Book Reviews

Evolution: What Is Required of a Theory?

Mathematical Challenges to the Neo-Darwinian Interpretation of Evolution. A symposium, Philadelphia, April 1966. Paul S. Moorhead and Martin M. Kaplan, Eds. Wistar Institute Press, Philadelphia, 1967. xii + 140 pp., illus. Paper, $5. Wistar Institute Symposium Monograph No. 5.

The idea of this symposium is supposed to have originated from a discussion at two picnics in Switzerland, when four mathematicians, Schützenberger, Ulam, Weisskopf, and Eden, had a discussion with the biologists Kaplan and Koprowski on mathematical doubts concerning the Darwinian theory of evolution. After heated debates it was proposed "that a symposium be arranged to consider the points of dispute more systematically, and with a more powerful array of biologists who could function adequately in the universe of discourse inhabited by the mathematicians." During the course of the symposium further heat was generated.

It is not easy to summarize the case made by the mathematicians, which involves both the challenge that computer simulation of evolution shows evolutionary theory to be inadequate and a complaint that the biologist has not provided sufficient information for efficient computer simulation. Eden was particularly concerned with the element of randomness which is claimed to provide the mutational variation upon which evolution depends. "No currently existing formal language," he contends, "can tolerate random changes in the symbol sequences which express its sentences. Meaning is almost invariably destroyed. Any changes must be syntactically lawful ones." He therefore conjectures that "what one might call 'genetic grammaticality' has a deterministic explanation and does not owe its stability to selection pressure acting on random variation." He points out that attempts to provide for computer learning by random variation have been unsuccessful, and that an adequate theory of adaptive evolution would supply a computer programmer with a correct set of ground rules. Schützenberger takes a more extreme position. Arguing that all genetic information should consist of a rather limited set of words in an alphabet of 20-odd letters—in which evolution is typographical change—he finds a need for algorithms "in which the very concept of syntactic correctness has been incorporated." He compares this "syntactic topology" with the "phenotypic topology" of organisms as physical objects in space-time, and a major part of his challenge to neo-Darwinian theory is "the present lack of a conceivable mechanism which would insure within an interesting range the faintest amount of matching between the two . . . topologies." ". . . an entirely new set of rules is needed to obtain the sort of correspondence which is assumed to hold between neighbouring phenotypes. . . ."

A major part of the biologists' answer to this challenge was in the claim that the neo-Darwinian theory used in computer models, based on the Haldane-Fisher-Wright interpretation of 1920–1930, misses out those forces which lead to continuing evolution, such as continued environmental change, the heterogeneous environment, epigenetic organization of phenotypes, and the progressive elaboration of the types of mutation possible. Waddington presented the main elements of a theory of phenotypes involving canalized processes of development (with switching mechanisms), the heritability of developmental responses to environmental stimuli, and a principle of "Archetypes," inbuilt characteristics of an evolving group which determine the directions in which evolutionary change is especially easy. Realistic models would need to build in these elements.

Many of the papers by biologists in this volume are peripheral to the theme stated by the mathematicians, providing an accompaniment of sophisticated evolutionary theory rather than a counterpoint to the mathematical challenge.

Most biologists are satisfied with a theory that can be tested and that proves predictive. It is a different challenge to a theory that it should have an effective working model, for failure may imply either imperfection in the theory or imperfection in the model. It is doubtful whether this symposium has done much to influence the theory of evolution; it may have done much to improve future models.

It must have been tremendous fun to attend this symposium, but the full record of argument and interruption is very irritating to at least one reader. An interchange between speakers which runs X "No," Y "No, no," X "O.K. let's waste time," Y "We understand the question," Z "The answer is no" surely needs no record in the literature of science. The short pre- and post-conference papers included in the volume are excellent succinct expressions of points of view, but much of the main text reads like a word-for-word record of a heckled political meeting. This may be a useful way to discuss problems in science; it is not the way to publish them.

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Climate and Life

Ground Level Climatology. A symposium presented at the Berkeley meeting of the AAAS, Dec. 1965. Robert H. Shaw, Ed. AAAS, Washington, D.C., 1967. xii + 395 pp., illus. $12.50; to members, $10.50.

A visiting Soviet agricultural climatologist who had a brief look at this symposium while I was driving him to the train seemed quite taken with it. So was I, at first glance. It was hopeful to see a book devoted to processes at and near the long-neglected surface of the earth. But as I looked for a framework that might unify this field and for studies that might demonstrate its capabilities to students and fellow scientists, disappointment grew. I looked for work like that of Brooks, Neiburger, and Leighly in California, Lettau, Tanner, Sargent, or Trewartha in Wisconsin, Hare in Canada, Landsberg in Washington, or America's greatest agricultural climatologist, the late Warren Thornthwaite, or his students, or for the excellent mass and energy budgets of corn by such men as the editor of the present volume—but found little. Recent exciting work is not represented or synthesized in the manner one has grown to expect from the AAAS imprint.

