mostly males, have tended to favor male-chauvinist theories. Anthropologists are all adults, and I suspect that they have favored adult-chauvinist theories also. Perhaps some young-in-heart female anthropologist could be persuaded to enlarge on G. E. Hutchinson's suggestion (*The Ecological Theater and the Evolutionary Play*, Yale University Press, 1965, pp. 91–94) that adult intelligence is an accidental and nonadaptive outcome of selection for minimal human intelligence arising as early as possible in childhood.

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A Theory of Biogenesis

Molecular Evolution and the Origin of Life. SIDNEY W. FOX and KLAUS DOSE. Freeman, San Francisco, 1972. xvi, 360 pp., illus. $16.

The title of this latest monograph on the beginnings of life suggests a general and balanced discussion of the subject as a whole. The book is better characterized as a detailed presentation of the thermal, or proteinoid, theory of origins embellished with only fragmentary excursions into other points of view. However, the authors' enthusiasm for the thermal theory is clearly based on the impressive body of experimental evidence reviewed in chapters 4 through 6. In fact, the chief merit of the book is that it presents in one continuous argument an array of carefully conducted, reproducible experiments spanning nearly the whole range of presumed prebiological events up to the appearance of microscopic structures. These "microsystems" exhibit a remarkable array of rudimentary analogs of cellular processes. In view of the considerable gap between the most complex microsystems and the simplest contemporary cells, however, the authors' direct application of such biological terms as "life-cycle," "replication," and "organism" to proteinoid microspheres is difficult to justify.

The authors stress the point that the heterogeneous, hypohydrous conditions often used in thermal experiments are more germane to prebiological evolution than the dilute aqueous model favored by other investigators. They point out that contemporary cells are not homogeneous aqueous systems but rather consist of numerous phase boundaries and hydrophobic regions. Convincing arguments are given that heat was a significant free energy source on the primitive earth (an idea which has been sharply criticized), and that specialized (for example simulated perivolcanic zones) rather than average geochemical conditions (for example the open seas) are preferable in origin-of-life research.

A major theme of the monograph is the extent to which nonrandom, internally directed ordering processes are detectable in the thermal experiments, especially in the pyrocondensation of amino acids. It is doubtful that such sequence ordering in the absence of nucleic acid represents prebiological accumulation of information as the authors imply. "Information" implies a choice among equally probable events, not simply the accumulation of order due to preferred chemical interactions. Of interest here are the recent results on primitive coding properties of microsystems containing synthetic homopolynucleotides (chapter 6). The authors claim that "conditions were found . . . which yielded for each of the four homocodonic amino acids . . . interactions suggestive of a stereochemical basis for the genetic code" (p. 231). This is sure to stimulate much critical discussion in view of the hitherto fruitless search for preferred direct interactions between amino acids and their respective codons.

An especially strong feature of this monograph is the authors' insistence on rigor in conducting and interpreting experiments. They aptly criticize claims of synthesis of biochemicals based on only a single analytical procedure and warn against premature judgments that go beyond the available hard data. Their discussion of the prebiotic synthesis of "micromolecules" (chapter 4) conforms admirably to their stated principles.

The high level of competence of chapters 4 through 6, which constitute the heart of the argument, is unfortunately not maintained in the rest of the text. Especially disappointing is the discussion of optical activity (chapter 8). The authors do little more than describe ways to resolve racemic mixtures. Much more can and should be said on this matter. The problem is not how stereoisomers might have separated on the primitive earth but how life came to "prefer" L- rather than D-amino acids and D- rather than L-sugars. This kind of cursory treatment of topics outside the thermal theory is one of the less appealing features of the book. Alternative pictures of biogenesis are often not adequately explored. The rich chemistry of ammonium cyanide, which includes the formation of dynamic microscopic units, deserves more extensive consideration as a major alternative model for protocell development.

In spite of its defects, this monograph is a major contribution to the literature of biogenesis. The sheer magnitude and scope of the laboratory evidence for the proteinoid theory of origins more than make up for the uneven quality of the writing.

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A Possible Phylogeny

Evolution of the Metazoan Life Cycle. A Comprehensive Theory. GÖSTA JÄGERSTEN. Translated from the Swedish edition (1968). Academic Press, New York, 1972. x, 282 pp., illus. $15.50.

No event exerted a more profound influence on all subsequent animal evolution than the origin of multicellularity. How many-celled animals originated and whether this step occurred one or more times and in one or more ways remain difficult and ever-debated questions that are perhaps, as John Corliss has said, "in the last analysis, quite unanswerable." Nevertheless, these questions continue to evoke interest among zoologists, and new evidence pertinent to the several competing theories of metazoan origin continues to accumulate, particularly as new sources (for example cell ultrastructure, comparative biochemistry, and genetics) are tapped.

In the 1950's the author of this book contributed a new theory of early metazoan phylogeny, based on Haeckel's 19th-century theory of origin via gastrulation of a flagellate protozoan colony. Jägersten proposed that metazoan origin was associated with the change from a pelagic *Volvox*-like colonial flagellate to a form which turned to life on or near the bottom, eventually crawling along with the aid of flagella. In connection with this change in habitat, it evolved an anterior-posterior axis of differentiation and a ventral side against the substratum. The ability to eat large food items would be advantageous to an organism with such habits, and the next stage was the arching up of the

ventral side, the first step in forming a digestive cavity by invagination. Jägersten's model ancestral metazoan, "*Bilaterogastraea*," thus emphasized (and provided adaptive significance for) the basic morphogenetic process of invagination, which the older theories had failed to account for. However, it also required that the primitive coelenterate that resulted be bilaterally symmetrical, benthic but not sessile, and with oral surface oriented downward.

