BOOK REVIEWS

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Post-Use Review. Biological Physics: Energy, Information, Life. Philip Nelson. 598 pp. W. H. Freeman & Co., New York, 2004. Price: $60.00 ISBN 0-7167-4372-8. (Stephen J. Hagen, Reviewer.)

What exactly is biological physics? Just about everybody knows that it is an important and growing area of research. It plays a larger and larger role at the major meetings, in the high-profile journals, and at the funding agencies. Many physics departments are eager to hire new faculty in this area. But as a biological physicist myself, I still get the sense that many of my colleagues in more traditional areas of physics are unsure exactly what the field involves. Does it involve deoxyribonucleic acid (DNA)? Gels? National Institutes of Health funding? It sounds like biology. And if so, what is this biophysics stuff doing in the physics department?

There is even uncertainty over the name. Many practitioners insist on drawing a distinction between ''biophysics'' and ''biological physics.'' They may argue that biophysics is the use of a physical tool (fluorescence, nuclear magnetic resonance, electron microscopy, etc.) to investigate an explicitly biological problem. Then, biological physics is roughly the reverse: The use of a biological system to justify the study of an interesting physics problem.

Whether or not you accept this distinction, it is quite clear that biological physics must have a vast scope. Like biology itself, it spans the full range that starts at the molecular level (DNA, proteins, membranes) and continues up to the level of the cell, its structures and operations, assemblies of cells (including the brain and the whole organism), and finally includes whole communities of organisms. It is not easy to identify a set of unifying themes, especially if (for example) one wishes to teach a credible introductory course in the subject. It has certainly been quite difficult to find a suitable textbook for such a course.

This is why Philip Nelson has done such an important service in writing *Biological Physics: Energy, Information, Life*. This creative and insightful textbook brings definition to the field and establishes a set of central themes, based on principles of statistical physics. Starting with very simple and general discussions of energy and order, Nelson builds up a rigorous set of statistical and thermodynamic models for understanding the molecular machinery of life. Always maintaining a solid physics perspective, he explores biological macromolecules, their structures and self-assembly, biomotors and locomotion, neurons, and more. The book is not a substitute for *Biology 101*, but it is a fascinating tour that will bring the reader within reach of many current research topics.

Nelson introduces the main themes—energy, order, entropy, and dissipation—in the first chapter, with an introduction to the big question that is implicit in the title: How does the flow of energy allow living organisms to acquire order? Chapter 2 takes the reader on a rather brisk tour of cell biology, mostly to explain key structures and terminology and to review the important biological molecules. This is the only purely, unapologetically, biological chapter. The following five chapters return to the physics; they develop the ideas of probability, random walks, diffusion, friction, dissipation, temperature, free energy, and entropic forces. Much of this physics will be familiar to the student, but its biological applications and significance, which are discussed in depth, will be surprising and rewarding. The remaining five chapters focus on self-assembly of biomolecules, cooperativity and folding transitions, enzymes, biomolecular motors, membrane pumps, and nerve impulses.

It is a lot of material, but very carefully presented. Nelson begins each chapter with a fairly qualitative discussion of key focus questions. He then starts to build quantitative physical models, which become more detailed and sophisticated as the chapter progresses and additional chemical and biological detail is introduced. Through comparison to real experimental data, the predictive power of the physics and the models comes into focus.

The book is really a pleasure to read. Nelson consistently maintains a conversational style, and avoids falling into dry recitation of facts or derivations. In fact, many of the derivations require reader participation: Often the key result does not appear in the text, but rather is obtained by the reader who completes the ''Your Turn'' exercises that are sprinkled throughout the text. Every chapter is leavened with simple examples, historical notes, applications to familiar situations (e.g., the physics of omelettes), and excursions into current research topics or practical advice on the scientific approach. These practical messages (e.g., using dimensional analysis, the character of physical laws, how to fit models to data, etc.) comprise a secondary theme of the book. They will be appreciated by students and instructors alike.

The book grew out of an undergraduate course taught by Nelson at the University of Pennsylvania. It is therefore aimed toward a diverse mix of intellectually curious undergraduates, which may include engineering, chemistry, and biochemistry majors and a few graduate students in addition to the physics majors. Thus, Nelson's only formal prerequisites are first-year calculus and calculus-based physics, plus ''a distant memory of high school chemistry and biology.'' (Each chapter also contains extra text and trickier homework under the heading ''Track 2,'' suitable for graduate students.)

However, although the text starts at the level of standard calculus-based introductory physics, it rises well above that level in some places. I have used this book in my own classroom, and my students had real difficulty following Nelson's math. For example, Nelson gives a very good discussion of biomolecular cooperativity and the helix-coil transition (Chapter 9), but by introducing eigenvalue methods he raises the mathematical level far above what appears in other familiar and widely used senior/graduate physical biochemistry texts. I suspect that many undergraduates will find it to be a pretty steep hike. For this reason, I am amazed that Nelson is able to cover most of the book's twelve chapters in one semester.

The students in my class also had trouble with the homework problems, not so much because of math but because the

subject itself can seem quite diffuse: How can one pose a biological problem in enough detail as to suggest a soluble physical model, yet not so much detail as to give away the solution? I look forward to seeing the additional problems that Nelson is presently developing. The publisher offers an instructor's compact disk with homework solutions, suggested demonstrations, and related goodies.

