# Book Reviews

## Sexual Reproduction

**The Masterpiece of Nature.** The Evolution and Genetics of Sexuality. GRAHAM BELL. University of California Press, Berkeley, 1982. 636 pp., illus. $45.

In this very lengthy essay, Bell has attempted with mixed success to solve the "major problem" of the prevalence among multicellular animals of amphimixis (the union of gametes from different individuals followed by nuclear fusion). His method of investigation firmly embraces what has been called the adaptationist program (R. C. Lewontin, *Sci. Am.* **239** (no. 3), 213 [1978]); he assumes that "selection alone is a sufficient explanation of organic diversity" (p. 79) and that the "proper function of theory is to identify these selection pressures as precisely as possible" (p. 81). Furthermore, because "the human intellect is inclined to prefer the simple to the complex" (p. 81), an explanation invoking selection at a lower level of biological organization, such as the gene or the individual, is preferred by Bell to explanations requiring selection at higher levels of biological organization such as families or populations.

His procedure is to survey existing theories of the evolution of sex and separate them first into historical and functional categories. The historical explanations, including recent discussion by G. C. Williams (*Sex and Evolution*, Princeton Univ. Press, 1975), are discarded because they violate the "axiom of perfection" and thus are not testable. On similar grounds attempts to distinguish between "primitive" and "derived" conditions, which have been central to classical evolutionary discussion in general and theories of sex in particular, are rejected as "unnecessary phylogenetic speculation."

The next step in Bell's approach is to partition the functional theories of the evolution of sex into "balanced hypotheses of individual selection" and "unbalanced hypotheses of group selection." The final step is to compare different taxonomic groupings in a search for the ecological correlates of sex; these ecological correlates represent to Bell the selection pressures for and against amphimixis.

In many evolutionary discussions, sex and recombination are treated interchangeably; it is generally considered that a proper theory of the evolution of sex will also be a theory for the evolution of recombination. Such is not the case in Bell's novel outlook. In fact, because he finds the ecological correlates of sex to be different from those of recombination, he concludes that the evolution of recombination will require a separate theory from the evolution of sex.

One of the interesting highlights of Bell's discourse is his outline of the historical development of the variety of current theories of sex, in particular his presentation of the history of ideas in the population genetics literature. Unfortunately, this part of the book is marred by a tendency to create new labels and to redefine (or misuse) older ones. For example, the terms "shifting balance," "environmental grain," "sib competition," and "environmental capriciousness" represent important concepts in modern evolutionary discussion and their usage tends to be associated with the ideas of Wright, Levins, Hamilton, and Lewontin, respectively. Bell redefines all of these terms with meanings different from and in some cases contrary to established usage, in addition to introducing a host of new and arguably unnecessary terms (examples are "Vicar of Bray," "The Tangled-Bank," and "autoselection"). Although a glossary of technical terms is provided, it includes none of these catch phrases and omits some of the important and frequently used terms in the text. Thelotoky, one of the two major categories of parthenogenesis, for example, is discussed at length and its sporadic taxonomic distribution is taken to be "the most important fact requiring explanation," yet it does not appear in the glossary and is defined only parenthetically (p. 42). By way of contrast, arrehenotoky is acknowledged as a well-known form of parthenogenesis, is not discussed at length, but does appear in the glossary.

There are many instances in nature of all-female species that are also gynogenetic, that is, they must mate with a male of the associated monoecious or dioecious sibling species in order to reproduce, although the male contributes nothing genetically to the progeny. Bell's discussion of these gynogenetic species provides an example of the type of pseudo-problem (and its pseudo-solution) that arise from the single-minded use of the "axiom of perfection" in evolutionary analysis. The gynogenetic system is assumed a priori to be at an evolutionarily stable equilibrium achieved by selection within populations: "In gynogenetic . . . animals sexual and parthenogenetic reproduction are necessarily in balance" (p. 404). The problem for Bell is "why should parthenogenetic development ever be dependent on sperm. The problem is particularly acute in gynogenetic animals" (p. 405). The solution posed by Bell is that "dependence on sperm entry is the price that gynogenetic females pay for an efficient mechanism of sperm destruction" (p. 405). At best this "solution" to the problem of gynogenetic species is a Pyrrhic victory for optimality. A very different approach to the same problem, taken by Kiester, Nagylaki, and Shaffer (*Theor. Popul. Biol.* **19**, 358 [1981]), is to begin with the known reproductive biology of gynogenetic species and theoretically examine the dynamics and stability of such a three-sex population. In dioecious populations the pattern of population dynamics "guarantees extinction," and in the monoecious case it is difficult to prevent it. Either population structure or a very high rate of origination of new gynogenetic clones is required for persistence; both possibilities are excluded a priori by the adaptationist approach.

In regard to writing style, the prose can be cryptic at times:

> Parthenogenetic insects are often flightless or nearly so, and this suggests that selection has been able to act effectively on morphological characters even in strictly parthenogenetic lineages. This does not necessarily follow: parthenogenesis and aptery tend to vary together, with wings being reduced even in sexual forms at high latitudes, for example, so that the immediate sexual ancestors of wingless parthenogenetic insects may have been wingless themselves. However, this does not convincingly account for the rather strong tendency for apomictic weevils to be wingless or nearly so, when their nearest amphimictic relatives are usually strong fliers [p. 346].

At other times it is sophomoric:

> The scientist strives to make the internal mental world of theory and the external physical world of fact fit like ferrules. Each is incomplete and, indeed, functionless without the other; and when properly fitted there is no discrepancy or disagreement between the two, but only the sweet conformity of a well-made fishing-rod. So far we have made only

the butt-end of the rod, and the female ferrule; or, rather, we have made a variety of butt-ends, some elegant and some crazy botched affairs, but all alike incomplete, and all awaiting the test of whether they will receive the male ferrule of fact. Some will no doubt prove too narrow to be united at all; others will be so broad that they would accommodate any conceivable partner, and the actually realized possibilities of the world will slop around inside them like a stick in a bucket. One—we can hope—will be just right [p. 160].

