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-