

was declared out of bounds, and for 40 years psychologists tried to do psychology without looking into the mind. This regimen was neither revealing nor rewarding, and, since World War II, scientists in a number of disciplines have returned to the study of mental phenomena. Consciousness was the first faculty to be dropped by the behaviorists; it has been the last to re-enter the fold of modern cognitive science. A sign of the current interest in its workings, however, is the publication of Ray Jackendoff's book, the first on the topic to be written by a linguist.

Like most cognitive scientists, Jackendoff assumes that the brain carries out computational processes that are organized in a highly modular way. These processes are unconscious. Indeed, Jackendoff drives a wedge between consciousness and computation. "I find it every bit as incoherent," he writes, "to speak of conscious experience as a flow of information as to speak of it as a collection of neural firings. It is completely unclear to me how computations, no matter how complex or abstract, can add up to experience." His grounds for this view are that we perceive not computations but objects in the world, and these objects have shapes and properties. An object can be square and blue and taste slightly of salt, but there are no square, blue, or salty computations.

In short, there is a mystery about how the quiddities of the conscious mind derive from computations, and Jackendoff takes this mystery—for which he has no solution—to be as deep as the traditional mind-body problem. He draws from it two important morals. First, the contents of consciousness can have no causal effect on the computations of the mind. Consciousness is an epiphenomenon that, in T. H. Huxley's phrase, is merely the bell on the clock, not the mainspring of action. Second, anything that we can be aware of depends in some yet to be fathomed way on the computations of our minds. This assumption licenses the meat of the book sandwiched between its layers of philosophical analysis: an expert study of the mental structures underlying vision, language, and music.

The burden of this study is that each faculty has its own chain of levels of representation, though the chains may intersect. Thus, as the late David Marr argued, the array of retinal intensities is used to compute a representation of the major regions of intensity in the visual field, which in turn is used to compute a representation of the relative depths from the observer of each point in the scene (the so-called "2½ D sketch"); and this representation is used to compute a full three-dimensional model of

the objective spatial relations among objects. Jackendoff argues for analogous levels of representation for language (sounds, phonology, syntax, and meaning) and for music (sounds, and a further five levels from the musical surface to a rich representation of abstract structure). Few cognitive scientists would quarrel with Jackendoff's case for levels of representation, but the particular levels he proposes are controversial. Part of the difficulty is that, in principle, an intermediate representation can be cut from the chain and the two loose ends tied together to form a single process. Hence, the question of which levels exist calls for an experimental answer, and there is as yet no decisive evidence either for Marr's 2½ D sketch or for some of the levels postulated by Jackendoff.

Of course, you are not aware of all the levels. And the centerpiece of the theory is, in fact, that you are only ever aware of the phonological level, the 2½ D sketch, and the musical surface. Consciousness, in other words, always contains imagery. But if you are aware only of these intermediate levels, you can never be aware of the significance of anything. You can be aware of the words that I utter and my tone of voice, but you cannot be aware of what they mean. (By an additional binary mechanism, Jackendoff allows that you can be aware that the utterance is meaningful.) The theory seems to be based on confounding two distinct states: being aware of what an utterance means, and being aware of the form in which its meaning is mentally represented. The latter is impossible, as Jackendoff points out; but it does not follow that the former is impossible. People can indeed be aware of the meaning of an utterance, and bilinguals can even grasp it without being aware of the language in which the utterance was spoken. Alas, we have come full circle back to the imageless thought controversy, and there still seems to be no way in which to resolve it.

Consciousness and the Computational Mind is provocative, highly informed, and essential reading for anyone interested in a scientific understanding of the mind. It ranges widely over language, music, and vision and calls for an equal sophistication on the part of the reader. But must we accept its thesis that consciousness is merely an appendix, a useless mental organ that becomes inflamed to no purpose? Jackendoff himself is not happy with this position, but he sees no retreat from it. An alternative hypothesis, however, posits that there are processes that construct the contents of consciousness and that these contents determine the course of still other computations. Their results can modify our behavior and our subsequent conscious experience. In this theory, unlike

Jackendoff's, the contents of consciousness are not freewheeling epicycles but a central link in the causal chain that governs our behavior.

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Vertebrate Phylogeny

The Biology and Evolution of Lungfishes.

WILLIAM E. BEMIS, WARREN W. BURGGREN, and NORMAN E. KEMP, Eds. Liss, New York, 1987. viii, 383 pp., illus. \$49.50. Also published as *Journal of Morphology*, supplement 1 (1986). Based on a symposium, Denver, CO, Dec. 1984.

