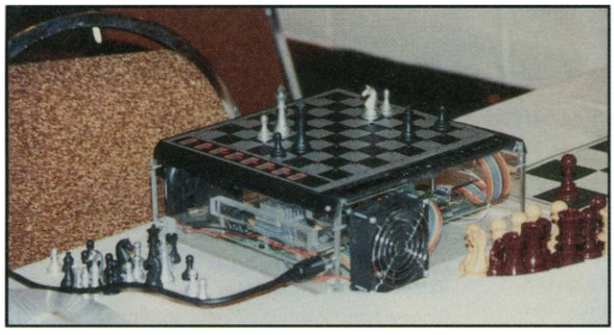
BOOK REVIEWS

AI as Sport

Kasparov versus Deep Blue. Computer Chess Comes of Age. MONTY NEWBORN. Springer-Verlag, New York, 1996. xiv, 322 pp., illus. $29.95 or DM 49.90. ISBN 0-387-94820-1.

Last month's victory of the IBM computer Deep Blue over world chess champion Garry Kasparov culminates a 22-year engineering effort. It was also a major sporting event.

Monty Newborn, who has been an active organizer of computer chess tournaments and helped arrange the Kasparov-Deep Blue matches, here recounts the 50 years of computer chess that led to the preceding, 1996, match, won by Kasparov.



"Fidelity's Experimental Chess Challenger, 1979." [From *Kasparov versus Deep Blue*]

Ideas about chess algorithms as well as advances in computer hardware were involved. However, it is a measure of our limited understanding of the principles of artificial intelligence (AI) that this level of play requires many millions of times as much computing as a human chess player does. Moreover, the fixation of most computer chess work on success in tournament play has come at scientific cost.

In 1965 the Russian mathematician Alexander Kronrod said, "Chess is the *Drosophila* of artificial intelligence." However, computer chess has developed as genetics might have if the geneticists had concentrated their efforts starting in 1910 on breeding racing *Drosophila*. We would have some science, but mainly we would have very fast fruit flies.

I mention three features of human chess play that are required by computer programs when they face harder problems than chess. Two of them were used by early chess programs but were abandoned in substituting computer power for thought.

1) Human chess players cannot examine all moves at every position they think about and therefore must *forward prune* the move tree and select the more promising moves for exploration; early chess programs also pruned. About 1969 forward pruning was eliminated, and computer power was relied upon to examine all moves. It made the programs work better, because early programs sometimes pruned good moves. Eliminating pruning was possible, because there are only about 40 moves in a position. In the game of Go, there are up to 361 moves in a position, so even computers must forward prune.

2) An early Soviet program could consider certain moves as analogous to moves that had been found to be bad in a parallel position. It would prune them unless something was observed that would rehabilitate them. This also was abandoned. Present programs spend most of their time rejecting the same moves millions of times apiece.

3) Human chess players often partition a position into subpositions, for example the king's side and queen's side. We analyze the subpositions somewhat separately and then consider their interaction. Present chess programs only consider the position as a whole, and computer power makes up for the inefficiency. Computer Go programs are weak, because partitioning is absolutely necessary for Go. We yet don't know how to make computers partition effectively. Imagine playing wide chess on an 8-by-32 board. Humans would play almost as well as on the normal board by using partitioning, but programs based on present principles would be unable to search deeply.

"Kathe and Dan Spracklen facing each other across the board, creators of Chess Challenger and Sargon, in Detroit, 1979." [From *Kasparov versus Deep Blue*]

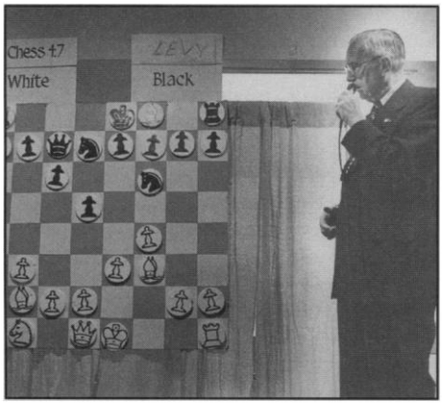
Much would have been learned had these important intellectual mechanisms not been rejected for tournament chess programs.

Newborn developed chess programs named Ostrich between the 1960s and 1982, especially versions running on parallel processors. His book is an accurate history of tournament-oriented computer chess and explains many of the ideas present in today's programs. Like other chess books, it includes the scores of many of the important games. However, his conventional chess commentary takes almost no advantage of the possibilities computers offer to determine which lines of play were actually examined and how much time was spent on them.

