exploitation of marine resources are all too aware of this urgency; they, and indeed all who use the sea, will find in these proceedings both a helpful guide to the current situation and a challenging list of problems which demand prompt solution.

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A Science in the East

A History of Japanese Astronomy. Chinese Background and Western Impact. SHIGERU NAKAYAMA. Harvard University Press, Cambridge, Mass., 1969. xvi + 334 pp., illus. $10. Harvard-Yenching Institute Monograph Series, vol. 18.

The history of astronomy in the cultures of East Asia, developing as that great science did in those regions wholly independently of the West, has always been one of the most fascinating chapters of the history of astronomy in general; but in Western languages there has been much less on Japan than on China. This has partly been because Japanese astronomy, though showing much originality, was fundamentally derivative from the older science of China, and partly also because the Japanese language and sources have been even less well known to sinological historians of science than those of the Chinese. Now, however, Japan has produced a scholar whose supremely competent book, here reviewed, is worthy to be placed on the same shelf as the basic contributions of Gustav Schlegel, Léopold de Saussure, and Henri Maspero. If it was not printed in Japan (and there is no evidence that it was), the Harvard University Press deserves warm congratulations for the masterly intercalation of the numerous Chinese characters in the text, abundant footnotes, and bibliography. This last follows the system of the *Science and Civilisation in China* series, but with the useful modification of keeping italics for the titles of published books, and putting the names of manuscripts within quotation marks—a point worth mentioning because it illustrates another great merit of the work, the author's copious use of manuscript material preserved in the Japanese libraries.

Nakayama's general approach is that of a study in the transmission of ideas. First he follows the absorption and adaptation of Chinese astronomy in Japan during the millennium from A.D. 600 to 1600, then he divides the period of the Tokugawa Shogunate into two. From 1600 to 1720 European astronomy was challenging the older ideas and methods in Japan, but the Chinese influence still remained overwhelming. From 1720 to 1880 the supremacy of "Western" (that is, modern) astronomy was gradually recognized. At this point the author terminates his study, which is illustrated by numerous graphs and geometrical diagrams. Particularly valuable for medievalists are a chapter on astrology and another on Chinese calendrical science. It is true, as Nakayama says, that the latter has been inadequately treated by previous historians, who have not always realized that each "calendar" was really an ephemeris, a treatise in itself and a new set of tables—and there were more than a hundred of them during the past two millennia—but this neglect was not only "because of technical complexity and the lack of a Western counterpart," it came about also because the only really adequate study of the calendars, due to Yabuuchi Kiyoshi, was (and to this day remains) in the Japanese language. Much of the most interesting material in Nakayama's book is contained in ten appendices, from which may be cited such appetizing items as "the derivation of Asada Gōryū's formula for the variation of tropical-year length" and "Takahashi Yoshitoki's epicyclic theory of trepidation."

The admiration of this reviewer for Nakayama's book will have already become evident, but there are two criticisms I cannot forbear voicing. First, it may be a little disappointing to some not to learn more about the observatories of late medieval and early modern Japan—where they were established, who supported them, and how they were equipped. Our author must certainly know, and perhaps could be persuaded to write a further monograph on this interesting subject. Second, one feels throughout a characteristic somewhat grudging tone toward Chinese civilization, mother of all East Asian science (see, for example, pp. 12ff., 15, 63, 74); modification of this would have given an even higher quality of objectivity to the whole. It is probably partly just because the author himself, trained, after all, as a modern scientist, feels he owes more to Western than to Chinese civilization; but possibly also partly because an admiration for traditional Chinese culture has been closely connected at times in Japanese history with the regrettably nationalist and insular outlook of Neo-Shintoism (p. 8), to say nothing of the absurdities of the Buddhist monk Entsū (1754 to 1834), who spent his life fighting against Copernican astronomy in the interests of the traditional Indian-Buddhist Mount Meru cosmology (p. 211ff.). However, there are places where the author speaks in reasonably generous terms of the scientific achievements of the parent civilization of East Asia.

All in all, the present volume must be saluted as one of the most valuable additions of our time to the growth of knowledge about the development of the exact sciences in the civilizations of East Asia.

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Zoological Engineering

Animal Mechanics. R. MCNEILL ALEXANDER. University of Washington Press, Seattle, 1969. xiv + 348 pp., illus. $9.50. Biology Series.

This unusual and interesting book describes the application of some of the principles of mechanics to a wide range of zoological investigations. Although Alexander comments that his book was written for zoologists with a long-forgotten knowledge of physics and no knowledge of engineering, this reviewer, an engineer with a limited background in biology, found the book very worthwhile.

The book is divided into seven chapters, each dealing with a different area of mechanics: force and energy; joints and mechanisms; elasticity and viscosity; strength; pressure, density, and surface tension; motion in fluids; and vibrations and sound. Within each chapter, sections describing the physical theory alternate with sections on zoological applications. The topics covered include such diverse matters as an elasticity theory interpretation of the shape changes of a flatworm, a study of fluid pressures in a burrowing bivalve mollusk, wind tunnel tests of the yaw stability of a gliding shark, and discussions of acoustic impedance matching in the human ear. The numerous comparisons between biological and engineering mechanisms are quite instructive. For example, the author shows that the alula feathers of a pigeon's wings increase the lift coefficient in a manner analogous to that of slots in the wings of a modern airplane. Often a single zoological topic is viewed from a number of mechanical aspects. For example, the forces exerted by the muscles of a jumping locust are estimated by means of engineering force balances; an examination is made of the elastic stability of a locust tibia with respect to these forces; the wing movements of a locust and energy requirements for flying are discussed.

