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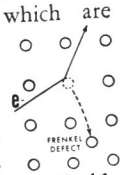
# The place of the Particle Accelerator in Basic Research...

"It has long been my ambition to have available . . . a copious supply of atoms and electrons . . . transcending in energy the alpha and beta particles from radioactive substances."
**Ernest Rutherford — 1927**

## High-energy Electrons in Solid-state Physics — I

Studies of radiation effects are vital to physicists in developing the theory of the solid state. For example: high-energy particles have been used extensively to produce defects in crystalline materials. The resulting vacancy-interstitial pair alters the mobility of the charge carriers, and therefore the electrical characteristics of the material. In conductors, this will result in decreased conductivity. In semi-conductors, the defects, which are primarily of the Frenkel type, will act as carrier traps and decrease the carrier lifetime. A knowledge of these effects which can be easily measured has been invaluable in extending the theory of crystal structure.




### Lattice Bonds

Theoretical studies in ionic and co-valent crystals have shown that the lattice binding energy is about 25 ev. The energy of an electron which can cause a single displacement is therefore of the order of 0.4 Mev. This figure is confirmed by a number of experiments with electrons from Van de Graaff accelerators. Reports of these experiments have come from Purdue University using the University of Notre Dame accelerator[1], North American Aviation, Inc.[2], Bell Telephone Laboratories[3], and others. All confirm the theory within the experimental errors. More refined measurements on such aspects as crystal orientation by Bell Laboratories[3], and minority carrier lifetime, by R.C.A. Laboratories[4], are under way and will serve to extend even further our understanding of the crystal structure.

### Type of Particle

Many different particles can be used for radiation studies. Their effects differ mainly in the momentum transferred to the lattice atom. Heavy particles transfer a large amount of energy. The ejected atom may have enough kinetic energy to cause subsequent displacements and produce a thermal spike in which a large number of atoms are involved. This type of damage is hard to analyze because of its complexity.

Light particles, such as electrons, can be accelerated to energies where only a single displacement will occur. It is possible to measure the binding energy of the atom in the lattice by suitable measurements following this type of bombardment.

The source of these particles can be an accelerator or a nuclear pile. The need for precise control of certain variables and the necessity for knowing the particle energy makes the accelerator a superior source. The Van de Graaff has been used extensively in these studies because its precision and energy stability best meet the requirements.

### Applications

Studies of radiation effects can be applied to current problems. Nuclear pile designers must know how much radiation a material can withstand before failure, and how well important instruments will stand up under particle bombardment. In particular, sensitive electronic systems must operate safely in high-intensity radiation fields. This is particularly true for nuclear-powered aircraft and guided missiles. Much work is now going on in testing components in radiation fields provided by particle accelerators.

There have been reports of high-frequency diodes being produced by irradiating semi-conductor materials to reduce the carrier lifetimes. While these have not been produced commercially, it appears that this is a simple method of producing traps in semi-conductors where they are needed.

### Accelerator Versatility

The studies described above are being carried out principally with the Van de Graaff®. Capable of accelerating charged particles such as electrons and protons, this versatile source of synthetic radiation can also produce monenergetic neutrons and high-intensity x-ray fields. The primary particle energy is continuously variable over wide ranges, and can be accurately measured for threshhold studies.

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1E. E. Klontz, K Lark-Horowitz, Phys. Rev. 86, 643, 1952
2D. T. Eggen, M. J. Laubenstein, Phys. Rev. 91, 238, 1953
3W. L. Brown, Bull. APS, 2, 156, 1957
4P. Rappaport, Phys. Rev. 94, 1409, 1954


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is perhaps more closely allied than it is with atomic energy.

There are some errors in the book (mainly resulting from attempts to oversimplify), such as in the definition of bases (page 42) and of atomic number (page 240). In some chapters the author diverges rather widely from his scientific theme, as in the long discussion of the post-World War II synthetic rubber controversy (page 198 *et seq.*). Some readers will share my antipathy to the breezy, *Time*-like phraseology prevalent in parts of the book—for example, the description of the eminent British physicist as "big burly effervescent Rutherford"!

Glenn T. Seaborg, in his introduction, points out the two-pronged social purpose of popularizations of science such as this book—the need to encourage young people into scientific careers and to enable the nonscientist citizen to make intelligent decisions concerning scientific developments. *Chemistry Creates a New World* is an honest attempt to satisfy these requirements and, despite the few shortcomings noted above, should prove to be of undoubted value to many nonscientist readers.

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**The Physiology of Reproduction in Fungi.** Cambridge Monographs in Experimental Biology No. 6. Lilian E. Hawker. Cambridge University Press, New York, 1957. 128 pp. $3.