I have expounded Jägersten's theory in some detail here because his book assumes the validity of the Bilaterogastraea theory and its consequences, although it devotes but a sentence (on p. 216) to review of it and does not defend it at all. The reader is merely referred to the author's earlier papers, although an understanding of them is required to appreciate some of the arguments presented in the book.

Much of the book documents the ubiquity of the "pelago-benthic" life cycle (consisting of pelagic larva and benthic, nonsessile adult) among the animal phyla to support the argument that this type of life cycle "dates back to the common ancestral forms of all metazoans" and that "the pelagic larval type has thus persisted in ontogeny without interruption since its first appearance." The main extension of theory is thus that *Bilaterogastraea* and most of its descendants retained a pelagic, distributive, primary larval phase in the life history, and that entirely benthic and entirely planktonic life cycles with direct development are derived or secondary phenomena.

Here Jägersten is on fairly firm ground. (Its stability does not depend on acceptance of the Bilaterogastraea theory.) He cites cases from a number of phyla of larval forms with benthic, direct embryogenesis showing distinct vestiges of adaptations to pelagic life. Benthic adult adaptations appearing in pelagic larval stages (the molluscan foot, for example) are considered accelerations that may fit the metamorphosing larva more rapidly for the adult habitat. Jägersten coins the term "adultation" for this precocial incorporation of adult characters in larvae and notes correctly that it should not be taken as evidence that the larvae resemble ancestral adults.

Jägersten's attributions of adaptive significance of larval features occasionally lead (as does the Bilaterogastraea theory) into brambly phylogenetic thickets. Two confusions mar some of the arguments: the author sometimes seems too ready to equate generality of a condition with primitiveness, and he does not provide clear recognition of the principle that from the finite genetic reservoir of an evolving line natural selection constantly effects compromises between conflicting selective pressures.

Science fiction, according to a current dictionary, is "fiction in which scientific discoveries and developments form an element of plot or background." Books such as this one, avidly propounding a particular theory of early metazoan evolution, belong to this genre. The early evolution of the animal phyla and the determination of their major features occurred gradually, perhaps over hundreds of millions of years and 2 or 3 billion years ago. The true phylogenetic relationships remain uncertain. Scientific discoveries and developments are largely restricted to comparative analyses of extant organisms, and the rest is speculation. However, the ratio of information to fiction continues to increase, and speculative syntheses stimulate improvements in the generalizations from observable facts by which we explain order and pattern in nature.

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Mechanisms and Perturbations

The Changing Chemistry of the Oceans. Proceedings of a symposium, Lerum and Göteborg, Sweden, Aug. 1971. DAVID DYRSSEN and DANIEL JAGNER, Eds. Almqvist and Wiksell, Stockholm, and Wiley-Interscience, New York, 1972. 366 pp., illus. $21.50. Nobel Symposium 20.

The assertion implicit in the title of this Nobel symposium volume is plausible, but very far from demonstrated. The editors and authors of this intelligently organized series of papers and discussions refrained, therefore, from presenting the usual disconnected string of horror stories one has come to expect from "environmentalists" and have rather directed their energies at trying to identify and understand the mechanisms controlling the composition of seawater and at posing the question What would it *take* to change the chemistry of the oceans? The one exception, a laconic account by Jun Ui of "A few coastal pollution problems in Japan," gains much of its very powerful impact from this context.

It is a common attitude that the environment is "given" or static, that if one dumps mercury or injects CO_2 or SO_2 or whatever into it it will change to some new state. This concept finds expression in "base-line studies" made to characterize a particular system at time zero before an unnatural event—dredging, spraying, clear-cutting—takes place. The results of these studies are indistinguishable from legal briefs and indeed are rarely used or referred to unless something goes wrong. Seldom is a conscious effort made to understand the mechanisms controlling the "base-line" values. The approach is empirical, not predictive.

It is a distinguishing feature of this symposium that little space is expended on such efforts. Indeed, L. Machta in updating the greatest and most elaborate base-line study of them all—the monitoring of atmospheric CO_2 levels—shows how inadequate short time series measurements are in the characterization of any species actively involved in the geochemical processes in the terrestrial environment.

The symposium was organized as a rather interesting mix of reviews and research papers. Most of the major perturbations that man knows he is in the process of inflicting on the environment are well discussed. Thus, in addition to the CO_2 system, the cycles of organic carbon (Sorokin, Skopintsev), sediments (Goldberg), phosphorus (Stumm), and sulfur (Berner) are given detailed treatment. A great deal of current information is assembled in the process, making the volume a valuable resource. Useful discussions of the large-scale oceanic circulation (Veronis), of the natural fluctuations of oceanic and atmospheric conditions (Namias), and of the factors controlling marine ecosystems (Steele) provide a context within which to place the measurements.

The research reports are a mixed bag. Those on manganese nodules and the trace element cycle (Lal) and N_2O (Hahn) contain much new information and are of considerable interest. Those on mercury (Jernelov) and DDT (Bowen) are rather short on numbers although they gain from the current importance of their topics. Large quantities of new data on marine aerosols are presented (Chesselet); they are not thoroughly discussed in relation to previous measurements, however, so the significance of the very peculiar reported enrichments of potassium and of the postulated presence of gaseous chlorine will be missed by the uninitiated.

Of the model papers, that on systems