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 contribution (and a very important one) appears to be evidence that tritium-labeled extra univalents found after heat treatment in his grasshoppers result from genuine heat-induced depression of crossover frequency later than the major premeiotic DNA synthetic period, rather than from complete chiasma terminalization.

Several symposium participants (D. G. Catcheside; D. E. A. Catcheside; Holliday, Lindsley, Sandler, Nicoletti, and Trippa) demonstrated ingenious use of meiotic mutants to study the mechanics of the process and pointed to their potential utility.

There are many other outstanding findings, deductions, and constructive speculations offered in the volume which cannot be mentioned in a brief review. The entire symposium is probably an indispensable reading and reference source for students of genetic recombination.

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Impact Structures

Shock Metamorphism of Natural Materials. Proceedings of a conference, Greenbelt, Md., 1966. BEVAN M. FRENCH and NICHOLAS M. SHORT, Eds. Mono, Baltimore, 1968. xii + 644 pp., illus. $25.

In 1807, Thomas Jefferson wrote in a letter concerning an alleged meteorite fall: "It may be difficult to explain how the stone you possess came into the position in which it was found. But is it easier to explain how it got into the clouds from whence it is supposed to have fallen?" Sixty years ago, few imagined that the earth had been bombarded throughout history by meteorites large enough to form impact craters. Yet in the past ten years more than 35 circular terrestrial geologic structures have been described as impact structures and have been accepted as such by most geologists. Many more have been recognized on the moon and Mars by manned and unmanned space probes. Impact may be a quantitatively significant geological process, for some postulated impact structures, such as the eastern shore of Hudson Bay, are hundreds of kilometers across, and others, such as Sudbury, Ontario, are large and of economic significance.

In order to recognize impact structures, certain criteria of impact must be developed. One of these criteria, and perhaps the main one responsible for the identification of so many new impact structures, is the presence of shock metamorphism. Investigations of shock metamorphism are concerned with the changes caused by shock waves in rocks and minerals, the mechanics of cratering, and the phase equilibria and changes in structure of materials subjected for short times to temperatures above 2000°C and pressures in the megabar range. The applications of such studies to extraterrestrial structures, and to the interpretation of meteorite and tektite mineralogy, are obvious. The field is new, active, and multidisciplinary, so that by 1966 it was ripe for that mixed blessing, a symposium, and a consequent symposium volume.

The 44 papers and 10 abstracts in the book may be classified in one or more of four categories: the physics of shock waves in solids; the effect of shock experiments on rocks and minerals; the geology, mineralogy, and petrography of cryptoexplosion structures; and (each the subject of a short section) the mechanics of cratering, shatter cones, and static high-pressure experiments.

There are many good papers, and several excellent ones, which more than justify the book's existence. French's introduction is a very concise summary of the field, and his discussion of the evidence for an impact origin for the Sudbury Basin is an excellent paper that is of particular interest to mining geologists. His microphotographs are the best in the book, where the general standard is high. Chao's and Von Englehardt's papers on progressive impact metamorphism are excellent discussions, although a joint paper perhaps would have been even better. Roddy's paper as a case history of a cryptoexplosion crater is outstanding. He discusses the geology and geophysics of the structure and compares them to those of volcanic craters, impact craters, and artificial craters. In so doing he develops a set of geological and geophysical criteria for impact. Cummings and Carter present tight papers on progressive shock metamorphism of biotite and quartz, respectively.

The book is patchy. Some papers are far too long, and filled with dreary descriptive detail, even to the inclusion of well logs. Admittedly the field is at a descriptive stage, but to devote approximately 120 microphotographs and 80 pages of text to shock quartz is out of balance when one or two competent review articles would suffice. One paper devotes 13 pages to a negative result. One or two other papers are merely rehashes of talks and papers which people in the field have heard now for several years.

Now that so much descriptive work has been accomplished, the next step is the understanding of the mechanisms of impact metamorphism from the crystallographic scale to the mega scale. No doubt detailed crystallographic analysis, which was lacking in the present volume, will be performed on shocked minerals, and the studies on the nature of high-pressure glasses and their pressure-temperature histories, as presented by Bunch *et al.*, Duke, and Bell and Boyd in this book, will become more extensive. The results of a second shock metamorphism symposium in about four years should be even more interesting than those of the first. In the meantime, a textbook on impact metamorphism and cratering is needed.

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Books Received

The Archaeology of Martha's Vineyard. A Framework for the Prehistory of Southern New England. A Study in Coastal Adaptation. William A. Ritchie. Published for the American Museum of Natural History by the Natural History Press, Garden City, N.Y., 1969. xviii + 254 pp., illus. $15.

Audience Analysis for Technical Writing. Thomas E. Pearsall. Glencoe, Beverly Hills, Calif.; Collier-Macmillan, London, 1969. xxii + 114 pp., illus. Paper, $3.95.

Audio-Tutorial Introductory Biology: Principles. Marvin R. Barnum, Robert J. Gillespie, Arnold J. Greer, and Louise K. M. Peardon. Glencoe, Beverly Hills, Calif., 1969. vi + 266 pp., illus. Paper, $4.95. Revised version of the 1967 edition.

Basic Technical Mathematics. Thomas C. Crooks and Harry L. Hancock. Macmillan, New York; Collier-Macmillan, London, 1969. viii + 472 pp., illus. $8.95.

Beyond the Milky Way. Galaxies, Quasars, and the New Cosmology. Thornton Page and Lou Williams Page, Eds. Macmillan, New York; Collier-Macmillan, London, 1969. xvi + 336 pp., illus. $7.95. Macmillan Sky and Telescope Library of Astronomy, vol. 8. Material first appeared in slightly different form in *The Sky, Sky and Telescope,* and *The Telescope.*

The Biological Code. M. Yčas. North-Holland, Amsterdam; Interscience (Wiley), New York, 1969. xiv + 362 pp., illus. $11.95. Frontiers of Biology, vol. 12.

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