This book—a compact, well-organized, and lucid review of the widely-dispersed literature concerned with the physiological aspects of reproduction in fungi—is a fit companion to its predecessors in the series of Cambridge Monographs in Experimental Biology. Following introductory chapters describing the types of reproduction and the development of reproductive structures found in various groups of fungi, there is a short chapter on the physiology of vegetative reproduction. Two rather extensive chapters on the effect of environmental and nutritional factors on reproduction constitute the bulk of the book. These are followed by a chapter on the physiology of sex in fungi, which contains brief discussions of heterothallism, hormones, and sex determination. In addition to being a sort of summary, the last chapter, which deals with reproduction in the natural habitat, points out the practical importance of the physiology of reproduction to the industrial mycologist and plant pathologist.

The author—or, indeed, the reader—of a review of the literature must be spurred in his efforts by the hope that, from the myriad facts that he must sift, there will emerge generalizations of broad application and profound significance. Although there is as yet too little information on the physiology of reproduction in the fungi for this hope to be realized, Lilian Hawker's book makes two very worth-while contributions. First, by presenting the facts in all of their diversity and complexity, it should help to lay to rest some of the teleological oversimplifications which have crept into the folklore of biology under the guise of generalizations. Second, the book should do much to stimulate investigation in an interesting and important field, and it is to be hoped that, from the results of experiments thus stimulated, it will be possible to deduce valid generalizations in the future.

ROBERT M. PAGE
*Stanford University*

## New Books

*Gregor Mendel und das Schicksal Seiner Entdeckung.* Ingo Krumbiegel. Wissenschaftliche, Stuttgart, Germany, 1957. 144 pp. DM. 10.80.

*High-Speed Aerodynamics (Compressible Flow).* Elie Carafoli. Translated from *Aerodinamica Vitezelor Mari,* Editura Academiei R.P.R., Bucharest. Pergamon Press, New York, 1957. 702 pp. $15.

*1001 Questions Answered about the Weather.* Frank H. Forrester. Dodd, Mead, New York, 1957. 432 pp. $6.

*Ancient Man in North America.* H. M. Wormington. Denver Museum of Natural History, Denver, ed. 4, 1957. 340 pp. Cloth, $5.25; paper, $3.65.

*Science in Everyday Life.* Ellsworth S. Obourn, Elwood D. Heiss, Gaylord C. Montgomery. 636 pp. $4.68.

*Grain Boundaries in Metals.* D. McLean. Oxford University Press, New York, 1957. 356 pp. $8.

*Safety Aspects of Nuclear Reactors.* C. Rogers McCullough, Ed. Van Nostrand, Princeton, N.J., 1957. 249 pp. $8.50.

*Nuclear Energy in the South.* Redding S. Sugg, Jr., Ed. Louisiana State University Press, Baton Rouge, 1957. 166 pp. $3.50.

*Soviet Education for Science and Technology.* Alexander G. Korol. Technology Press and Wiley, New York; Chapman & Hall, London, 1957. 538 pp. $8.50.

*The Aphidoidea of the Middle East.* F. S. Bodenheimer and E. Swirski. Weizmann Science Press, Jerusalem, 1957. 378 pp.

*Source Books of Industrial Solvents.* vol. II, *Halogenated Hydrocarbons.* Ibert Mellan. Reinhold, New York; Chapman & Hall, London, 1957. 267 pp. $7.

*Principles of Electrical Measurements.* H. Buckingham and E. M. Price. Philosophical Library, New York, 1957. 623 pp. $15.

*An Introduction to Transistor Circuits.* E. H. Cooke-Yarborough. Oliver and Boyd, London; Interscience, New York, 1957. 166 pp. $2.75.

*A History of Nutrition.* The sequence of ideas in nutrition investigations. Elmer Verner McCollum. Houghton, Mifflin, Boston, 1957. 461 pp. $6.

*Dynamic Aspects of Biochemistry.* Ernest Baldwin. Cambridge University Press, New York, ed. 3, 1957. 546 pp. $5.50.

*Liver-Brain Relationships.* Ian A. Brown. Thomas, Springfield, Ill., 1957. 211 pp.

*The Life of Mammals.* J. Z. Young. Oxford University Press, New York, 1957. 835 pp. $10.

*Livestock Improvement in Relation to Heredity and Environment.* J. E. Nichols. Oliver and Boyd, Edinburgh, Scotland, ed. 4, 1957. 251 pp. 16s.

*Of Men and Marshes.* Paul L. Errington. Macmillan, New York, 1957. 159 pp. $4.50.

