account for all properties of the life-giving substance.

The second paper, by Wayne Thornburg, on "Mechanisms of Motility," examines a possible common basis for the many kinds of automotion of living matter. Is the swimming of eels and snakes merely analogous to the swimming of spermatozoa? Can the small forces that make a chromosome move one micron per second, or two feet per year, have the same mechanochemical origins as those that contract a muscle cell in milliseconds? There are few data to answer these questions. In 50 pages the wide-open and difficult subject is examined impartially, and up to the most recent possible hypothetical mechanism, namely, the allosteric transition in proteins.

The third paper, on "Biologic Control Mechanisms," considers "Human Accommodation as an Example of a Neurological Servomechanism" and is by Lawrence Stark, Y. Takahashi, and G. Zames. It is clear that certain experimental subjects, such as this one, may eventually entail crews comprising several different specialists. The ramifications of a subject can create a need for Big Science. The enormity of biophysical topics is here demonstrated in the nonlinear servoanalysis of human lens accommodation, not so much by the intricacies but by the many unknowns that have to be guessed at.

The inevitable subject of radiobiology is represented in the fourth review, "Mechanism of Action of Different Ionizing Radiations on the Proliferative Capacity of Mammalian Cells," by G. W. Barendson. The carefully limited topic permits a quantitative estimate of the sensitive volume in the cell nucleus. Apparently lethal injury follows when 15 to 20 chemical changes are induced by ionizations within a volume having dimensions of about 10 nanometers. The cytoplasm is not as sensitive as the nucleus. All the details of the hazy picture that emerges cannot be listed here. The review is satisfying in the manner it neatly separates the interwoven factors determining cell sensitivity.

"The Genetic Code—1964" by Carl R. Woese, the fifth paper, is a summary useful to experts and to nonspecialists in code lore. There are almost three pages of definitions followed by 64 pages of cryptogrammetry, the art of unraveling the most exciting molecular puzzle in science. The story starts with the Gamow era: "This one communication (in 1954) of Gamow's did more than any other single event to fire scientific interest in the biological code." At the end, an appraisal of the evolution of the fantastic machinery that reads and translates the code conveys a sense that large molecules have special properties. These must be physical attributes that make it possible for life to withstand random motions and events at the molecular level.

The physical entity that contains the primary, encoded molecules is discussed in the last paper, "Chromosome Structure," by Arthur Cole, which summarizes the 20 different models of chromosomes that have been proposed since 1956. This is a valuable review because it pulls together the results of widely diverse experimental methods of analysis. There are fibrils; there are coiled structures, and there is evidence for the histones. But the problem remains: How is this central and self-replicating source of information put together? How is the 200-cm-long DNA molecule wrapped up to fit into the 15-micron-diameter tissue cell?

The editor has given biophysics a new, and much needed, point of view in a timely and stimulating volume 1. The copious and up-to-date references after each paper cover the subjects thoroughly. Illustrations and supporting tables are numerous and more than adequate. There is an author and a subject index in addition to the table of contents.

* * *

The reviewer carries on biophysical research in the physics department of the State University of New York at Buffalo.

Waves around the world and over the horizon

IONOSPHERIC RADIO PROPAGATION. (Reprint of 1965 ed.) By Kenneth Davies. 470 pp. Dover, New York, 1966. Paper $2.25

by H. J. Hagger

The knowledge of electromagnetic wave propagation in the ionosphere is not only important for long-distance communication at high frequencies, but also for scatter propagation in over-horizon links on very-high frequencies. For both, the behavior of the ionospheric medium to electromagnetic waves is of particular interest.

This book is a reprint of NBS Monograph No. 80 published in 1965 and an extension of an earlier publication by NBS (1948) due to special efforts made during the IGY(1964–65). In chapter 1 the author discusses the roots of the problem, for example the atmosphere of the earth, its magnetic field and the influence of the sun. In the next chapter the reader becomes familiar with the basic ideas of ionospheric radio-wave propagation. Starting with the principles of electromagnetism, the book considers motion of charged particles in electric and magnetic fields and Appleton's formula for the refractive index of the ionosphere, and some properties thereof are derived.

