National Institutes of Health, 12 April 1977.
5. *Chronicle of Higher Education*, 1 August 1977.
6. Recommendations for the Conduct of Research with Biohazardous Materials at Princeton University, 6 December 1976; Report to the Canadian Medical Research Council, from its Ad Hoc Committee on Guidelines for Handling Recombinant DNA Molecules and Animal Viruses and Cells, January 1977.
7. In their book *Who Should Play God?* (Delacorte, New York, 1977), T. Howard and J. Rifkin, of the People's Business Commission, put recombinant DNA research squarely in the tradition of "Eugenics: The ideology behind genetics research" (chapter 2). They see this tradition running from Victorian England through Nazi Germany to modern genetics research.
8. See, for example, the proceedings of the March 1977 National Academy of Sciences forum, *Research with Recombinant DNA* (National Academy of Sciences, Washington, D.C., 1977).
9. E. Chargaff, *Science* **192**, 938 (1976).
10. Support for this statement is given in correspondence under the heading "Evolution and Education" in *Science* **187**, 389 (1975).
11. L. Thomas, *Daedalus* **106**, 163 (1977).
12. P. Handler, in his annual report to the National Academy of Sciences; reprinted in *Chem. Eng. News* **55** (No. 19), 3 (1977).
13. See, for example, the questions raised about the spread of "nontransmissible" plasmids from *Escherichia coli* K-12 to other host bacteria within the gut: B. R. Levin and F. M. Stewart, *Science* **196**, 218 (1977).

A Phyletic Analysis

The Origin and Early Evolution of Animals. EARL D. HANSON. Wesleyan University Press, Middletown, Conn., 1977. x, 670 pp., illus. $35.

The origins of self-replicating living systems, of eukaryotic cells, and of multicellularity were pivotal events that profoundly affected the whole subsequent course of organic evolution. Hanson's opus focuses on the origin and evolution of unicellular and simpler multicellular animals, organisms that progressively lost crucial biosynthetic capabilities while evolving the ability to ingest organic compounds and other organisms to meet their material and energy needs.

This book primarily expands and elaborates on two earlier papers by the author. Hanson's goal is "the elucidation of evolutionary history and of the biological innovations that have emerged within the course of that historical development." His approach is to develop objective methods of evaluating the phyletic informational content of extant organisms, to examine and analyze the surviving descendants of supposed primitive animals within as rigorous a phylogenetic framework as possible, and to infer the major evolutionary trends leading particularly to the modern protozoans, sponges, cnidarians, and flatworms.

The origin and phylogeny of the simpler multicellular animals present a set of old and perhaps unanswerable questions that continue to evoke interest, largely because pertinent evidence continues to accumulate. How does Hanson's book stand in presenting new relevant facts, original theory, incisive analysis, and critical synthesis? Are new trails blazed through forests of phylogenetic trees? Are any phylogenetic hedges pleasingly pruned?

Most of the descriptive factual material derives from standard monographs on protozoology and invertebrate zoology. The book must have been inordinately long in production, because the review of original literature largely ends at 1971, unfortunately missing a number of subsequent studies relevant to the author's arguments. Examples are documentation of the presence of syncytial digestive tissue in acoel flatworms and of one cilium per cell in some pseudocoelomate worms (E. N. Kozloff, *Trans. Am. Microsc. Soc.* **91**, 556 [1972]; R. M. Rieger *et al., Zool. Scr.* **3**, 219 [1974]). And photoreceptor ultrastructure, a subject of extensive comparative analysis and controversy regarding its phyletic importance in lower metazoan groups over the last decade, is totally ignored.

Because its theoretical content also derives entirely from earlier studies (perhaps all possible ideas of the origin and early evolution of animals have already been proposed), the success of the book depends on the quality of its critical synthesis. This rests on: (i) Hanson's concept of the *seme*, the unit of phylogenetic information; (ii) adoption of Remane's criteria for detecting homologies; and (iii) a primarily cladistic approach, following Hennig, emphasizing the branch points of evolutionary trees over other aspects of change in time.

"A seme is an information-containing entity in an interbreeding population of organisms, but it will be most commonly used in reference to a structural or functional part of an organism, starting at the molecular level" (p. 89). A list of phyletically important structural, functional, developmental, and molecular semes is provided. Lack of information often precludes the use of more than a few. In each phyletic analysis where knowledge is judged adequate, Hanson employs about 12 semes. Examples are size, shape, and symmetry, feeding and digestive apparatus, skeletal structure, and pattern of ontogeny. All semes used are weighted equally. Each is coded as a qualitative multistate character, and an original generalized distance measure (R) is calculated from them. The value of R for a pair of taxonomic units increases with the number of neosemes (n; new character states) and aposemes (a; derived character states) and decreases with the number of plesiosemes (p; shared, primitive character states) according to the weighting indicated in the formula

$$R = [-p + (2a)^2 + (3n)^2]/t + 1$$

where t is the total number of semes compared. This measure is operationally defined, but arbitrary. The author's arguments would have been strengthened by comparison with other possible weightings and with unweighted methods and by comparison, and particularly demonstrated congruence, with other distance functions used in such analyses (discussed at length in Sneath and Sokal's *Numerical Taxonomy*, Freeman, 1973).

Hanson considers available knowledge adequate to permit determination of R values only within acantharian and ciliate Protozoa and turbellarian flatworms. Relationships between taxa generally regarded as classes and phyla are of necessity less rigorously presented. Hanson reiterates his earlier conviction that the turbellarian flatworm arose by cellularization of a ciliate. The sponges and cnidarians are derived from zooflagellates by colony formation and considered evolutionary dead ends. The evidence supporting these theories remains only as strong as in the earlier literature.

Hanson adheres rigorously to Remane's strong, objective criteria for determining homology, less so to Hennig's criteria of cladistic relationships. For example, "synapomorphy" (similarity because of shared, derived character states) is important in Hennig's methodology but does not enter the formula for R.

The three components of Hanson's synthesis listed above all have merit. His original contribution, the seme concept, guides selection of phylogenetically relevant characters. As Hanson points out, Remane's criteria of homology and Hennig's of cladistic relationships can be blended into a more inclusive theory and methodology for phyletic analysis. However, in my opinion these are more thoroughly treated by Sneath and Sokal in *Numerical Taxonomy*, evidently published after the completion of Hanson's manuscript, for it is not cited.

Hanson's general approach does clarify and increase objectivity in phyletic analysis, and it emphasizes the total biology of the organisms. However, the data base has not permitted a major breakthrough in our level of understanding the third evolutionary milestone.

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