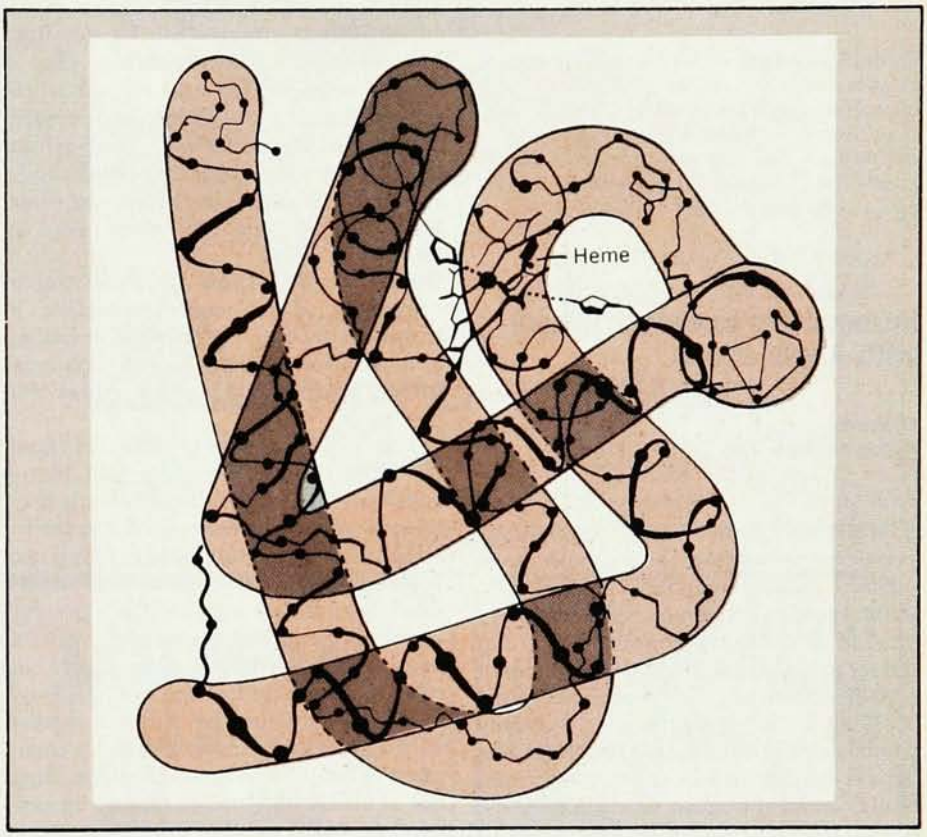
Improving communication between biologists and physicists

Molecular Biophysics

M. V. Volkenstein
621 pp. Academic, New York, 1977. $36.50

Reviewed by George I. Bell



Myoglobin structure, according to Max Perutz, contains helical and nonhelical regions as well as the prosthetic heme group. M. V. Volkenstein in his *Molecular Biophysics* (reviewed below) discusses the physical processes that determine the shape and oxygen-storing function of this protein.

Physicists have, for at least a decade, appreciated that molecular biology is a hot field in which exciting scientific discoveries are being regularly reported. Many have wondered whether there were problems in molecular biology that could be solved by their experimental or theoretical tools. Various efforts, including the devotion of two issues of the *Reviews of Modern Physics* in 1959 to a Biological Science Study Program and the organization of a Division of Biological Physics of The American Physical Society, have been made to improve the communication between molecular biologists and physicists. It has, however, remained difficult for physicists to get a feel for the applicability of their skills to real problems in molecular biology.

Molecular Biophysics, by the eminent Soviet theoretician Mikhail Volkenstein, will be useful to theoretically inclined physicists seeking to understand the field as well as a valuable resource to practicing biophysicists. Volkenstein brings an historical perspective to his subject, because for the past 40 years he has applied physical theory to problems in molecular biology. His publications include several books that have been translated into English, such as *Enzyme Physics* (Plenum, 1969), *Molecules and Life: An Introduction to Molecular Biology* (Plenum, 1970) and *Configurational Statistics of Polymeric Chains*.

The book under review concerns the molecular physics of biological processes and its main emphasis is on the physics of proteins and nucleic acids. These giant molecules are essentially linear flexible chains of elementary subunits, the amino acids and nucleotides respectively, that are capable of existing in an enormous number of different configurations. A central theme is the explanation of those features, including the interactions of subunits with each other and with water molecules and ions in the environment, that collectively determine the actual conformation and therefore function of these macromolecules. While it is not possible to predict conformations, much less functions, *ab initio*, Volkenstein shows that one can understand or at least rationalize much of what is observed using deductions from quantum mechanics, statistical mechanics and phenomenological models. Since rigorous solutions cannot be given to most of the important problems of macromolecular structure or function, good judgment is required in developing approximate models and in drawing conclusions from these models. To my taste, Volkenstein has done extremely well in the selection and interpretation of models and in pointing out unresolved issues.

Molecular Biophysics also includes a theoretical analysis of x-ray, optical and other methods for studying biomolecules and introductory chapters on the relationship between physics and biology and the facts of molecular biology. Especially in the introductory chapter, but also throughout the book, Volkenstein does not hesitate to take a position on controversial issues, such as the significance of non-equilibrium thermodynamics for biology. However he also includes references to opposing points of view.

Each chapter contains an extensive and valuable set of references. Few extend beyond 1972, which appears to be when most of the book was finished. Therefore the latest developments in molecular biology are not included, but this is less serious in a book emphasizing imperfect theory rather than experimental methods and data.

The publisher must be faulted for a sloppy production, including numerous

typos, missing symbols in equations and a notation for vectors that is virtually undetectable.

