a charged particle into a solid. The section concludes with reports by R. Behrisch *et al.* and T. M. Buck *et al.* on the effect of surface conditions on the backscattered fraction of charged hydrogen and helium atoms in the medium energy range (5 to 200 kev). These papers suggest that new aspects of surface physics await discovery by those who search for an explanation of the dependence of the backscattered charged fraction upon surface conditions.

Surface effects are treated from a different point of view in section 7, where the energy spectra and angular distributions of backscattered particles are discussed. The paper by S. K. Erents and G. M. McCracken is of special significance because of its bearing on practical applications. Erents and McCracken have investigated the desorption of condensed gases from surfaces bombarded by 5-kev protons. A thermal spike mechanism in the copper substrate can explain the results for deuterium and helium, but it apparently fails to predict the results for heavy gas atom desorption. Nor does a conventional momentum-transfer sputtering theory work. Additional unexplained data on the desorption of condensed gas mixtures underscore the need for pursuing this kind of research in order to develop a quantitative understanding of the underlying physical processes.

The present status of studies of x-ray emission from ion-ion collisions in solids is set forth in section 5. It appears that a whole new branch of atomic physics involving united-atom phenomena is rapidly developing. F. W. Saris begins the section with a review of molecular orbital theory leading to an understanding of molecular orbital x-ray production. Subsequent papers explore the complexities that arise in the production of noncharacteristic x-rays, that is, x-rays that cannot be attributed to either the target or the incident projectile. From the viewpoint of a solid state physicist, an exciting development is the recent observation of radiative electron capture. F. Bell and H.-D. Betz report their findings in a paper on heavy-ion collisions at Mev energies. A paper by H. W. Schnopper and J. P. Delvaille on the same subject appears in section 6. The important point in both papers is that radiative electron capture of bound target electrons leads to x-ray spectra that can be understood in terms of the electron momentum distribution of the target electrons. If this feature can be exploited it will be a welcome addition to the small family of techniques available for studying electron momentum distributions in solids and will represent a triumph in the study of atomic collisions in solids.

The clarity of the presentations and the inclusion of some theoretical papers among the experimental ones make these volumes a first-rate review of the many contributions being made to physics through studies of atomic collisions in solids.

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Energy Transformation

Bioenergetics of Photosynthesis. GOVINDJEE, Ed. Academic Press, New York, 1975. xvi, 700 pp., illus. $43. Cell Biology.

Bioenergetics of Photosynthesis is a valuable book, for those doing research on photosynthesis and for anyone else who desires authoritative and well-written general discussions of the various physical aspects of photosynthesis.

The book covers the following general topics: chloroplast structure (including chlorophyll organization); the initial physical and photochemical events in photosynthesis and the relationship to membrane structure and chlorophyll organization; electron transport and the mechanism of oxygen evolution; and mechanisms of energy conservation and photophosphorylation.

There has been considerable planning in the preparation of the book. The chapters complement each other well, with little overlap, and they have been reviewed by authorities in the field. The information they contain is current insofar as this is possible. The excellent chapter by Arntzen and Briantais on chloroplast structure was completed before the new information concerning individual polypeptides and their relationship to chloroplast membrane structure became available, but a note summarizing the later data is appended.

The chapter by Kenneth Sauer is a lucid presentation of the physical aspects of the primary steps of photosynthesis and contains a useful description of the various physical methods used in these measurements. Sauer also considers the physical and photochemical properties of reaction centers from chloroplasts and bacteria. There is some overlap between this chapter and the one by Litvin and Sineshchekov, which considers the molecular organization of chlorophyll. It is surprising that the work of Joseph Katz and his group is not given more recognition, in particular as it relates to the nature of the chlorophyll in P700. This should have been considered in the chapter by Litvin and Sineshchekov.

André Jagendorf presents an excellent review of the difficult topic of phosphorylation and with the aid of some informative drawings gives a very understandable outline of the various possible mechanisms for energy conservation and adenosine triphosphate (ATP) formation, with emphasis on the chemiosmotic theory. It is helpful to have in the same book a summary of the work and concepts of Witt's group pertaining to the generation and properties of the electrochemical membrane potential of chloroplasts, since over the years these workers have accumulated a wealth of data in support of the chemiosmotic theory of ATP formation in chloroplasts. The only feature missing in this area is a treatment of the recent work by Stoeckenius and his group, reported after the manuscripts were prepared, concerning bacteriorhodopsin and its role in ion movement and ATP formation in *Halobacterium halobium*. That work gives an added dimension to the biological uses made of radiant energy and must be considered in any future general review of energy conservation mechanisms.

The theoretical aspects of energy transfer and migration are beautifully covered by R. S. Knox, who indicates that there are more physical tools available to biophysicists than they are currently using in their analysis of the photosynthetic process.

I highly recommend this book, which I expect will become a standard reference book in photosynthesis laboratories and for all who specialize in bioenergetics.

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Pollution Indicators

Pollution Ecology of Freshwater Invertebrates. C. W. HART, JR., and SAMUEL L. H. FULLER, Eds. Academic Press, New York, 1974. xvi, 390 pp., illus. $24.50. Water Pollution.

Biological measures for assessing water quality date back to the early 1900's when the Saprobiensystem was used throughout much of Europe to characterize organic pollution in streams and rivers. Although this system has been subjected to much criticism and revision because of its rigidity and its inapplicability to inorganic effluents, the biological indicator concept inherent in it and other formal systems is widely used in the monitoring of changes in water quality. As the editors say, this volume is an attempt to summarize the "nor-

mal" and "pollution" ecology of ten groups of freshwater invertebrates, primarily benthic macroinvertebrates, that traditionally have been used as pollution indicators. The ten papers are organized along taxonomic lines, and the emphasis is on North American organisms, although Sawyer's paper contains some discussion of European species of leeches. Several of the papers contain useful summaries of current systematics of the groups they discuss. There are also good reviews of the ecology of some minor taxa of freshwater invertebrates that often are omitted or overlooked in pollution surveys and ecological studies. Bushnell's paper on the Ectoprocta contains some interesting observations on the life history and ecology of this phylum. In addition, the paper includes new data on the acute toxicity to several bryozoan species of some heavy metals, pesticides, herbicides, and sewage.