In chapter 3 the various methods for measuring the ionospheric parameters are discussed. In the next chapter high-frequency propagation (3 to 30 MHz), both for plane and curved earth and ionosphere, are investigated. The maximum frequency for reflection, experimental results and problems of long-distance (multihop) and multipath transmission are considered. In chapter 5, on signal strength, the author discusses the factors affecting the average power at the receiver (system loss) and the parameters that produce variations about the average (fading). In the first part of the chapter absorption and polarization effects are included in the discussion.

Chapter 6 is devoted to ionospheric disturbances and the author uses this term for numerous ionospheric conditions that show some departure from the usual state. Some of these are related to solar flares and to ionospheric storms associated with magnetic storms. In chapter 7 the reader is given an idea of how propagation in the ionosphere may be predicted, an analysis based on sun-spot number,

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the operation frequency, the season, the solar zenith angle and the radiation angle. We have to distinguish between permanent prediction, which is correct over a complete solar cycle, and monthly predictions, which are published several months in advance and mostly serve localized areas. The author then discusses the calculation procedures for one-hop distances over the F_2 layer (less than 4000 km) by using charts and nomographs. Later on larger transmission distances are considered.

In chapter 8 then the very important scatter-propagation problem is investigated. The author discusses D-region scattering at turbulent irregularities of the ionosphere, meteor scattering and reflections from a meteor trail, equatorial F scatter and auroral scatter. In the last section the author discusses the electron-density profiles of the atmosphere derived from radar scatter measurements. In the last chapter low- and very-low-frequency waves are considered. These waves, reflected from the lower boundary of the D-layer, can serve as an alternative to higher-frequency waves and they are less affected by ionospheric disturbances.

Extensive lists of references are added to each chapter and the book contains large indexes of subject, author and place. As a whole this book is well balanced between theoretical models and aspects and experimental data on ionospheric propagation. It will be extremely helpful to everybody who is engaged in propagation problems at high frequencies where the ionospheric layers of the earth play such an inportant role.

* * *

The concern of an electronic engineer engaged in systems engineering includes propagation phenomena of transmission. H. J. Hagger is associated with Albiswerk/Zürich, in Switzerland.

Physics and philosophy: closer

MIND AND COSMOS: ESSAYS IN CONTEMPORARY SCIENCE AND PHILOSOPHY. Robert G. Colodny, ed. 362 pp. U. of Pittsburgh Press, Pittsburgh, 1966. $8.00

by R. Bruce Lindsay

With the ever increasing preoccupation of professional philosophers with the facts and theories of science, the relations between the two disciplines have been growing ever closer. One result has been the proliferation of symposia and lecture series with the mutual participation of both scientists and philosophers. The present book is the outgrowth of such a series given under the auspices of the Center for the Philosophy of Science at the University of Pittsburgh in 1963–64.

Prefaced by an introductory summary by editor Robert G. Colodny, the book consists of ten essays of which the first eight are devoted to consideration of various problems posed by human thinking on the nature of science, while the last two (corresponding to the *cosmos* of the title) by Thomas Gold and Henry Margenau discuss respectively "Cosmic Processes and the Nature of Time" and "The Philosophical Legacy of the Quantum Theory," and hence are concerned with more specific aspects of science.

By far the larger part of the volume may be fairly described in terms of the word *mind* in the title, though the various contributions cover a wide and rather disparate array of subjects. Thus Herbert A. Simon of the Carnegie Institute of Technology leads off with an article entitled "Thinking by Computers," which is a brief analysis of the psychology of human thinking in terms of the way in which man has taught the computer to "think" (that is, solve problems) by appropriate programing. This is followed by a somewhat more ambitious essay by the same author on "Scientific Discovery and the Psychology of Problem Solving," in which an attack is made on what is undoubtedly one of the most challenging problems in the philosophy of science: an understanding of the ways in which scientific geniuses make their discoveries and inventions. Simon seeks a clue to this elusive puzzle in terms of a theory of problem solving, which deserves more extensive development, though in its preliminary form scarcely offers a guaranteed recipe for success in science.

The University of Chicago philoso-