

Mathematics of Genome Analysis

Jerome K. Percus
Cambridge U. Press, New York,
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The sequencing of the human genome alerted researchers to the importance of sequence data for modern molecular biology. Acquiring and interpreting that data requires powerful quantitative methods, and the rapidly growing field of computational biology develops such methods. Computational biology draws heavily on several disciplines (such as computer science, mathematics, statistics, and statistical physics), and in turn stimulates new research in those areas by posing new kinds of problems.

Mathematicians have led the way in computational biology. Many of their contributions are summarized in the textbook, *Introduction to Computational Biology: Maps, Sequences, and Genomes* (Chapman and Hall, 1995) by Michael S. Waterman, a leader in the field. Waterman's book introduces many of the fundamental techniques of computational biology and focuses on real-world applica-

tions while maintaining mathematical rigor.

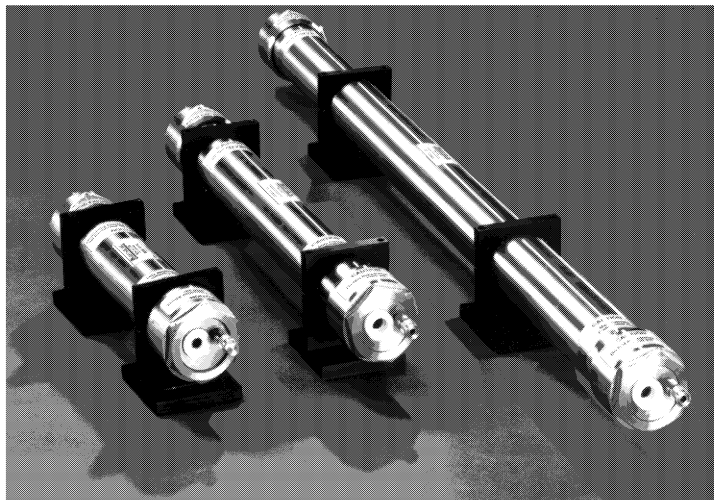
In *Mathematics of Genome Analysis* (in the Cambridge Studies of Mathematical Biology series) Jerome K. Percus takes a very different approach. As the book's title suggests, Percus's focus is mathematics rather than biological or computational application. His theme is the DNA molecule and its sequence, and indeed the book discusses many aspects of DNA, including sequencing and statistical properties of genomes, comparison of DNA sequences, and such physical properties of the DNA molecule as its melting behavior. Percus uses such practical questions about DNA and its sequence to showcase a variety of mathematical problems triggered by the biological questions, and to offer techniques for solving them. Many of those techniques—including stochastic processes described by the Fokker-Planck equation, correlation functions, power spectra, transfer matrices, and the WKB approximation—are rooted in physics. Others involve more mathematics, reflecting the breadth of Percus's own research.

The book, based on a mathematics course that Percus taught at New York University, features a variety of assignments that exemplify the tech-

niques and can be used for problem sets. Its moderate length is well suited for a textbook of a one-semester course, and its witty language makes it easy for the mathematically inclined reader to join the author in his obvious excitement. However, the dense technical detail and mathematical symbols demand very careful reading and at times obscure the bigger picture. One should definitely work through the text—it is not bed-time reading.

Because of the book's focus on mathematics, I would not recommend it as a source to learn biology. Although the book gives biological background, it does so only to the extent needed to understand the mathematical problems. That limitation often leaves the reader with wrong impressions. One example is the chapter on determining DNA sequences. That chapter elaborates the statistics needed to sequence a randomly generated genome, but fails to mention that the main challenge in determining real-life genomes is the repetition of subsequences that are far longer than would be expected at random. Another example is the chapter on sequence comparison. By artificially restricting himself to DNA sequences, the author implies that they are the

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topic's main application. However, most real applications compare sequences of protein rather than of DNA. Reducing the important protein case to a side remark is especially puzzling, since it can be treated in the same way as the comparison of DNA sequences.

The biggest downside of the book is its references. The author admits the reference list is "very incomplete" and I can confirm that at least for my own area of expertise. Such a subjective choice of references may be adequate in a book written for experts, but for a textbook, I would prefer a bit more diligence. Another reference-related problem is that it is sometimes difficult to tell which parts of the book present other people's results and which are the author's own ideas.

In summary, despite its shortcomings in biology, *Mathematics of Genome Analysis* is a suitable textbook for a mathematics course aimed at raising awareness of the challenges that are posed by computational biology. It is also good first reading for mathematics students and professionals who want to get an idea of the exciting mathematical problems in the analysis of biological sequences.