Molecular Biophysics might be used as a text, but only for sophisticated students. A mastery of elementary statistical mechanics and quantum mechanics would be required and a familiarity with biochemistry is needed in many sections. But the presentation is authoritative and unique and the book should be seriously considered by anyone concerned with theoretical and physical aspects of molecular biology.

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Introduction to Group Theory with Applications

G. Burns
Academic, New York, 1977. $18.50

Ever since the mid-1920's, when Eugene P. Wigner, John von Neumann and others begin to apply group-theory methods in physics, many people have realized that great beauty and great simplicity can emerge from the collaboration of group theory and physics. In many branches of physics the use of group theory can reveal unifying underlying principles that may be obscured in a welter of special results. This is the case in solid-state, atomic and molecular, and nuclear physics, to give a few examples. In other branches of physics, where "exact" calculations are not reliable owing to some lack of knowledge of the coupling constants or other aspects of the dynamics, "symmetry reigns" as the major tool. Despite this long and successful record of usefulness, there does exist, even now, among some physicists a certain discomfort with "the group pest." For some people the group-theoretic, or algebraic, approach to the analysis of physics problems requires overcoming a certain barrier or "activation energy" before one can conceptualize and solve problems using group-theory formalism.

In his *Introduction to Group Theory with Applications*, which is primarily directed toward an audience of condensed-matter scientists, Gerald Burns has attempted to provide assistance in overcoming this barrier. As he puts it, his "goal is to provide a 'feel' for the subject." I think he has succeeded rather well. At the outset I should emphasize that this is *not* a mathematical, formal or rigorous treatise. It is, however, of a genre of illustrative texts that serve an important pedagogical function—namely, to supplement the rigorous treatments and to give numerous examples (including pedestrian and very specific ones), and to motivate the reader to press on, by emphasizing the rewards for persistence.

In 13 chapters the book touches on many important aspects of group theory of interest to the atomic, molecular and solid-state scientist:

- as a mathematical tool—selected abstract definitions and properties of groups and their finite-dimensional (unitary) irreducible representations;
- as a means by which the physical eigenstates of systems can be classified into irreducible representation—that is species of molecular and crystal vibrations; atomic, molecular and crystal eigenstates including molecular-orbital and energy-band symmetry labels; and
- as a calculational procedure—by which some simple selection rules can be found.

Burns provides nice illustrations on symmetry of molecular vibrations in simple molecules, crystal-field splitting, and selection rules including such rules for infra-red and Raman vibrational processes.

It would be easy to criticize this book for its omissions. Burns does not discuss the Jahn–Teller effect (which lends itself to very pretty illustrations of just the introductory type I have always found useful to a student), or "accidental" degeneracy (defined on page 132) as a possible concomitant of higher symmetry (for example, in the hydrogen atom, where the relevant group is O(4) and not SU(2) (or O(3)), to explain the Balmer series). Burns gives an extremely sketchy treatment of continuous groups and mentions not at all Lie algebra (or groups) in connection with angular momentum and many novel applications in atomic and molecular physics. In view of Burns's general success in achieving his goal of conveying a "feel," such criticism should be understood rather as expressing some of my own prejudices and favorite topics.

On the other hand, one could expect more care in proofreading. Tanabe's name should not have been misspelled in the table of contents (page xi). In the discussion on time reversal (page 337) the statement "terms like $(C_2)^2 = E$ and not E" should have been corrected or omitted entirely, and in discussing the rotation group (page 352) the equation $D^2 \times D^2 = D^1 + D^1 + D^0$ should have been correctly given. The students who use this text are I assume very likely to be confused by these misprints and others, which ought to be eliminated in future printings.

All in all, Burns (a well known physicist and staff member of the T. J. Watson Research Laboratory of IBM), who has made notable contributions to our understanding of ferroelectrics, has written a useful book. I can recommend it, in conjunction with one or another more thorough and rigorous texts, such as Wigner's *Group Theory & Its Application to the Quantum Mechanics of Atomic Spectra* (Academic, 1959) or Morton Hamermesh's *Group Theory & Its Application to Physical Problems* (Addison-Wesley, 1962).

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Crystallography and its Applications

L. S. D. Glasser
224 pp. Van Nostrand Reinhold, New York, 1977. $24.95 clothbound, $12.50 paperbound

The steadily increasing importance of crystallography, in fields ranging from solid-state physics to molecular biology, ensures a steady flow of texts on the subject; *Crystallography and its Applications*, by Lesley S. Dent Glasser, is one of the latest. It differs from most of the others in that Glasser did not intend to provide a complete account of crystal-structure determination, and she describes a variety of other crystallographic techniques in enough detail to show at least their range of usefulness. The book is for advanced undergraduate students and research workers who occasionally need to use crystallographic methods and read crystallographic reports. Glasser, a lecturer in chemistry at the University of Aberdeen, is a card-carrying crystallographer in the fine British tradition.

After an introduction to the basic concepts of lattices and symmetry, Glasser turns to studies of optical properties of crystals by use of the polarizing microscope. She argues that a modest investment of time in learning this art is well repaid by quick results in identifying materials, determining if more than one phase is present, determining symmetry and orientation, and even in estimating the density of crystals. The presentation is refreshingly clear, and Glasser suggests a few experiments to encourage the beginner.

The major part of the book is a description of x-ray diffraction: the production of x rays, the geometry of diffraction (by way of the reciprocal lattice), single-crystal diffraction photographs, the determination of structure and the assessment of the accuracy of the results. Glasser gives briefer treatment to diffraction from powders and to neutron and electron diffraction from crystals. A final brief chapter indicates the advantages and limitations of various techniques, and includes suggestions for what material to learn and what equipment to buy, de-