Book Reviews

Group Theory in Physics

The use of group theory in physics has been, until recently, synonymous with symmetry considerations. The simple notion of symmetry of shapes (crystal symmetry) was soon generalized to the symmetry of the fundamental equations of physics. The symmetry manifests itself in the coordinate-free form of these equations; all coordinate systems (in space-time or even in phase space) belonging to a certain class, depending on theory, are physically equivalent, or the form of the equations is the same for every one of the coordinate systems in the specified class of coordinate systems (for example, inertial systems). These classical invariance properties of the equations of motions under coordinate transformations lead immediately to the well-known fundamental conservations laws and associated constants of the motion, like the conservation of total momentum and of total angular momentum, for example.

In quantum mechanics the group theory, more precisely the theory of group representations (linear representations of groups in Hilbert space), plays a more fundamental role than in classical theories. This is because the states of a quantum mechanical system form a linear manifold; that is, one can select a set of so-called basis states such that every other conceivable state of the system can be written as a linear combination of these basis states. This is not possible in classical theories. The same linear superposition principle holds for the vectors in the representation space of groups. In fact, the theory of group representations is so closely related to quantum theory that the former provides the basic framework on which quantum principles operate: The states of the system are defined and labeled by the representations of the symmetry groups. This is most clearly exhibited by the symmetry of the space-time: The unitary representations of the Galilei group (nonrelativistically) or the inhomogeneous Lorentz group (relativistically) determine all the quantum numbers and all the quantum states of motion of a free system. For interacting systems, the group representation theory has been extensively used in exploiting the symmetry properties of the Hamiltonian, itself too complicated to be susceptible to an exact solution. Here the group or the (Lie) algebra is formed by the set of operators commuting with the Hamiltonian. Dozens of books have been written on this subject, beginning with Wigner's classical *Group Theory* (1931).

More recently, physicists have tried to use group representations and related algebraic techniques (mainly commutation relations of the underlying operators) in a more dynamical sense than just in the sense of the symmetry of the Hamiltonian. The basic motivation behind these new developments is the fact that, whereas we know the complete form (but not the spectrum) of the Hamiltonian of the atomic and molecular spectroscopy, we do not know the complete constituents and interactions in the case of nuclear structure, much less in the case of the spectroscopy of fundamental particles. Having discovered that some multiplet of states (particles) exist belonging to a symmetry group, one is faced with the question as to what multiplets will be found next. This led to the dynamical grouping of several and, in general, of all the multiplets of the system together, and it turned out that all states of the system can be described by the representations of groups which are now not symmetry groups but *dynamical groups* that contain the symmetry groups as subgroups. The algebraic commutation relations or the generators of the noncompact dynamical groups contain in them the operations of transitions between different multiplets belonging to different energies (or masses) which is, or course, the essence of dynamics.

Symmetry Groups in Nuclear and Particle Physics [Benjamin, New York, 1966. 334 pp., $4.95 (paper); $9 (cloth)] by Freeman J. Dyson and **Lie Groups for Physicists** (Benjamin, New York, 1966. 203 pp., $12.50) by Robert Hermann, the two books under review, are outcomes of these recent developments: The first shows the developments in physics; the second is a mathematician's answer to the physicist's quest for more mathematical knowledge in the theory of continuous groups. That the amount of modern mathematics which the theoretical physicists need is increasing very rapidly is clearly shown in these books. Dyson's book contains, aside from three short lectures in which he reviews some similarities of the symmetries and structures between nuclei and strongly interacting particles (hadrons), 32 selected reprints of articles that trace the background and the recent developments which I discussed in the previous paragraphs. The reprints of Wigner's classic and fundamental papers on the representation of Poincaré group (1939) and on the supermultiplet theory (1937) and Elliott's paper "Collective motion in the nuclear shell model" (1938) are welcome, and they should be required reading for the students in this field. The bulk and the main emphasis of the book is the collection of papers on SU_6-symmetry of the strongly interacting particles, an approximate symmetry scheme combining the spin quantum number and the so-called internal symmetry group SU_3 (isospin and hypercharge). Different subselections include the experimental successes and failures of SU_6, attempts to make this symmetry relativistic, and the difficulties encountered in these attempts. Finally, there are papers that deal with general results of combining spin and internal symmetries, and papers that show the usefulness of using Lie algebras, even though they are not symmetry groups of the system. Although I suppose not everyone will be quite happy with the selection of the articles, it is a very useful book indeed. It shows the dynamics of the theoretical physics itself in the last two years.

Hermann's book contains a lot of material not available previously in book form. Once the reader has learned the "language" of this book, which may be a bit difficult at first, he will find in it much useful material. Detail proofs of a number of theorems are omitted, but this does not hinder continuous reading. It seems to me that many of the concepts used in this book ("symmetric spaces," "vector bundles," and "Iwasawa decomposition," for example) are quite adapted to physical situations and concepts and will be very useful. What physicists mainly need, however, are explicit calculations of the representations of specific groups of their problems rather than general theorems, a need not met in this book, nor in any other book.

