oxygen at higher temperatures. But so does a bit of hamburger, and that does not tell much about a cow.

What I mean is that only an uncertain view can be obtained from conventional respirometry, osmotic, and temperature measurements. From my own experience, the critical factor in the success of an organism can be some unpredictable event such as a hurricane, a cold snap at maximum low tide, or a couple of weeks of cloudy weather just as a spring phytoplankton bloom is starting. These may have their cause in some remote factor such as sunspots. But in the real world one must treat the ensuing results as random.

When we look at the kind of data this book presents, we find most animals sitting in the middle of their tolerance regime. Limiting physiological stresses are usually not apparent. Without considering the unexpected cataclysms one can miss the key.

This is important to understand amid the increasing demand for advice on environmental matters. Usually we don't understand a situation well enough to predict the result of a given action. The proper response of "no comment" is not always forthcoming, particularly when ecologists get into the act with their plausible but unsubstantiated theories.

So the Vernbergs' book, which is presented as an aid in environmental questions, can only give a partial view. They have done a creditable job with what is available. But understanding bits of nature as a unit (ecology) is difficult and we have barely begun to crawl.

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Chemical Attractants

Insect Sex Pheromones. MARTIN JACOBSON. Academic Press, New York, 1972. xii, 382 pp., illus. $22.50.

Insects of many species have evolved visual or sonic signals for communication between potential mating partners. However, the most common means for such transfer of information in the class Insecta is by odors or tastes. The chemicals involved, which may be used to attract individuals of the opposite sex or to stimulate them to copulate, are called sex pheromones.

Scientific man tends to be anthropocentric in assigning research priorities. Thus, insect communication by vision and by sound, with which we can readily identify, has been comparatively well researched. We have little intuitive feel for communication by sex pheromones, and the study of this important aspect of insect life has lagged accordingly.

Developments during the past 15 years, however, have caused a shift in research interests, and this previously neglected subject is now among the most active in biology. One such development has been the realization that manipulation of insect behavior by means of sex pheromones offers an alternative to the use of conventional chemical insecticides. No practical system for insect control based on sex pheromones has yet been developed, but some breakthroughs seem imminent.

The fact that amounts of sex pheromone contained in an individual insect are extremely small, generally less than 1 microgram, has been one of the sources of difficulty. With modern chemical instrumentation, however, it is possible, in some cases, to identify a pheromone when less than 1 milligram has been obtained. The first insect sex pheromone, that of the silkworm moth female, was identified in 1959. Today, such identifications are becoming commonplace.

Martin Jacobson has been prominent among the chemists specializing in the identification of sex pheromones. His earlier book, *Insect Sex Attractants*, published in 1965 by Wiley, was the first monograph surveying the literature in this field. A number of symposium volumes and isolated reviews have appeared since then, but no other monograph on the subject has been published until this new contribution by Jacobson. The work is essentially an expansion and updating of his previous book.

My only disappointment with the book arises from its lack of critical analysis and integration of the information presented. The work consists mainly of a collection of summaries, ranging from a sentence to a paragraph in length, of the findings reported in individual research articles. This lack of criticalness is balanced by the comprehensiveness of the coverage. The bibliography consists of about 1400 entries, and most of them are mentioned in the text. All aspects of the subject are included. Jacobson has reviewed literature on the structure of known sex pheromones and on the means by which they are identified. He has considered the glands that produce the chemicals and the sensory structures that perceive them. He has included the ways in which sex pheromones are used in insect behavior and, finally, the ways in which man might use the pheromones to his advantage, to "outwit" and control the insects. Thus the general reader is given a view of the scope of the field and the specialist is provided with the most complete available entry into its literature.

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Evolutionary Biology

Problemy Evolyutsii (Problems of Evolution). Vol. 2. N. N. VORONTSOV, Ed. Nauka, Novosibirsk, 1972. 300 pp., illus. 2 rubles, 30 kopeks.

This is the second volume (the first was published in 1968) of a Russian equivalent of *Evolutionary Biology* (edited by M. K. Hecht, W. C. Steere, and myself). It contains 23 papers by 18 authors, most of them generalizing reviews of various topics and problems and some of them accounts of original investigations which could as well have been published in specialized journals. Since most biologists are at least to some extent interested in evolutionary problems, and since almost all biological disciplines are of some interest to evolutionists, the series includes a great range of topics: molecular biology, physiology, comparative anatomy, biogeography, variation and natural selection, species formation and reproductive isolation, and (in volume 1) anthropology. Only a few of the highlights of the present volume can be mentioned. V. A. Ratner gives a review of comparative studies of amino acid sequences in proteins of different organisms; O. Y. Orlov discusses the evolution of color vision in vertebrates; Y. I. Novozhenov analyzes the geographic variability of the cockchafer beetle; V. A. Zaslavsky treats of reproductive isolation of closely related species (or semispecies) of weevils; S. D. Matveev gives an interesting but controversial analysis of genetic phenomena observed at the boundaries of distribution areas where closely related forms come together. A serious drawback of the volume is that all pa-

pers published therein were received by the editor as far back as 1967. A lapse of five years between the reception and the publication of a scientific paper, particularly a review paper, may very appreciably reduce the value of the work. Being another editor, I make this complaint with commiseration and understanding.