Now that computers have reached world-champion level, it is time for chess to become a *Drosophila* again. Champion-level play is possible with enormously less computation than Deep Blue and its recent competitors use. Tournaments should admit programs only with severe limits on computation. This would concentrate attention on scientific advances. Perhaps a personal computer manufacturer would sponsor a tournament with one second allowed per move on a machine of a single design. Tournaments in which players use computers to check out lines of play would be man-machine collaboration rather than just competition.

Besides AI work aimed at tournament play, particular aspects of the game have illuminated the intellectual mechanisms involved. Barbara Liskov demonstrated that what chess books teach about how to win certain endgames is not a program but a predicate comparing two positions to see if one is an improvement on the other. Such qualitative comparisons are an important feature of human intelligence and are needed for AI. Donald Michie, Ivan Bratko, Alen Shapiro, David Wilkins, and others have also used chess as a *Drosophila* to study intelligence. Newborn ignores this work, because it is not oriented to tournament play.

Research support agencies have trouble with the idea of chess as a *Drosophila*. When I explained to a DARPA program manager in the 70s how a student's pro-



"Max Euwe, former world champion, commentating on the Chess 4.7 and David Slate versus David Levy one-game match in Detroit in 1979." [From *Kasparov versus Deep Blue*]

gram that discovered mating combinations contributed to recognition of complex patterns in general, he replied, "Well all right, but when he publishes his dissertation, would he kindly not acknowledge our support."

An extended commentary on making computer chess more scientific will be available at http://www-formal.stanford.edu/jmc/chess.html.

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Crystals That Came in from the Cold

Physics of Cryocrystals. VADIM G. MANZHELII and YURI A. FREIMAN, Eds. English-language version edited by Michael L. Klein and Alexei A. Maradudin. AIP Press, Woodbury, NY, 1996. xx, 691 pp., illus. $135 or £99. ISBN 1-56396-537-2.

Ninety-nine years ago Sir James Dewar cooled hydrogen to record low temperatures and so turned the lightest and most tenuous of gases into a liquid and then, the following year, into a crystalline solid. Though not recognized at the time, a novel state of matter was created, later to be called the quantum crystal. The study of such solidified gases has been a testing ground for fundamental theory, contributing in a major way to the development of modern condensed-matter physics and chemistry. The reason is simple: though modern physics dictates that quantum mechanics must prevail for both the electrons and the atomic nuclei, the classical viewpoint for treating the latter makes the problem of describing fundamental properties of matter both mathematically tractable and physically accessible. However, crystals composed of very light elements push this approximation to its limits—indeed, cause it to break down. Here, the molecular meets the many-body, the classical meets the quantum mechanical, creating new physical phenomena and fueling a creative tension for theory.

Physics of Cryocrystals is a review of the state of knowledge, both theoretical and experimental, of these unique materials. The treatment is limited to the solids formed from the linear molecules such as H_2, N_2, O_2, CO, and CO_2, but this class of materials is both the most important and the best understood. The editors, V. G. Manzhelii and Y. A. Freiman, have written large sections of the book, together with various members of the Verkin Institute of Low-Temperature Physics in Kharkov. This institute has remained one of the leaders in this field for decades, despite the hardships of both the Soviet and the post-Soviet eras. The book derives from a volume published in 1983 in Russian from the institute. It is also a welcome successor and companion to J. van Kranendonk's elegant treatise *Solid Hydrogen*, as well as to the earlier (but still impressively current) *Rare Gas Solids*, edited by M. L. Klein and J. Venables.

One of the pleasures of reading *Physics of Cryocrystals* is the historical perspective it provides. The successive discoveries of such phenomena as free molecular rotation and rotational melting, anharmonic lattice dynamics, crystal plasticity and orientational ordering, and quantum diffusion—together with the efforts to understand these phenomena theoretically—delineate the development of both low-temperature and solid-state physics.

The book contains 20 chapters in two groups, the first devoted to the quantum solid, H_2, and the second to its classical counterparts, the so-called N_2-type crystals. The study of both types flourishes, with continuing discoveries of new physics, especially as a result of the application of the combined variables of temperature and pressure. The extensive compilation of current experimental data makes the book an essential reference for researchers and engineers. The theoretical sections capture the essential physics of the field in an accessible manner that offers useful material for graduate students as well as specialists.