Despite the fundamental importance of lungfishes (Dipnoi) as a clade standing at a pivotal point in vertebrate evolution, there has been no attempt prior to this book to organize and synthesize information on most major aspects of their biology and evolution. Furthermore, most of the papers in the volume present significant new information and are not mere reviews of previously published data.

Lungfishes have, since the discovery of the first living species in 1836, occupied a key place in discussions of vertebrate phylogeny. They represent a clade of ambiguous morphology, allied with both amphibians and fishes by investigators in the last century. Lungfishes possess a confusing mosaic of traits. Some characteristics, like the morphology of the circulatory system, indicate a close phylogenetic relationship with tetrapods. Other aspects of form are shared with ray-finned fishes and coelacanths. At the same time, lungfishes possess numerous specializations, notably in skull and jaw morphology, that confound attempts to determine homologies across lower vertebrate clades.

The debate on the phylogenetic position of lungfishes is not resolved in this volume, but the prominent role accorded to historical and systematic analysis (usually lacking in books of this type) is welcome. Several of the papers included are in sharp and open disagreement on the major patterns of lower vertebrate evolution. Schultze, Campbell, and Barwick advocate the view that coelacanths are the closest living relatives of tetrapods, with lungfishes being the closest living relatives to both of these clades together. On the other hand, Forey emphasizes characters indicating that lungfishes are the relatives of terrestrial vertebrates, with coelacanths as the outgroup taxon. Many other disagreements on details of lower ver-

tebrate phylogeny are present in these papers. The controversy on lungfish phylogeny that has resurfaced in the last ten years after being dormant for most of this century is thus well represented in this volume.

What is disappointing about the papers on phylogeny is the near total lack of quantitative methods in the analysis of characters. Only Marshall makes an attempt to develop a taxon-by-character data matrix and to analyze it using parsimony algorithms. All the other authors present unconvincing qualitative analyses of their data that suffer from the unjustified a priori exclusion of characters, and even Marshall concludes by adducing ad hoc reasons for not believing the results of his analysis. Schultze explicitly ignores all soft-tissue characters derived from the study of living lungfishes, claiming that because such characters are not discernible in fossil material they should not be included in a phylogenetic analysis. In contrast, other authors such as Northcutt (writing on neural characters of lungfishes), Bemis (analyzing the morphology of the skull and feeding mechanisms), Wake (who sum-

marizes urogenital morphology), and Burggren and Johansen (who evaluate the circulatory and respiratory systems of lungfishes) all present data that have important implications for the phylogenetic position of lungfishes and the relationships of the three living genera.

Continuing the practice of qualitative data analysis and authoritarian a priori exclusion of characters will only lead to continued confusion over the pattern of historical diversification in lower vertebrates. A summary data matrix of all characters known in both living and fossil clades is needed, and a parsimony analysis of this matrix should be executed to produce the best overall branching diagram available from current data.

Another strength of this volume is the information provided on the natural history and ecology of the living genera. Greenwood reviews the biology of African species, Kemp provides data on the Australian lungfish, and Fishman and his co-authors describe the process of estivation in *Protopterus*. Relatively little information is given on the South American genus, *Lepidosiren*,

owing primarily to the surprising lack of knowledge about its biology. These papers emphasize the clear distinctions among the three lungfish genera and the remarkable diversity of ecology in what is often taken to be a relatively homogeneous group. Finally, Conant provides a useful indexed bibliography of over 2200 references from 1811 to 1985 on all aspects of lungfish biology and evolution.

Given the extensive research on vertebrate phylogeny over the last century, there is still a remarkable lack of agreement on principal features of the historical record. Lungfishes, which have played a central role in generating controversy in vertebrate phylogeny, will likely play an equally crucial role in ultimately resolving it. Volumes such as this which present new data and interpretations contribute significantly to progress in understanding the pattern of vertebrate evolution.

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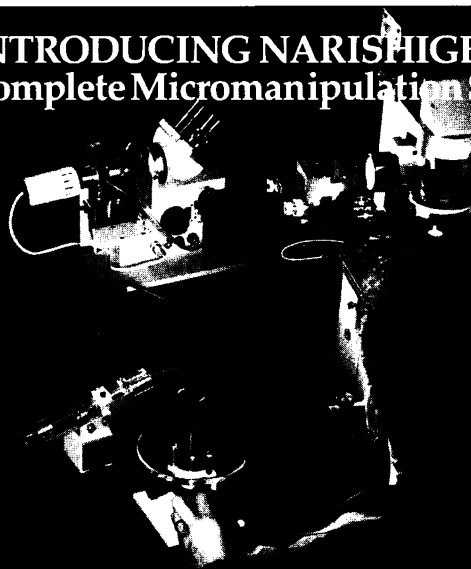
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