The author explains the fundamentals of the various mechanical principles with clarity and in great detail. Most of the mathematical derivations are omitted, but their sources are thoroughly referenced. Similarly, the bibliography of the zoological investigations is very complete. The large number of diagrams includes not only graphs of final results but drawings of the experimental details as well. The style of writing is pleasantly relaxed and informal, qualities infrequently found in scientific publications.

Animal Mechanics can be recommended to several kinds of readers. It could serve as an excellent text for an undergraduate course in zoology, although an instructor would probably wish to treat many of the topics in greater depth. The zoologist should find the book a useful guide to the literature (Alexander cautions, however, that the book is not a review, but is intended to be an interesting and representative sampling of the research in the field). Finally, the engineer or physical scientist will find a description of nature's engineering sophistication both fascinating and enjoyable reading.

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Problems in Genetics

Replication and Recombination of Genetic Material. A conference, Canberra, Australia, 1967. W. J. PEACOCK and R. D. BROCK, Eds. Australian Academy of Science, Canberra, 1968. vi + 278 pp., illus. Paper, $5.50.

This symposium of 24 papers serves as a much-needed review of modern experiments aimed at deduction of the mechanisms of genetic recombination, across the spectrum of organisms, and, to a more limited extent, DNA replication. Despite the fact that two years have elapsed since presentation of the papers, they are still relevant and highly thought-provoking, and in some cases they anticipate more recent work. In view of the delightfully and admittedly speculative mood which seems to have prevailed for some authors, it is a tribute to their intuition that so few reversals of opinion have since occurred. The comparatively primitive state of development of work with higher organisms appears in sharp contrast to the more rigorous documentation in microorganism research. One of the more exciting byproducts of the work with microorganisms is Spiegelman's report of test-tube selection through a number of generations of an abbreviated form of an RNA virus possessing high affinity for its replicase and thus possible specific ability to interfere with replication of the normal ancestral virus.

Although some form of break and reunion (probably involving formation of hybrid DNA) was regarded as the probable mechanism for all or most forms of crossing over, synapsis and the establishment of breaks at precisely corresponding points in homologues (a requirement of all such models) remain enigmas. It was commonly agreed that the only molecular mechanism in sight for homologous synapsis at the nucleotide level invokes complementary base pairing. Holliday suggested that discontinuities responsible for polarity of recombination in molds may represent specific nucleotide sequences ("recombinators"). If these are distributed with fairly high frequency along chromosomes, either the chance of recombination at any location would be low (as conceived in Pritchard's effective-pairing-region model) or the activity of the breaking enzyme would be so low it would bind to only a few sites. Holliday further supposed that this enzyme would have two binding sites and an ability for allosteric transition, which would allow endonucleitic properties only when both are bound, with the desired result: breakage at corresponding sites in homologues. (He pointed to a superiority of his recombination model over that of Whitehouse and Hastings for such a system as well as for the solution of other knotty problems.) Other studies lead to the concept of preformed gaps or weak linkages in nucleotide chains as potential locations of crossover initiation. Howard-Flanders, Rupp, and Wilkins proposed a genetic repair mechanism in bacteria following radiation damage and replication whereby a gap opposite a dimer would be filled by copying a sister duplex which is intact and undamaged at this point. In the process sister exchanges might also occur. Plaut envisioned a pattern of replication coordinated throughout the chromosome of higher organisms. Rhoades enumerated a number of careful studies of correlation of genetic recombination with pachytene synapsis and argued (with questionable plausibility) that these suggest complete synapsis prior to establishment of crossovers.

Martin stressed some of the evidence for polynemy in eucaryotes (particularly discontinuous variations in genomic DNA content among related species) and presented electron micrographs showing apparent subchromatid structure in *Vicia faba*. Holliday pointed out that while polynemy is not an insurmountable obstacle to the application of hybrid DNA recombination models (such as his own and that of Whitehouse and Hastings), conversion, postmeiotic segregations, and allelic recombination (which such models seek to accommodate) are unknown in organisms where polynemy may exist, a contention only partly true, since there is evidence for both allelic recombination and polynemy in at least two organisms, maize and *Chlamydomonas.*

A common apparent misconception of a number of participants was that the nuclei of *Chlamydomonas reinhardi* (octet strain) gametes have been shown to be in G_2 at zygotic fusion. At the time of this symposium the matter was at least in doubt, while more recent work strongly implies that gamete nuclei at fusion may contain the DNA quantity typical of G_1. The issue is of considerable importance because this and other peculiarities of the life cycle of the organism, together with its apparent conventional nuclear genetics, suggest the existence of a chromatid structure which is at least bineme.

Wolff and Heddle raised timely cautionary notes on the use of experimental procedures which may introduce serious errors which are easily overlooked—tritiated thymidine may induce some exchanges, and radiation may upset cell cycle synchrony.

Peacock concluded, with probable undue confidence from the results he described, that crossing over occurs at pachytene (unless one accepts his unique definition of the stage as including a very early period when one autosome is heteropycnotic and others diffuse, instead of the traditional: period of maximum synapsis). His conclusion that sister chromatid exchange and homologous chromatid exchange require different mechanisms also seems perilously founded. His most uncontroversial con-