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Encyclopedia of Chemical Physics and Physical Chemistry

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Volume 1: Fundamentals

Volume 2: Methods

Volume 3: Applications

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Because we live in a world of molecules and materials, the *Encyclopedia of Chemical Physics and Physical Chemistry* provides a know-how guide to the way this world works—like a homeowners' manual of home construction and repairs. This three-volume encyclopedia is a comprehensive survey of the present state of knowledge and the research frontier in nearly every area of chemical physics and physical chemistry. Written by current experts, the 95 stand-alone articles appear in three volumes: Fundamentals (microscopics, thermodynamics, statistical mechanics, and dynamical processes); Methods (determining materials and molecular

properties, dynamic measurements, techniques for applying theory); and Applications (microscopic systems, extended and macroscopic systems, chemical kinetics and dynamics). Article titles are available at www.ecppc.iop.org.

Unlike many technical encyclopedias, this one seeks accessibility to readers with a minimum of specialized background. The goal has been to make each article enjoyable, informative, and concisely relevant to its named topic. These goals are well met, but tempered by the significant depth of coverage and by the stand-alone format. The articles do presume some education in chemistry or physics and should be useful to graduate students, advanced undergraduates, and research scientists who wish to delve into topical details. To confirm that hypothesis, I solicited the opinions of a postdoctoral research associate (Zhenhong Yu) and an undergraduate student of chemistry and physics (Patrick Medley).

Are there mistakes? Of course, but they are few. Are some nonstandard notations used? Of course. Such criticisms are trivial given the huge scope and depth of the work. From this bold project, the reader can learn the structure and catalytic function of zeolites or be educated in the group representation theory of the energy levels of nonrigid molecules. Topics such as coherent control of molecular dynamics, protein folding, single molecule spectroscopy, liquid crystal displays, and atom traps are well developed with current references. Classics such as quantum mechanics of atoms and molecules, classical thermodynamics, statistical mechanics of weakly interacting systems, and electronic spectroscopy are well written and somewhat more concise than will be found in standard texts. The articles relating to dynamics are current and not readily found in standard texts. Those on chemical kinetics and molecular dynamics may help physicists outside chemical physics and physical chemistry to gain greater appreciation for the broad importance of the articles' topics. Subtopics include simple gas-phase reactions, statistical theories, and reaction dynamics in solution and on surfaces. Broad applications are found in electrochemistry, corrosion, etching, and deposition. In its discussions, the *Encyclopedia* strikes an excellent balance between theory and applications.

Spectroscopy, imaging, and microscopy are presented at a level of current research activity. Several of the articles discuss nonlinear spectroscopies and laser methodologies. Others

mention terrestrial and astronomical applications. Magnetic resonance is treated at a level that should entice the reader into learning how protein structure is determined. Although nuclear magnetic resonance dominates the magnetic-resonance articles, electron paramagnetic resonance and chemically induced spin polarization are nicely illustrated. Biophysical chemistry is briefly but broadly treated through discussion of structural and kinetic determinations. Articles on current problems highlight such questions as modeling protein folding, using single-molecule spectroscopy to probe enzymatic reactions, and examining cooperativity in the binding of oxygen by hemoglobin.

Many of the articles provide literature references through 1999, including monographs. These references whet the reader's curiosity and guide further growth.

Very few of the appropriate topics seem to be missing from this encyclopedia. Most conspicuous is the lack of reference to computational software packages. The ease and accuracy of computation (when software is available) have greatly changed almost every subfield. References to these packages appear to be somewhat sporadic. On the other hand, the article by Jack Simons on applications of electron structure methods offers a particularly excellent guide to relevant computational packages.

An excellent index links the stand-alone articles in the *Encyclopedia*, but it would be even more helpful if the linkages could be enhanced through a Web-based version. In my opinion, future editions of this, as well as most future encyclopedias, will be Web-based. Perhaps the present version will be the last in hard copy.

The *Encyclopedia* is a most remarkable and successful enterprise, and makes very enjoyable reading. At a time when increasing specialization and fragmentation dominate every area of science, this inclusive compendium provides a most enjoyable breadth and cohesion to a beautiful and useful part of science. The editors have avoided artificial distinctions between basic and applied topics, and that approach helps each chapter to stand alone. Moreover, the work does not exclude topics traditionally associated with chemical engineering. It will serve as an excellent learning springboard for the intellectually curious. Just as active seminar programs can serve universities and research laboratories, the *Encyclopedia of Chemical Physics and Physical Chemistry* can broaden one's educa-