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Books Received

Black Holes. Gravitational Interactions. P. D. D'Eath. Clarendon (Oxford University Press), New York, 1996. xii, 286 pp., illus. $80. ISBN 0-19-851479-4. Oxford Mathematical Monographs.

Boron. Mineralogy, Petrology and Geochemistry. E. S. Grew and L. M. Anovitz, Eds. Mineralogical Society of America, Washington, DC, 1996. xx, 862 pp., illus. Paper, $32; to MSA members, $24. ISBN 0-939950-41-3. Reviews in Mineralogy, vol. 33.

Comet Hale-Bopp. Find and Enjoy the Great Comet. Robert Burnham. Cambridge University Press, New York, 1997. iv, 60 pp., illus. Paper, $12.95. ISBN 0-521-58636-4.

Communicable Disease Epidemiology and Control. Roger Webber. CAB International, Oxford, UK, 1996. xiv, 352 pp., illus. Paper, $35. ISBN 0-85199-138-6.

Constitutions of Matter. Mathematically Modeling the Most Everyday of Physical Phenomena. Martin H. Krieger. University of Chicago Press, Chicago, 1997. xxii, 343 pp., illus. $65 or £51.95. ISBN 0-226-45304-9.

Developmental Biology. Werner A. Müller. Springer-Verlag, New York, 1996. x, 382 pp., illus. $39.95. ISBN 0-387-94718-3. Translation of the German edition (1995).

A Guide to Fossils. Helmut Mayr. Princeton University Press, Princeton, NJ, 1997. 256 pp., illus. Paper, $18.95. ISBN 0-691-02922-9. Translated from the German edition (Munich, 1985) by D. Dineley and G. Windsor.

An Introduction to the Biology of Vision. James T. McIlwain. Cambridge University Press, New York, 1996. x, 222 pp., illus. $60.95, ISBN 0-521-49548-2; paper, $24.95, ISBN 0-521-49890-2.

Introduction to the Theory of Ferromagnetism. Amikam Aharoni. Clarendon (Oxford University Press), New York, 1996. xii, 315 pp., illus. $70. ISBN 0-19-851791-2. International Series of Monographs on Physics, 93.

Molecular Basis of NK Cell Recognition and Function. L. Moretta, Ed. Karger, Farmington, CT, 1996. xii, 184 pp., illus. $86.25 or CHF 99 or DEM 119. ISBN 3-8055-6332-9. Chemical Immunology, vol. 64.

Nanotechnology. Integrated Processing Systems for Ultra-precision and Ultra-fine Products. Norio Taniguchi, Ed. Oxford University Press, New York, 1996. xvi, 406 pp., illus. $165. ISBN 0-19-856283-7.

Protein Targeting. Stella Hurtley, Ed. IRL (Oxford University Press), New York, 1996. xx, 214 pp., illus. $110. ISBN 0-19-963562-5. Frontiers in Molecular Biology, 16.

Quantum Field Theory and Critical Phenomena. Jean Zinn-Justin. 3rd ed. Oxford University Press, New York, 1996. xxii, 1008 pp. $90. ISBN 0-19-851882-x. International Series of Monographs on Physics, 92.

Restless Genius. Robert Hooke and His Earthly Thoughts. Ellen Tan Drake. Oxford University Press, New York, 1996. xiv, 386 pp., illus. $55. ISBN 0-19-506695-2.

Schrödinger's Philosophy of Quantum Mechanics. Michel Bitbol. Kluwer, Norwell, MA, 1996. xii, 285 pp. $117 or £52 or Dfl. 180. ISBN 0-7923-4266-6. Boston Studies in the Philosophy of Science, vol. 188.

Tropical Deforestation. The Human Dimension. Leslie E. Sponsel, Thomas N. Headland, and Robert C. Bailey, Eds. Columbia University Press, New York, 1996. xxx, 365 pp., illus. $49.50, ISBN 0-231-08480-3; paper, $19.50, ISBN 0-231-08481-1. Methods and Cases in Conservation Science.

Venomous Snakes. Ecology, Evolution and Snakebite. R. S. Thorpe, W. Wüster, and Anita Malhotra, Eds. Published for the Zoological Society of London by Clarendon (Oxford University Press), New York, 1996. xx, 276 pp., illus. $145. ISBN 0-19-854986-5. Symposia of the Zoological Society of London, no. 70. Based on a symposium, London, April 1995.

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Correction

The title of a recent book by Walter Alvarez was garbled in the Browsings section in the issue of 23 May (p. 1210). The title of the book as it should have appeared is ***T. rex* and the Crater of Doom**.