoanalysis and of many trips and voyages. These accounts often read as if they were transcribed directly from a diary and lack the more expansive narrative style that makes the first half of the book so riveting. Here, by contrast with the account of the war, we are not allowed to peer too closely into the author's psyche. This is perhaps appropriate, for the biography of a scientist is primarily the story of his work and of his colleagues.

Research in elementary particle physics began in earnest after World War II. Pais was one of the pioneers in this field, which exploded in the early '50s when the new accelerators unearthed a host of new particles. Among these were the strange particles, so named since they were strange indeed. These particles were the first sign of a new type of matter, which contained, as was understood later, a new kind of heavier quark not present in ordinary matter. Pais made seminal contributions to the understanding of these particles. Strange particles, especially the K-mesons (bound states of the strange quarks and the ordinary, up and down quarks), have beautiful properties, many of which were elucidated by Pais and collaborators. These properties allow them to be used as sensitive probes of the symmetries of nature. Indeed both the violation of parity conservation and the violation of CP-invariance (or equivalently time-reversal symmetry) were first exhibited in the behavior of K-mesons. Pais gives a fascinating account of these developments. Since he does not provide a true history of the evolution of elementary particle physics (this he has done elsewhere, in *Inward*



Above, Abraham Pais "fiddling around, Norway, 1946." Right, Abraham Pais "on top of the Matterhorn, 1962." [From *A Tale of Two Continents*]

Bound [Oxford University Press, 1988]) the non-expert might find his account of the science skimpy and hard to follow. But he does convey the excitement and passion that characterize creative work in this frontier area of science.

Pais knew everyone, including Einstein, Dirac, Bohr, Feynman, von Neumann, Kramers, Pauli, Oppenheimer, Uhlenbeck, Sakharov, and non-scientists such as Chaim Weizmann, George Kennan, Erwin Panofsky, Pablo Casals, Theodore Reik, Lillian Hellman, and many others. He is a marvelous raconteur. The book teems with anecdotes and stories of the great men and women he encountered, wonderful stories that often capture the personalities of these historic figures in a single paragraph. For the scores of thumbnail portraits alone the book is worth the price.

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Vignettes: Fateful Metal

Copper was indeed queen of the Nile until about 3000 B.C., when some no goodnick in Iran added a pinch of a white metal called tin to the liquid copper. . . . Faster than priority mail, copper had a partner and the Bronze Age was upon us.
—*Ron L. Morton*, in *Music of the Earth: Volcanoes, Earthquakes, and Other Geological Wonders* (Plenum)

It might be thought that the politico-economic-social structure of Europe in the early 19th century was determined by the military alignments in Europe of the period. This is another misapprehension. It was, perhaps surprisingly, determined by the allotropy of tin. This shiny familiar metal turns below 13°C into a yellow powder. . . . The buttons on the uniforms of the soldiers of Napoleon's armies were largely composed of tin and in the long drawn out campaign against the Russians, the buttons turned to powder and fell off the soldiers' uniforms. This made them more concerned with wrapping their uniforms round them in the hostile climate than pointing their rifles at the Russians. The retreat from Moscow . . . was the result.
—*Charles J. M. Stirling*, in *The Future of Science Has Begun: The Communication of Science to the Public, Science and The Media* (Fondazione Carlo Erba)

Evolution Step by Step

Selection. The Mechanism of Evolution. GRAHAM BELL. Chapman and Hall, New York, 1996. xxvi, 699 pp., illus. $75 or £55. ISBN 0-412-05521-x.

The Basics of Selection. GRAHAM BELL. Chapman and Hall, New York, 1996. xxii, 378 pp., illus. Paper, $37.50 or £24.99. ISBN 0-412-05531-7. Briefer edition of *Selection: The Mechanism of Evolution.*

The goal of evolutionary biology is to explain the complex and intricate organization of living things, and this is done by identifying mechanisms that cause evolution and by demonstrating their consequences. Bell's two books are about the main mechanism, natural selection. Mechanisms such as genetic drift can cause heritable changes in populations and species (one definition of evolution), and mechanisms such as mutation and migration can hinder evolution, but only selection can cause evolution of complex structures. *Selection: The Mechanism of Evolution* is a detailed and erudite monograph on the topic, and *Basics of Selection* is a summary of the major points found in *Selection*. The focus of the books is on how selection can work and its consequences, rather than on adaptation or how selection has worked.

Bell begins with an outstanding introduction to the process of natural selection. He proposes 10 principles: (i) Heritable variation in replication rate causes evolution. (ii) Heritable variation arises as random alterations of genes; it does not in itself direct the course of evolution. (iii) Replication rate is the only attribute that is selected directly. (iv) Characters that cause changes in replication rate will be selected indirectly and may evolve as a consequence. (v) Adaptation caused by selection in given conditions is likely to be associated with loss of adaptation in others. (vi) Selection proceeds by sequential substitution of superior variants, not exclusively by sorting pre-existing variation. (vii) A given character state can evolve from a prior state only if the two states are connected by a continuous series of modifications, each being advantageous. (viii) Selection causes the modification of prior states of organization but cannot abruptly give rise to wholly novel states; its course is contingent on the fortuitous occurrence of particular variants. (ix) Selection tends to improve performance in given conditions but does not necessarily optimize performance; improvements will vary geographically. (x) Because selection is caused by differences in replication rates, its outcome will often depend upon the kinds of competitors present, not just physical conditions of growth. These processes will be modulated by developmental, physiological, genetic, and ecological circumstances in which they operate. The rest of the books discuss these principles and their consequences.

Bell makes frequent use of selection experiments, mostly from the rich microbial evolution literature, which might otherwise be unknown to more ecologically oriented readers, and they successfully illustrate and test the validity of the broad general principles.

Bell distinguishes between selection and sorting. Sorting is the population geneticist's version of selection, in which some existing alleles spread at the expense of others, and does not include the origin of new variants. Selection includes the origin of new alleles, with consequences having to do with chance, contingency, and cumulation. (Some would quibble that what Bell means by selection is in fact evolution by natural selection.) Sorting takes place on shorter time scales and is predictable, whereas cumulation of mutations takes place on longer time scales and is affected by chance and contingency. Sorting is well understood, but there has been confusion about the influence of chance, contingency, and cumulation.

One usually thinks of chance affecting selection only as the variance around the mean trajectory expected from standard population genetics theory. However, this applies only to sorting. The result of long-term selection has three phases, as shown by most artificial selection experiments: sorting of variation expressed in base population, that is, selection of existing genes and blocks of linked genes; sorting of the variation that is newly expressed every generation as a result of recombination; and sorting of newly arisen variants (mutants). Population size will affect the timing of the phases, and the latter two Bell calls cumulation. Not much is known about the second phase and even less is known about the third. Cumulation may not occur if the selective environment