Although the emphasis in most chapters is on single-species comparisons, Cairns's chapter on the Protozoa makes a strong case for considering the entire microbial community in pollution surveys designed to monitor water quality and in laboratory bioassays to assess potential pollutants. His use of microcosms colonized with protozoan communities from natural waters appears to be a promising approach for assessing the effects of complex effluents on the structure of a freshwater community despite the problems associated with sampling and identifying members of this phylum.

Even though most of the authors recognize the shortcomings of the indicator-species concept, the theme of most chapters is species-by-species comparisons (typically based on only one stage of the life history) of sensitivity to water quality parameters or ranges of parameters of the waters from which the species were collected, or qualitative comparisons of species composition in "polluted" waters. This emphasis points up the lack of the ecological data that are necessary for the assessment and prediction of the environmental consequences of modifying the physical, chemical, and biological integrity of aquatic ecosystems. Although the use of indicator species clearly is the simpler method for assessing the impact of pollutants, it lacks the sensitivity and broader applicability of the more complex community and ecosystem analysis approach taking into account both micro- and macroinvertebrates. Moreover, in such a community approach both primary and secondary effects can be considered. The community approach is more difficult and requires more taxonomic specialists, but the chapters in this book indicate that too little is known regarding both the normal and pollution ecology of most freshwater invertebrates to warrant reliance on a few species as pollution indicators.

This book provides a useful summary of the ecology of many freshwater benthic invertebrate taxa despite the fact that most of the reviews are cursory. Unfortunately, the aquatic insects, about which more is probably known in terms of normal and pollution ecology, receive a superficial and biased treatment. An adequate review of the ecology of aquatic insects would, however, require a volume in itself.

Pollution biologists still should find this book a useful reference. Strict application of ambient water quality parameters presented in this volume as measures of either limiting conditions or safe limits for the various taxa should be done with caution, however, because most of the values are based on limited surveys of polluted environments and thus do not necessarily represent the tolerance range of the various taxa.

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Biological Time

Biological Rhythms and Endocrine Function. Proceedings of a conference, Columbia, Mo., Oct. 1973. LAURENCE W. HEDLUND, JOHN M. FRANZ, and ALEXANDER D. KENNY, Eds. Plenum, New York, 1975. x, 194 pp., illus. $19.50. Advances in Experimental Medicine and Biology, vol. 54.

The role of hormones in biological rhythms is a subject of intense interest to biologists in general and to endocrinologists in particular. The demonstrations of biological rhythms in practically all forms of life have introduced a new dimension, biological time, that demands as much consideration as biological space and form. The contributions in this volume, the proceedings of the Midwest Conference on Endocrinology and Metabolism, reveal some of the potential and much of the complexity of the new three-dimensional approach to biology. Although they are not considered in an organized manner, several general concepts emerge. The daily or circadian rhythm is basically a cellular phenomenon. Cellular rhythms are synchronized so that they produce tissue and organismal rhythms of metabolism and behavior. The circadian rhythms at all levels of organization often persist in the absence of obvious environmental cues, but the phases of the rhythms are usually entrained by the daily schedule of light and dark. The neuroendocrine system has a central role in organizing cellular rhythms, mediating environmental entrainment, and adjusting the individual to its environment. Interactions of the circadian rhythms in turn are responsible for the establishment of conditions that make up longer cycles such as those found during the rodent estrous cycle and during annual cycles.

Because the adrenal cortex has multiple vital influences, it is appropriate that a considerable effort has been made to understand the corticosteroid rhythms. Three contributions are focused on the regulation of these rhythms. The consensus is that the circadian rhythm of plasma corticosteroid concentration is driven by a rhythm of pituitary ACTH release that in turn is entrained by a periodic release of hypothalamic releasing hormone. Although this renowned pathway has the legitimacy of familiarity, the reader might bear in mind that the proofs for it are for the most part correlative.

Because corticosteroid rhythms synchronize many other rhythms, it is regrettable that more attention is not given to their synchronization functions. Discussion of these would have been of special interest in the light of studies cited by Halberg that demonstrate that timed activities, such as feeding, can alter the corticosteroid rhythm. "When we eat is what we are" could be a topic of interest for a future conference.

Whereas the adrenal cortex has received considerable attention because its importance is well recognized, the pineal has drawn much attention, it appears, for opposite reasons. Given the difficulty of interpreting the literature, Reiter does an excellent job of reviewing the roles the gland may have in reproduction. Despite considerable effort, it still is uncertain whether melatonin is the principal antigonadotrophic substance produced by the pineal. If melatonin is indeed a physiologically significant hormone, then the evidence that Lynch cites concerning stress-induced changes in melatonin production is of interest. Reiter argues that the pineal has a role in regulating the annual cycle of reproduction. This idea has merit for the hamster, but the reader would do well to resist any invitation to accept such a generalization as apropos for all vertebrate species.

If the reader is searching for a careful, seasoned appraisal of hormone rhythms he may be disappointed by this volume. An emphasis on the pineal and adrenal is balanced by a lack of consideration of the thyroid and other parts of the endocrine system. In addition, researchers often have more enthusiasm for the potential of their fields of interest than can be justified. It is not unusual to find that data of dubious