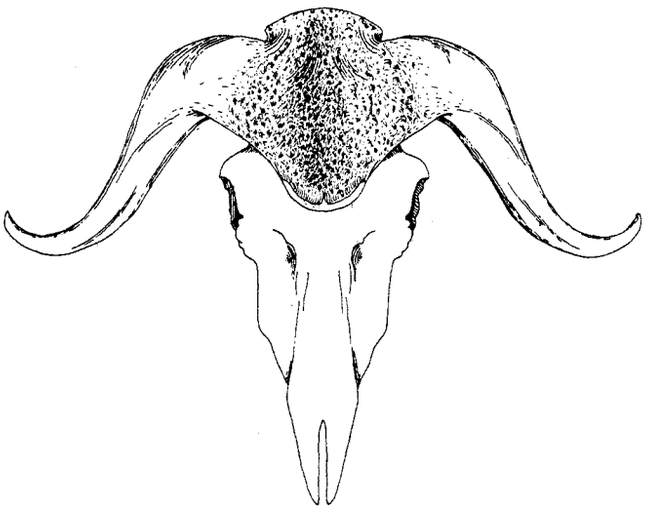
tion tables with insufficient discussion of possible alternatives. The European chronology neglects the important Italian work, which was surely available to the authors, although some important paleomagnetic data have appeared only very recently (Arias *et al.*, *Quat. Res.* **13**, 65 [1980]). The correlation with the Russian sequence is rather too simplistic and would have been better presented as a figure with a linear time scale to allow greater freedom of matching than in a table constrained by ruled "compartments." However, the final section of this chapter is very interesting, showing that the inauguration of the Blancan, the Irvingtonian, and the Rancholabrean coincided with faunal interchanges between North America and Eurasia.



"Bovidae. *Symbos cavifrons*, Rancholabrean, skull, composite drawing. Not to scale." This species, woodland muskox, "was taller and had a more slender build than the extant muskox. Diagnostic of *Symbos* is the pitted, rough-basined surface (exostosis) between the horn-cores." [From *Pleistocene Mammals of North America*; drawing by Barbro Elgert]

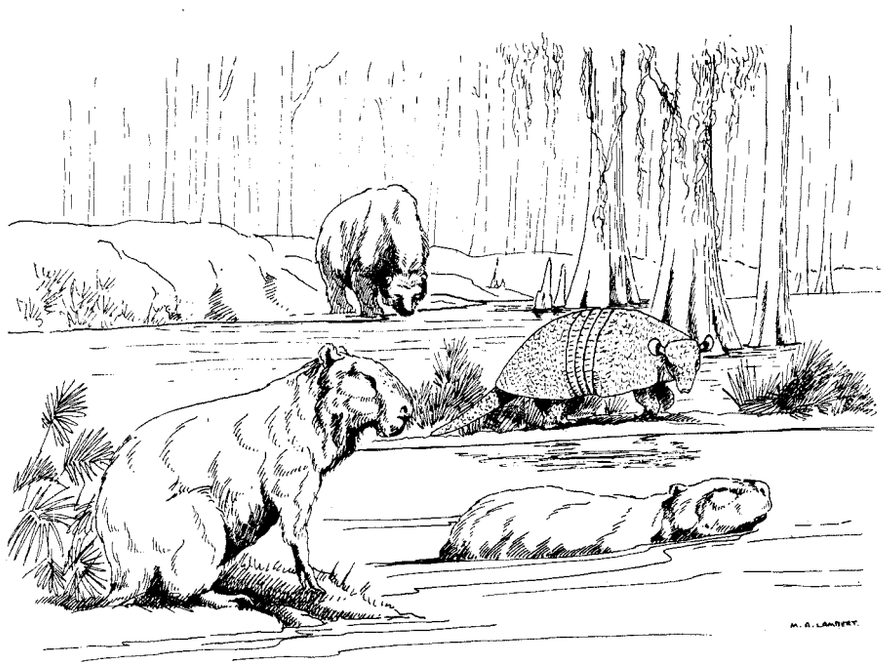
Part 2 is arranged systematically, with a chapter for each order. The presentation is excellent. There is a short discussion of each family and brief consideration of generic and subgeneric characters, but the emphasis is on species. Data routinely given include a vernacular name (unusual for fossil species), the scientific name, author and date of initial description, significant synonymy, and citations of the most important literature. The descriptions are reasonably diagnostic, and an attempt is made to indicate habitat and distribution. The amount of detail varies greatly, from a few lines to a page or more, but this is hardly surprising in view of the wide variation in the quality and quantity of the material available. There are distribution maps for nine of the species and illustrations for 68 out of the 562 that are described. The illustrations are very good, and the dozen reconstructed scenes (mostly by Margaret Lambert) that accompany the site descriptions in chapters 2 through 4 are both scientifically accurate and artistically delightful. The stratigraphic ranges of the taxa are presented in tabular form in an appendix, and the information is both useful and enlightening.

