

as an "awkward" and "provisional" hypothesis—definitely not a candidate for reality (*The Scientific Papers of James Clerk Maxwell, Vol. 1*, Dover, New York, pp. 467–68, 486). Tolstoy, unfortunately, glosses over these fine distinctions that Maxwell was so careful to make. On the basis of his own 20th-century perspective, Tolstoy takes a dim view of the whole model—regarding both vortices and idle heels as "bizarre" and "outlandish" (pp. 78, 124)—and would have us believe that Maxwell felt similarly. Thus Tolstoy quotes at length Maxwell's comments on the "provisional" and "awkward" nature of the idle-wheel particles (page 122), while entirely leaving out Maxwell's characterization of the molecular vortices as a "probable" hypothesis. Other passages indicating Maxwell's substantial commitment to the reality of the molecular vortices are similarly left out. Tolstoy, then, presents us not with the real Maxwell, who was a 19th-century mechanist, but with an imagined Maxwell, who is in fact a 20th-century physicist transported into the 19th century. This may serve didactic purposes, but it is not good history. *Caveat lector.*

Goldman's is a bigger book, and he is able to pass on more of the biographical information from Campbell and Garnett; he does this well on the whole. Goldman is also able to do more in the way of supplementing and interpreting this material, but this is not entirely a blessing, for the additional background material is often not well integrated into the narrative, and comes across as digression. The presentation is also marred by Goldman's raconteur style and penchant for editorializing. This inserts the narrator between his subject and his audience in a manner that ultimately becomes obtrusive. Goldman is able to treat Maxwell's scientific work in greater depth than Tolstoy, and it is clear that Goldman has read much of Maxwell's *oeuvre* with care and understanding. He presents the material clearly, and his commentary is often penetrating and insightful. As concerns the molecular-vortex model of the electromagnetic field, Goldman understands well the subtle mixture of commitment and doubt that characterized Maxwell's stance concerning the reality of the model. Goldman's discussion of the physical details of the model, and its importance in the background of the displacement current and the electromagnetic theory of light, is on the whole sensitive and nuanced. Always the raconteur, however, Goldman cannot resist twitting Maxwell for "fill[ing] the whole of space with a Meccano set of wheels, axles and cogs" (page 153): This is a gross exaggeration at Maxwell's expense. Beyond this, for a work with serious historical intentions,

Goldman's book makes all too little use of existing scholarship on Maxwell and 19th-century physics. The result is that he makes errors from which the literature could have saved him, and he is able to establish only a thin historical thread rather than the rich tapestry characteristic of the best historical writing.

These two recent biographies both have their virtues and should be read. For a completely reliable modern overview of Maxwell's life and work, however, one still cannot do better than C. W. F. Everitt's *James Clerk Maxwell: Physicist and Natural Philosopher* (Scribners, New York, 1975).

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## Solid Clues: Quantum Physics, Molecular Biology, and the Future of Science

Gerald Feinberg

287 pp. Simon and Schuster, New York, 1985. \$17.95

Prophecy can be a hazardous business, even if confined to current technological trends or to the rise of new technology out of established science. How much more risky, then, is forecasting the future of science itself? Not enough, apparently, to daunt Gerald Feinberg.

His book takes a broad view of "fundamental" science, from particle physics and cosmology to biology. Feinberg opens with a brief summary of the "state of the art" in each area. He then presents his choices for the most promising, open questions, and reviews some of the approaches to answering them. From this base, he sketches a scenario for science in the 21st century. Along the way, he speculates about the surprising utility of mathematics in the real world.

Feinberg is rarely so sanguine as to pinpoint the specific achievements of any future science. He concentrates instead on the problems scientists will be likely to attack, the tools and methods they will employ and the "sociology" of the community and institutions in which they will work.

Though this book is clearly written with the general reader in mind, it is likely to find its most appreciative audience among "insiders" to the scientific enterprise. Feinberg does not neglect the impact of science on the lives of our children's children, but he has far more to say about the professional lives of our students' students.

Furthermore, there are sections that would challenge anyone who has not followed the topics under discussion at a level, for example, of *Scientific American*. Kaluza-Klein theories and the inflationary universe are not every-

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one's cup of tea. Feinberg seems to have decided that it is better to slide by such topics with cryptic references than to neglect them entirely.

These are minor flaws in an otherwise admirably lucid work. Feinberg's introductions to each subject area are models of clarity and brevity, and may be recommended to anyone who wants a quick overview of an unfamiliar field.

His choices for the most interesting unsolved problems are hard to fault. In his own field of particle theory, he stresses the vistas opened by its cosmological implications. In biology, he senses that molecular biology is (or soon will be) "complete," in the way that nonrelativistic quantum theory was complete by 1930. Studies of the origins of life, or of developmental biology, promise more in the way of fundamental advances, at least in the long run.

Feinberg endorses the optimistic view that once a problem is clearly formulated, its solution must surely be near at hand. Here history holds up a distorting mirror; when the solution is not immediately forthcoming, the formulation may be soon forgotten. The "standard model" of particle physics solves a problem that was clearly formulated by 1935. Its underlying premise, that matter is an artifact of point-like centers of force, was clearly formulated by Rudjer Bosovich in the 18th century.

Theory without experiment has too many options. The prospects for empirical help with quantum gravity, for example, look slim at present. Gravity-wave and neutrino astronomies, as Feinberg sees, need only patience and money to become realities. But each could well find wonders in the cosmos without shedding light on fundamental questions.

Any knowledgeable reader is bound to find in this volume much to agree with, a few things to disagree with, and some tidbits of food for thought.

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### Quantum Mechanical Tunnelling in Biological Systems

Don DeVault

207 pp. Cambridge Univ. Press, New York, 1984. \$44.50

DeVault's book is intended to acquaint graduate students and interested senior scientists with developments in the last 20 years concerning quantum-mechanical tunneling in biological systems. Although the book stresses electron tunneling, there is also some mention made of molecular tunneling. Don DeVault earned his PhD at Berkeley under Willard Libby and performed

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