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Chemical Processes

Ions and Ion Pairs in Organic Reactions. Vol. 1. MICHAEL SZWARC, Ed. Wiley-Interscience, New York, 1972. xii, 400 pp., illus. $17.95.

In this, the first of two projected volumes, the editor has collected chapters which, in his own words, deal "with the physical techniques fruitful in unraveling the problems of structure, energetics, and dynamics of ions and ion pairs." And, in large part, it seems to this reviewer that this objective has been met.

The physical techniques that are treated, largely spectral, include mass spectrometry (P. Kebarle), spectrophotometry (a particularly informative and interesting chapter by J. Smid), infrared and Raman spectroscopy (W. F. Edgell), electron spin resonance spectrometry (J. H. Sharp and M. C. R. Symons), and nuclear magnetic resonance spectrometry (three separate chapters by L. D. McKeever, by E. de Boer and J. L. Sommerdijk, and by M. Szwarc).

Although, as the title implies, the emphasis is on organic chemistry, the chapters by Kebarle and Edgell deal largely or entirely with inorganic systems. This being the case I find it unfortunate that no discussion of the elegant physical relaxation techniques developed by Eigen and utilized by him for the study of (largely inorganic) ion-pair phenomena is included.

The reader should be cautioned that the emphasis throughout this volume is on ion pairs, not free ions. Except in the extremely interesting chapter by Kebarle free ions are discussed only tangentially. Another limitation of this first volume is that attention is restricted almost entirely to organic ion pairs composed of an organic carbanionic component (frequently a radical anion) and an inorganic component, $R^{\ominus}M^{\oplus}$. The complementary combination of an organic carbonium ion portion electrostatically associated with an inorganic anionic component ($R^{\oplus}X^{\ominus}$) is not discussed, presumably because spectral techniques have not yet been developed to investigate these generally unstable species. It is hoped that volume 2 will deal with these species. Incidentally, about this second volume Szwarc has written that it "is devoted to the role of ions and ion pairs in chemical reactions such as proton transfer, electron transfer, or ionic polymerization."

This reader at least was left with two overwhelming impressions after reading this volume: (i) that the traditional textbook definitions of chemical bonds as resonance hybrids of two distinct types, ionic and covalent, must be reexamined; it is increasingly obvious that the fundamental difference is one of degree, not kind; and (ii) that the potential for obtaining information about the nature of bonding by means of spectral techniques is great indeed.

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Space-Time Problems

General Relativity. Papers in Honour of J. L. Synge. L. O'RAIFEARTAIGH, Ed. Clarendon (Oxford University Press), New York, 1972. x, 278 pp., illus. $24.

This festschrift honors Synge's 75th birthday. Although there is hardly an area of mathematical physics that has not benefited from Synge's work, the present volume is confined to general relativity, to which Synge made and continues to make many important contributions. Perhaps the hallmark of Synge's work in relativity has been his consistent emphasis on the geometrical point of view; it must be gratifying to him that a number of the papers share this geometrical spirit.

Weyl showed in the 1920's that a Riemannian structure of Minkowski signature generated conformal and projective structures on a manifold which could be identified by studying the paths of massless and massive test particles, respectively; the use of test rods and clocks to determine the metrical structure could thereby be eliminated. In their paper "The geometry of free fall and light propagation," Ehlers, Pirani, and Schild solve the reverse problem. Compatible conformal and projective structures on a manifold are defined, and additional conditions yielding a unique Riemannian structure are derived. The existence of such a structure need not therefore be assumed beforehand in order to construct it from the behavior of null and massive test particles. Since this method of test particles has recently come into favor, it is very satisfying to see it fully developed. Of course, each of the three methods currently proposed for explicating the significance of the metric structure of space-time (rods and clocks, paths of massive particles and clocks, and paths of massless and massive particles) has advantages and drawbacks. Thus, it is perhaps better to regard them as alternative ways of looking at the implications of a metrical structure for space-time than to claim absolute superiority for one.

Trautman's paper "Invariance of Lagrangian systems" is a geometrical treatment of invariance properties of Lagrangians and related conservation laws using the methods of fiber bundle theory. The geometrical content of symmetries, which tends to get lost in the usual treatments involving local coordinate systems, is thereby elegantly brought out.

Penrose's paper "The geometry of impulsive gravitational waves" takes up the question of the propagation of discontinuities in the curvature tensor on null hypersurfaces. Detailed attention is devoted to the study of intrinsic geometric structures which a null hypersurface inherits from the Riemannian structure of the manifold. This study of intrinsic null geometry could well find further useful applications.

"Global and non-global problems in cosmology" by Ellis and Sciama shows "that some cosmological problems are more global than others"; and indeed which properties are truly global varies from model to model. Their very thorough survey of this question only reinforces the residual uneasiness that all cosmological discussions provoke in me. Their paper provokes the question, If local observations cannot determine certain global properties of *some* model universes, how can we ever be sure of the applicability of *any* model?

Two historical papers survey "Einstein's path from special to general relativity" (Lanczos), a topic all too little studied as yet by historians of science, and "The acceptability of physical theories: Poincaré versus Einstein" (Balazs). The latter briefly