These days physical scientists need to understand more biology, just as biological scientists need to understand more physics. Nelson's engaging and satisfying book opens the doors in both directions. It will intrigue both the student and the professor.

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BOOKS RECEIVED

Atmospheric Circulation Dynamics and General Circulation Models. Masaki Satoh. 643 pp. Springer, New York, 2004. Price: $179.00 ISBN 3-540-42638-8.

The Chemistry of Explosives (second edition). J. Akhavan. 180 pp. Royal Society of Chemistry, Cambridge, 2004. Price: $69.95 (paper) ISBN 0-85404-640-2.

China's Space Program: From Conception to Manned Spaceflight. Brian Harvey. 349 pp. Springer, New York, 2004. Price: $34.95 (paper) ISBN 1-85233-566-1.

The Early Universe and Observational Cosmology. Edited by N. Bretón *et al.* 468 pp. Springer, New York, 2004. Price: $79.95 ISBN 3-540-21847-5.

The Essential Exponential! For the Future of Our Planet. Albert A. Bartlett *et al.* 291 pp. University of Nebraska, Lincoln, NE, 2004. Price: $25.00 (paper) ISBN 0-9758973-0-6.

A First Course in String Theory. Barton Zwiebach. 558 pp. Cambridge U. P., New York, 2004. Price: $60.00 ISBN 0-521-83143-1.

General Relativity: With Applications to Astrophysics. N. Straumann. 674 pp. Springer, New York, 2004. Price: $79.95 ISBN 3-540-21924-2.

An Introduction to Galaxies and Cosmology. Edited by Mark H. Jones and Robert J. A. Lambourne. 442 pp. Cambridge U. P., New York, 2003. Price: $110.00 (cloth) ISBN 0-521-83738-3; $65.00 (paper) ISBN 0-521-54623-0.

Introduction to the Physics of Gyrotrons. Gregory S. Nusinovich. 335 pp. Johns Hopkins U. P., Baltimore, 2004. Price: $89.50 ISBN 0-8018-7921-3.

Introduction to Quantum Optics: From Light Quanta to Quantum Teleportation. Harry Paul. 241 pp. Cambridge U. P., New York, 2004. Price: $65.00 ISBN 0-521-83563-1.

Ion Exchange Membranes: Preparation, Characterization, Modification and Application. Toshikatsu Sata. 314 pp. Royal Society of Chemistry, Cambridge, 2004. Price: $279.00 ISBN 0-85404-590-2.

Knowledge and the World: Challenges Beyond the Science Wars. Edited by M. Carrier *et al.* 327 pp. Springer, New York, 2004. Price: $79.95 ISBN 3-540-21009-1.

Microoptics: From Technology to Applications. Jürgen Jahns and Karl Heinz-Brenner. 319 pp. Springer, New York, 2004. Price: $129.00 ISBN 0-387-20980-8.

Photodynamic Therapy. Edited by T. Patrice. 284 pp. Royal Society of Chemistry, Cambridge, 2003. Price: $389.00 ISBN 0-85404-306-3.

Photoreceptors and Light Signalling. Edited by Alfred Batschauer. 388 pp. Royal Society of Chemistry, Cambridge, 2003. Price: $398.00 ISBN 0-85404-311-X.

Predictive Simulation of Semiconductor Processing: Status and Challenges. Edited by J. Dabrowski and E. R. Weber. 490 pp. Springer, New York, 2004. Price: $179.00 ISBN 3-540-20481-4.

QCD as a Theory of Hadrons: From Partons to Confinement. Stephan Narison. 779 pp. Cambridge U. P., New York, 2004. Price: $150.00 ISBN 0-521-81164-3.

Reflecting Telescope Optics I (second edition). R. N. Wilson. 569 pp. Springer, New York, 2004. Price: $89.95 ISBN 3-540-40106-7.

Science from Fisher Information: A Unification (paperback edition). B. Roy Frieden. 490 pp. Cambridge U. P., New York, 2004. Price: $65.00 ISBN 0-521-00911-1.

The Search for Other Worlds. Edited by Stephen S. Holt and Drake Deming. 331 pp. American Institute of Physics, Melville, NY, 2004. Price: $125.00 ISBN 0-7354-0190-X.

Speakable and Unspeakable in Quantum Mechanics: Collected Papers in Quantum Philosophy (second edition). J. S. Bell. 248 pp. Cambridge U. P., New York, 2004. Price: $75.00 (cloth) ISBN 0-521-81862-1; $35.00 (paper) ISBN 0-521-52338-9.

Stochastic Numerics for Mathematical Physics. Grigori N. Milstein and Michael V. Tretyakov. 594 pp. Springer, New York, 2004. Price: $119.00 ISBN 3-540-21110-1.

Topological Solitons. Nicholas Manton and Paul Sutcliffe. 493 pp. Cambridge U. P., New York, 2004. Price: $115.00 ISBN 0-521-83836-3.

Topology, Geometry and Quantum Field Theory. Edited by Ulrike Tillmann. 577 pp. Cambridge U. P., New York, 2003. Price: $90.00 (paper) ISBN 0-521-54049-6.

Wafer Bonding: Applications and Technology. Edited by M. Alexe and U. Gösele. 499 pp. Springer, New York, 2004. Price: $179.00 ISBN 3-540-21049-0.