disappear," whereas on page 53 we are told that many mRNA's appear to be stable and have, in fact, been isolated. Furthermore, these chapters are written with a historical approach that tends to cloud current concepts with details of older experiments. In summary, this half of the book is too disjointed for novices to the nucleic acid field, while being too elementary for those familiar with the subject. The same subject matter is more successfully covered in several of the current biochemistry textbooks.

The second half, on the other hand, conforms to the title of the book and is more profitable. Various enzymes of importance in nucleic acid research—albeit only nucleases and phosphatases—are individually discussed with respect to their use as reagents in the study of nucleic acid structure and function. The specificity, availability, and contaminating activities of preparations of virtually all known nucleases and phosphatases are described. A 26-page synoptic table of nucleolytic enzymes—probably the best tabulation of this sort to date—concludes this half. This section of the book should prove to be extremely useful to workers in the field as well as to those in other fields—for example, to geneticists, who are becoming more and more reliant upon these enzymes as specific catalysts.

It is unfortunate that the author chose to append to his treatment of enzymes the introduction to nucleic acids. Perhaps a future edition might instead expand the enzyme theme to include similar descriptions of other enzymes used to study nucleic acids, such as the various DNA and RNA polymerases, polynucleotide kinases, nucleotide kinases, DNA ligases, DNA and RNA methylases, and the DNA glucosylases.

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Smithsonian and Satellites

Trackers of the Skies. E. NELSON HAYES. Doyle, Cambridge, Mass., 1968. xiv + 178 pp., illus. Cloth, $5; paper, $3.

Before the beginning of the satellite programs in 1958, there was a curious and tantalizing situation. Within the United States, or within Europe (or India, or Japan), distances and directions could be calculated with an accuracy of the order of 2 parts in 1 million. However, equal or even shorter distances between points in Europe and points in the United States could be calculated only with a precision of the order of 100 parts per million; and even larger errors were feared. Each large triangulation system was thus like an iceberg, rigid in itself, but with only tenuous relations to other icebergs. There was an obvious military need to correct this situation. In addition, depending on what was supposed about the relations between these icebergs, one could obtain a wide range of theories of the general gravitational field of the earth. Isostasists such as Heiskanen believed that the general field approximated closely that of a fluid in hydrostatic equilibrium; while others, Jeffreys in particular, maintained that there were broad deviations from isostasy, which implied stress differences up to 100 bars deep in the mantle.

The satellite-tracking programs of the last ten years have cleared up this century-old difficulty in a most striking way, so that intercontinental distances and directions are now very nearly as precisely calculated as those within the continental triangulation nets. It has turned out that Jeffreys was right; the field is substantially as he believed and the interior is indeed in a state of stress. In this great advance, the precise optical determinations of the Smithsonian Astrophysical Observatory have had more weight than those of any other program, and very likely more than those of all other programs combined.

This book is a history of the Smithsonian program by an insider, a member of the Cambridge staff. It gives a good idea of the difficulties of the program as seen from within: the embarrassing delays in the procurement of telescopes; the built-in problem of field directors versus central staff; the steady change from a rough-and-ready group of pioneers to a well-organized and precisely functioning system; the public need for information about the program and for participation in it, especially through the Moonwatch program. All of these headquarters-type problems are set out with clarity and humor.

The weak point of the book is in its discussion of the relation of the Smithsonian program to geodesy in general, to other tracking programs, and to investigators who were not at the Smithsonian. The question of intercontinental connections is not mentioned; the utilization of Smithsonian data at U.C.L.A., Tokyo, the Applied Physics Laboratory, and elsewhere is not discussed. The part played by persons outside the Smithsonian in shaping the program is omitted. These omissions deprive the book of a good deal of color, and they deprive the reader of insight into the meaning of the Smithsonian program to the scientific community and the nation.

The book will be of interest to those who have had contact with the tracking problem, whether through the Moonwatch effort or through a relation to mapping or geodesy.

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Astrophysics

Principles of Stellar Evolution and Nucleosynthesis. DONALD D. CLAYTON. McGraw-Hill, New York, 1968. xii + 612 pp., illus. $22.50.

There has been a conspicuous lack of a readable, up-to-date textbook in the related fields of nuclear astrophysics and stellar evolution theory. This book, aimed at the beginning graduate student, goes a long way toward filling that need. Indeed, the initial reaction of students appears to be receptive.

The book is well suited for a two-term course, with equal emphasis on the nuclear and stellar aspects. Three of the chapters are concerned with the former and three with the latter, in addition to an introductory chapter dealing mostly with the observational basis of the subject. Although the order of the chapters does not correspond to this division, they are to some extent independent.

A major merit of this book is that it is easy to read, with a pleasantly high ratio of words to equations. However, mathematical details are usually not neglected if necessary for an understanding of the meaning of a result. The derivations which are included are straightforward and usually in contact with the physics of the situation. Examples are the discussions of sources of opacity and the nuclear Coulomb penetration factor. There are many useful formulas, tables, and figures not easily found in the literature.

One of the few criticisms that may be advanced is the tendency of some

of the references to previous results in the text to be obscure. In addition, the basic observational data for the theory of nucleosynthesis, the observed abundances, receive insufficient attention. Misprints and numerical errors appear to average about one per ten pages; many of them are not critical, however.