*Rice in India.* Compiled by R. L. M. Ghose, M. B. Ghatge, V. Subrahmanyan. Indian Council of Agricultural Research, New Delhi, 1956. 517 pp. Rs. 21.

*A Scientific Vocabulary for Beginning Zoology Students and Non-Scientific Students.* Mary J. Brown. Pageant Press, New York, 1957. 104 pp. $3.

*Particulate Clouds: Dusts, Smokes and Mists.* Their physics and physical chemistry and industrial and environmental aspects. H. L. Green and W. R. Lane. Van Nostrand, Princeton, N.J., 1957. 444 pp. $11.25.

*Analytical Conics.* Barry Spain. Pergamon Press, New York and London, 1957. 152 pp. $5.

*Rocket.* Philip Joubert de la Ferte. Philosophical Library, New York, 1957. 190 pp. $6.

*Research in Photosynthesis.* Papers and discussions presented at the Gatlinburg Conference, 25–29 Oct. 1955, sponsored by the Committee on Photobiology of the National Academy of Sciences–National Research Council and supported by the National Science Foundation. H. Gaffron, C. S. French, R. Livingston, E. I. Rabinowitch, B. L. Strehler, N. E. Tolbert, Eds. Interscience, New York, 1957. 538 pp. $12.

*Handbook of Magnesium-Organic Compounds.* vol. I, *Reactions of Magnesium-Organic Compounds Nos. 1–7284;* vol. II, *Reactions of Magnesium-Organic Compounds Nos. 7285–13395.* vol. III, *Indexes of End-Products of Reactions, Magnesium-Organic Compounds, Authors and Co-Authors.* S. T. Yoffe and A. N. Nesmeyanov. Pergamon Press, London and New York, 1957. 2048 pp. $72.

*The Proterozoic in Canada.* Royal Society of Canada Special Publ. No. 2. James E. Gill, Ed. University of Toronto Press, Toronto, Canada, 1957. 201 pp. $5.95.

*The Appraisal of Applicants to Medical Schools.* Report of the Fourth Teaching Institute, Association of American Medical Colleges, Colorado Springs, Colorado, 7–10 Nov. 1956. Helen Hofer Gee and John T. Cowles, Eds. Association of American Medical Colleges, Evanston, Ill., 1957. 247 pp. $3.

*Chemical Engineering in the Coal Industry.* An international conference organized by the National Coal Board, Great Britain, June 1956. Forbes W. Sharpley. Pergamon Press, London and New York, 1957. 146 pp. $8.50.

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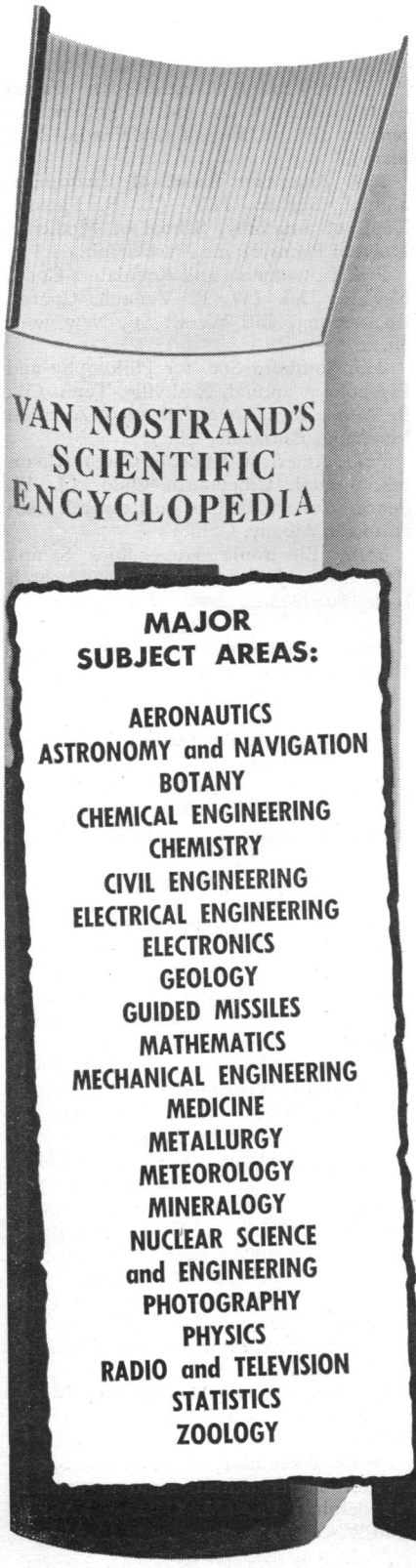


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