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Individual Adaptation

Since antiquity adaptation has been recognized as the central problem of understanding and explaining organisms. Final cause, in the Aristotelian sense, only evaded the question and must be either radically redefined or altogether abandoned in scientific pursuit of the subject. That pursuit has shown the concept of adaptation to be extremely complex, to such a point that the word out of context is hopelessly ambiguous. "Adaptation" may mean the process of acquiring a characteristic that is an adaptation. The process may be genetic, in the evolution of populations that are adapted as such, that is, as reproductive continua. In the case of mankind, the process and its adaptive outcome may be cultural, also a phenomenon of populations as reproductive continua and related to genetic evolution because the capacity for culture is genetic and has evolved. Those two interacting aspects of human adaptation were treated with great skill by Th. Dobzhansky in his Silliman lectures at Yale, published as *Mankind Evolving* [reviewed in *Science* **136**, 142 (1962)].

Another aspect of adaptation in general and human adaptation in particular is that individuals adapt. That was the subject of another outstanding series of Silliman lectures by René Dubos, now published as **Man Adapting** (Yale University Press, New Haven, Conn., 1965. 549 pp., $10). This book was prepared as a companion volume to Dobzhansky's, and a simple expression of judgment of both is that they are worthy of their subjects and of each other. It is not necessary to read one to profit by the other, but the profit is more than doubled if both are studied. There is virtually no repetition, but there are complementarity and connection. The genetics of the individual are fixed at conception (for all usual cases), but the capacity for individual adaptation is genetically determined and results from the evolution of mankind collectively and not individually. Furthermore, individual adaptation has two inseparable but different aspects, one biological and the other cultural, just as does populational adaptation. The two also involve both static or homeostatic adaptation to a given environment and dynamic adaptation by changing response to environmental variables and new stresses. Dubos has treated all aspects of individual adaptation with thoroughness, skill, and authority.

For the rest, Dubos's book is so rich in detail and so extensive in coverage that its contents must be indicated rather than reviewed. It starts with man as a product of evolution, a unique product because man's nature is not only biological but also social, his mentality not only reactive but also manipulative of symbols. The individual with these group characteristics develops under his particular influences, pre- and postnatal. He lives in a physical world, reacting rhythmically to its cyclic forces and variously to its climates and other characteristics. Individual responses to nutrition and malnutrition are especially noticeable, and especially modifiable by cultural means.

Discussion of biological synecology and the human social environment introduces a series of chapters on physiological derangement and adaptation, fascinating in depth and with some astonishing tidbits: the indigenous microbiota (absence of an intestinal biota can produce radical anatomical abnormality); nutrition and infection (a surprise here is that dental caries is discussed without mention of fluorides); evolution of microbial diseases (modern medicine has not conquered them; "the morbidity rates of infection have not decreased significantly and in some cases have actually increased"); changing patterns of disease (increase in population density is a possible accelerating cause of disease). In spite of that last bit, the next chapter, "Adaptation and its dangers," points out that mankind has proved to be extraordinarily adaptable and that the general state of health has in fact improved in the thoroughly unnatural conditions of crowded cities. Nevertheless the adaptability of populations is paid for by maladaptation in some individuals, and adaptability itself is a threat if it involves the ability to accept or to produce the destruction of "the values most characteristic of human life."

The topic of population density and human life is familiar enough, but here is a summary free of extremism. (Even though I personally am repelled by the opinion that establishment of permanent settlements all over the earth is inevitable and does not imply true overpopulation to the extent that it occupies "new territories," eliminating jungle, desert, or all open space.)

The final five chapters (of 16 in all) may be of somewhat less general interest, being devoted to the practice of medicine, which nevertheless has its own fascination for the practicioners and for their clients, who are all of us. I shall only list the chapter titles: "Hippocrates in modern dress"; "Man meets his environment"; "Eradication versus control"; "The control of disease"; and "Medicine adapting."

This is an altogether fine book, one that cannot fail to interest any intelligent reader.

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Levant Geology

M. A. Avnimelech has been associated with the Department of Geology of the Hebrew University of Jerusalem since 1930. He prepared this volume, **Bibliography of Levant Geology: Including Cyprus, Hatay, Israel, Jordania, Lebanon, Sinai, and Syria** (Israel Program for Scientific Translations, Jerusalem; Davey, New York, 1965. 204 pp., $6), a 22 by 27½ cm, double-column, offset-printed book to fill a void in bibliographic information. He plans to augment these data by supplements.

The introduction (pp. vii to x) contains a short synoptic history of geological research in the Levant countries. The book is divided into four parts: Bibliography (pp. 1 to 104), Chronological index (pp. 107 to 135), Analytical subject index (pp. 139 to 184), and List of quoted periodicals and serials (pp. 187 to 192). The frontispiece, an outline map, delimits the geographic scope. "Hatay," not labeled on this map, is that part of Turkey between the