In summary, most of the basic physical principles necessary to begin work in this fundamental area of astrophysics are presented clearly in this book. It is a welcome appearance.

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Brain Circuits and Body Movement

Neurophysiological Basis of Normal and Abnormal Motor Activities. Proceedings of the third symposium of the Parkinson's Disease Information and Research Center of Columbia University, New York, 1966. MELVIN D. YAHR and DOMINICK P. PURPURA, Eds. Raven Press, Hewlett, N.Y., 1967. xii + 451 pp., illus. $25.

How do we move? The problem of finding out is inherently difficult. It is hard to produce and control movement of the vertebrate animal in the laboratory. The "output stage" of the motor system is a complex array of muscle, tendon, bone, and joint, and the normal activities of the system are not easily observed with accuracy. The neural structures that control its output are many and are not interconnected in any simple, linear fashion; moreover, they are intimately connected with many other, "nonmotor" parts of the brain. But this is the question and the problem which brought scientists and physicians together in 1966 for the third symposium of the Parkinson's Disease Information and Research Center in New York. The result is a book consisting of 17 individual articles and the recorded discussions; it is written in professional language and is addressed primarily to workers in the field. Though the book is not a review, with its discussions and bibliographies it includes or refers to most of what is new knowledge and, in displaying the kinds of questions that are asked and approaches that are used, it permits the reader to judge the prospects for future discovery.

The questions often concern the layout of anatomical circuitry. Oscarsson summarizes his work on pathways connecting peripheral nerve and spinal cord to cerebellum, discovered with the classical methods of electrical shock, potential-recording, and ablation. Ajala and Poppele discuss vestibular connections to cerebellum and spinal cord. Welt *et al.* describe a path from skin and deep receptors in small portions of a limb to columns of cells in the motor cortex, which then project back to muscles within that portion of the limb. Preston *et al.* study differences between cat and baboon with regard to how pyramidal tract neurons of the motor cortex are connected through to spinal motoneurons. Klee and Wagner offer evidence that the spinal afferent fibers that excite the motoneuron across a single synapse contact its dendrite and the fibers that excite it only after several synapses influence mainly its soma. Another question concerns the kind of synapse—excitatory or inhibitory—that exists between cells in a particular pathway. Ito describes how cerebellar Purkinje cells inhibit and cerebellar nuclear cells excite the cells that they contact; Shimazu how inhibitory as well as excitatory neurons exist within vestibular nuclei and what pathways link them; and Purpura *et al.* how thalamus, caudate, putamen, globus pallidus, and substantia nigra are linked by excitatory and inhibitory connections.

Several approaches are aimed at defining the function of an element—a cell or group of cells—in the circuit in which it is placed. One approach asks what kind of output information is made by an element from its input information. Granit and Kellerth discuss how natural stimuli and gamma-motoneurons influence muscle receptors (with a concise summary of what is known about tendon organs and nuclear bag and nuclear chain spindles) and how the output then influences motoneurons. Henatsch, in similar experiments, applies control theory to analyze the input-output relationship and further specify how spindles might operate as elements in a feedback loop controlling muscle tension and length. Eccles, arguing from the type and distribution of information that enters the cerebellum from the spinal cord and the characteristics of the cerebellar machinery that processes it, predicts properties of the cerebellar output. Another way of specifying how an element functions in a circuit is to over- or underactivate it and look for differences in the output of the system: deVilliers *et al.* stimulate various parts of the brain in an attempt to learn more about the tremor of Parkinson's disease; Denny-Brown reviews his work on ablating parts of the brain and deducing from the behavioral deficit what they normally contribute to behavior. A final approach consists of observing the behavior of neurons during the natural behavior of the animal to see if some specific relationship exists between the two—a relationship that might serve as a clue to what the neurons contribute to the circuits that control behavior. Pompeiano thoroughly reviews work showing a "disconnection" of visual and somesthetic pathways during the eye and body movements that occur in dream-sleep, and gives reasons for believing that the vestibular nuclei are fundamentally involved. Evarts describes a new technique in which cell activity is recorded in monkeys during arm movements that they have been taught to make. Cells in the motor cortex that give rise to the pyramidal tract discharge in advance of and in relation to the exertion of force by the monkey during movements of the arm, a causal relationship being thereby suggested.

Two papers are directly concerned with pathologic movement: that of Eldred *et al.*, which demonstrates changes in muscle spindles resulting from immobilization; and that of Mettler, which offers a description of movements altered by brain lesions.

One might wonder how applicable some of these findings are to the patient with Parkinson's disease or to normal man. One problem is that the need to simplify an experiment often results in the choice of an animal that is very different from man, one that may be too different if our object is to learn about human movement. A more serious problem stems from our long habit of simplifying an experiment by surgically simplifying a complicated animal. The problem is that movement—for students of it—consists so completely of stereotyped reflexes and postural adjustments that we at times risk losing sight of what we are trying to explain. But this book gives no cause for pessimism. It illustrates powerful methods for outlining brain circuitry and some promising new methods for discovering how the circuits work.

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