Some papers indeed are interesting. Several that use energy budgets illustrate one of the unifying themes of climatology, but many are out of place in a hard-cover book. Some apparently were written in innocence of relevant work in other countries; some attempt to review a problem without controlling the primary literature; others report investigations that plainly are not yet finished. Some look curiously as if they had been written before Geiger published his great work in 1927. Few papers are informed by theory.

Such difficulties are common in symposia (though only to a minor degree in two recent symposia on agricultural climatology in Australia and England), and it is preferable to dwell on useful points. One is the evidence of a trend to consider all parameters of the environment of plants and animals, including those not taken into 19th-century meteorology. Solar radiation is such a neglected parameter, still not a part of synoptic reporting networks, though it is an important energy-exchange process. Radiation data are used profitably in the study by Newman *et al.* comparing growth of oranges in different parts of the United States, in Bond's study of heat loads on cattle and hogs in field environments, in McDowell's study of energy input-output relations of cattle, and in Fritschen and Nixon's description of effects of irrigation in small-scale climates. Fritts employs radiation data in the best-reasoned statement I have yet seen on the possible connections of environment and tree-ring widths, with leaf temperature as the critical intermediary.

Although the book does not epitomize present knowledge in the field, it does present one important statement about the future—Whittaker's warning to stop fooling with systems we don't yet understand. While he is, perhaps, needlessly impressed by the claims of weather-"control" operators, he is right in saying that weather modification, whatever it may turn out to be, is too important to be left to one profession. Meteorology, dealing with atmospheric perturbations that move downstream and soon die, may too easily accept disturbances in systems at the atmosphere-earth interface, which, as Whittaker points out, have long lives, may become unstable, and do not obligingly move elsewhere. The cloud-seeder, in fact, reminds one of an amateur chess player, boldly advancing his queen into a complicated terrain for an immediate profit or just to see what might happen, while Whittaker might be the kibitzer looking into the flinty countenance of the master across the board and thinking, "Well, maybe so at first. . . . What's the next exchange? . . . And the next? Let's hold on a second. . . ."

This book, disappointing in some ways, does bring us, in a place of emphasis, this warning of the vulnerability of systems at the earth's surface to sudden changes in their environment, and reminds us of our ignorance of their connection with that environment.

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Organic Photochemistry

Reactivity of the Photoexcited Organic Molecule. Solvay Institute of Chemistry. Proceedings of the 13th conference on chemistry, Brussels, Oct. 1965. Interscience (Wiley), New York, 1967. x + 350 pp., illus. $15.

This volume is an excellent state-of-the-art collection of reviews covering the full range of vantage points toward organic photochemistry, from that of the preparative organic chemist to that of the theoretical kineticist concerned with the details of the crossing of potential energy surfaces. Although a wide variety of reactions is discussed, each presentation is written from the point of view of one or more unifying themes. Each is followed by a lively discussion which sharpens the issues of greatest controversy.

Stereochemical factors are stressed by Yang in discussing the type of product observed in photochemical solution reactions of ketones, but the importance of subtler features of the reaction profile is recognized in that note is taken of the differential ease of hydrogen abstraction from a primary as compared with a secondary carbon. Hammond centers attention on sensitization and shows the usefulness of this technique for distinguishing between singlet and triplet reaction paths and for demonstrating the differential excitation of different geometrical isomers in the butadiene series, not always equilibrated in the excited state. Dauben, in dealing with the intramolecular photochemistry of butadiene, shows the applicability of the Woodward-Hoffman symmetry rules of electrocyclic reactions. Havinga and Daudel both discuss the importance of pi-electron densities in predicting reactivity and orientation influences in excited states of aromatics. Porter raises questions about the significance of excited state charge densities in cases, such as heterolytic substitution, where the atomic rearrangement does not occur during the lifetime of the excited state; and he places as a matter of greatest urgency the understanding of the internal conversion process and the subsequent vibrational relaxation, during the course of which most photochemical reactions probably proceed. Schmidt's review shows the powerful technique of solid state photochemistry in which advantage is taken of polymorphism and of crystal structure variation within homologous series, especially in the acrylic acids, to learn the steric requirements for forming the transition state in bimolecular reactions.

Coulson's contribution on detailed descriptions of excited state energies and shapes points up the limited successes achieved for very small molecules with the help of Walsh correlation diagrams, molecular orbital calculations, symmetry arguments, the Hellman-Feynman theorem, and experimental resolution of rotational structure in vibronic spectra. At the same time, the reader experiences frustration at the realization that we are far from the point of having good theoretical descriptions of the excited states of organic molecules of practical interest. Perhaps newer developments not discussed in this volume, such as electron correlation calculations, flexible molecular orbital procedures incorporating both sigma- and pi-electrons for medium-sized molecules, or still others, will provide the breakthrough in keeping theory and experiment in pace with each other in the next decade. Porter summarizes the general state of affairs in hoping that new methods, both experimental and theoretical, "should, over the next few years, narrow the gap to the point where our ignorance of excited state reactivity is no greater than our ignorance of reactivity in the normal ground state."

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