In summary, it is difficult to recommend this book except to patient specialists.

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## Southern African Geology

**Crustal Evolution of Southern Africa.** 3.8 Billion Years of Earth History. A. J. TANKARD, K. A. ERIKSSON, D. R. HUNTER, M. P. A. JACKSON, D. K. HOBDAY, and W. E. L. MINTER, with a contribution by S. C. Eriksson. Springer-Verlag, New York, 1982. xviii, 524 pp., illus. $45.80.

Komatiite, Fig Tree Group, Bushveld Complex, Damara Province, Dwyka tillite, Karoo volcanics—these and numerous other names from southern Africa not only help to fill the geologic glossary, they represent major concepts in the understanding of planet Earth. Komatiite immediately makes one think of early crustal evolution, the Fig Tree Group of the development of life on Earth, the Bushveld Complex of metallogenesis par excellence, and the Damara Province of possible intracratonic orogenesis; the Dwyka tillite is virtually synonymous with climatic change; and the Karoo volcanics are on anyone's list of igneous rocks related to continental fragmentation. A. L. Du Toit's 1954 volume *Geology of South Africa* and L. C. King's 1962 volume *The Morphology of the Earth*, which is also based upon a southern African perspective, are classic contributions to the geologic literature. The new book by Tankard and his colleagues is the first complete geologic history of the southern part of the African continent to be published since the broad acceptance of the plate tectonics paradigm for at least the late Mesozoic and Cenozoic. With many earth scientists currently exploring the nature of earlier tectonic activity, as well as the history of life on Earth, the book is a timely contribution that will be of widespread interest. Unquestionably it should be on the shelves of every geologic library, and indeed probably on those of every serious historian of the earth.

The authors divide the geologic history of southern Africa into five stages: Archean Crustal Development, Early Proterozoic Supracrustal Development, Proterozoic Orogenic Activity, The Gondwana Era, and After Gondwana. Spatially they consider the African continent south of approximately 18°S latitude to be composed of ten distinct tectonic provinces defined on the basis of such parameters as lithology, structure, metamorphism, and predominant radiometric age. Some of these provinces will be familiar to readers outside of southern Africa (Kaapvaal Province, Namaqua Province), others less so (Saldanian Province). Inevitably there are a large number of unfamiliar names for the outsider to absorb, but numerous clearly drafted maps and tables help to overcome this obstacle.

The six principal authors must have put a lot of effort into coordinating their contributions, because the discussions of such subjects as structural geology, petrology-geochemistry, and sedimentology-stratigraphy blend well into the account of the various temporal and spatial subdivisions, and the geologic problems, discussed. As is pointed out in the foreword by Brian F. Windley, an impressive attempt is made to separate a review of factual data from consideration of various interpretations of those data, and space is not wasted on unwarranted speculation.

It is no criticism of the volume to point out that scientists seeking detailed information on the state of knowledge of, say, the Pan-African belts or the Cape fold belt will want to follow up the references in the bibliography, which covers material into the earliest 1980's. The space devoted to the five stages of southern African crustal development is approximately proportional to the time intervals involved. Thus the late Precambrian Pan-African orogenic activity is described in just over 50 pages and the early Mesozoic Cape orogeny in one page. One can quibble with the weight of the treatment given to one topic or another, but any suggested alternative arrangement will probably merely reflect one's own special interests. This reviewer, for example, would like to have found more Gondwana-wide comparisons even though the book does by no means treat southern African geology in vacuo.

The strength of the volume lies in lucid description of a panoply of important and evolving geologic processes that occurred in one unique and important location through virtually the entire span of geologic time. It takes little foresight to predict that this work on one part of a large continent will be carefully scanned for years to come in the formulation of hypotheses concerning the tectonic history of the earth as a whole.

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## Porphyry Copper Deposits

**Advances in Geology of the Porphyry Copper Deposits.** Southwestern North America. SPENCER R. TITLEY, Ed. University of Arizona Press, Tucson, 1982. xiv, 560 pp., illus. $35.

Southwestern North America is one of the great copper provinces of the world and accounts for most of the copper production and reserves of the United States, the world's leading copper-producing country. The region attracted the attention of several generations of geologists, and much has been written about it, including the predecessor to this volume, *Geology of the Porphyry Copper Deposits, Southwestern North America*, published in 1966 and edited by Titley and C. L. Hicks. Nevertheless, discoveries of more deposits, accumulation of geological information, and advances in concepts of porphyry deposit geology make this volume a welcome, timely addition to the literature on this classic porphyry copper region.

The book is divided into two parts: Topics in Porphyry Copper Geology and Deposit Descriptions. There are chapters on grades and tonnages of deposits, geological settings, fluid and heat transport, fracture and dike patterns, style and timing of mineralization and alteration, hydrothermal alteration in silicate rocks, skarns, a rock geochemical study at Kalamazoo, the sulfur and copper in magmas and rocks and the petrology and chemistry of igneous rocks at Ray, leached cappings, geochemical prospecting, and 12 selected porphyry copper deposits and one district. Deposits have been included for which no previous reports have been published and for which substantial additions have been made to the information contained in earlier studies. Because the volume lacks descriptions of some of the most important porphyry copper deposits of the region, it should be used in conjunction with the 1966 volume and other papers.

The quality of papers and editing is generally high. Some papers, especially those by Titley, reflect many years of