The final chapter, on extinction, contains useful statistical analyses and indicates that the process was continuous, although it is suggested that endemic American species were more prone to extinction than Beringian immigrants. Possible causes are discussed, but the results are inconclusive.

In addition to an extensive (37-page) reference section and two appendixes the book has four indexes—of Latin names, vernacular names, localities and stratigraphic terms, and authors—all of which make for ready access to the immense amount of information that is present in this compact volume. The book is well produced, attractive in layout and design and having remarkably few typographic errors.

It must be emphasized that this is not a mere compilation but a critical revision and overview that will be an essential reference for all students in the field and will form a basis for further advances in the discipline. The criticisms that have been offered are very minor in relation to the importance of the work as a whole.

H. B. S. COOKE
Department of Geology,
Dalhousie University,
Halifax, Nova Scotia, B3H 3J5, Canada



"The late Rancholabrean fauna in coastal Florida near Melbourne included *Neochoerus pinckneyi*, *Tremarctos floridanus*, and *Holmesina septentrionalis*." Among the 49 mammalian species of this fauna there was "an important element of browsers and other swamp . . . , river . . . , and forest . . . species, as well as some plains species. . . . Twenty-three mammals are extinct." [From *Pleistocene Mammals of North America*; drawing by M. A. Lambert]

Respiratory Specializations

The Evolution of Air Breathing in Vertebrates. DAVID J. RANDALL, WARREN W. BURGGREN, ANTHONY P. FARRELL, and M. STEPHEN HASWELL. Cambridge University Press, New York, 1981. viii, 134 pp., illus. $27.50.

By most accounts the acquisition of aerial oxygen uptake was a unique and major event in the evolution of terrestrial vertebrates from their aquatic ancestors. In contrast, this innovative and exciting

work by David Randall and his colleagues suggests that extraction of oxygen from air is commonplace among diverse aquatic vertebrates; the "unique event" was the reassignment of the regulatory and excretory functions of gills to other structures when gills were lost.

This book reviews the specializations of some amphibious vertebrates (fishes, amphibians, reptiles) for regular "metering out" of oxygen to the tissues during submergence and effective ventilation at the water's surface when submergence ends. As the authors emphasize, this is not a simple matter of the animal's holding its breath. Submergence necessitates an intricate concatenation of changes in heart rate, distribution of cardiac output, and blood and lung gas concentration, all in phase with an irregular rhythm of breathing. The review is not merely a catalogue of unrelated facts. Its purpose is to document parallel evolution, that is, how different vertebrates use diverse structures, behaviors, and regulatory systems to achieve very similar patterns of air breathing.

A second theme is the physiological adjustments that evolution of air breathing entails and deserves special emphasis here. Randall *et al.* suggest that evolution of aerial oxygen uptake was a relatively routine matter for vertebrates. For example, fish and amphibians have elaborated such diverse structures as gills, lungs, the swim bladder, the mouth, the pharynx, the suprabranchial chamber, the operculum, and even the gut as aerial gas exchangers. Such specializations occur in many vertebrates that exploit aquatic environments in which oxygen is scarce.

In hypoxic aquatic environments, however, fish readily lose oxygen to the water through their gills. Hence gills may be a liability in such environments, and are reduced or lost in many lineages. Yet evolutionary loss of aquatic gas exchangers probably posed major difficulties. As Randall *et al.* point out, the gills of fishes regulate concentrations of diverse ions, especially hydrogen ions, and are the major organ of carbon dioxide excretion. Coupled with these roles are specializations in the enzyme carbonic anhydrase, relatively sluggish circulation, and regulation of plasma *p*H via bicarbonate concentration (rather than carbon dioxide concentration as in mammals). Therefore loss of gills necessitated major changes in many systems, and also in the way vertebrates inspire air. Randall *et al.* speculate that ion homeostasis and carbon dioxide excretion were allocated to the skin in amphibians and in those fishes that have reduced gills, which restricts them to aquatic environments (but see below). Only when lungs and specialized osmoregulatory organs assumed these functions could vertebrates become fully terrestrial.

Both specialists and nonspecialists with knowledge of introductory physiology should find this book fascinating. Chapters on gas transfer, ventilation-perfusion relationships, mechanisms of ventilation, and regulation of gas exchange begin with simple explanations of general principles and then proceed into lucid discussion of primary data. Abundant figures and some spectacular photographs of respiratory structures add clarity. Many sections are speculative, but the speculation is presented as such and is provocative. My single complaint is that the authors neglect the diversity and success of nonpiscine vertebrates that are able to breathe both air and water. Salamanders, larval amphibians, turtles, and marine snakes are not discussed. In particular, the authors characterize amphibians as largely restricted to aquatic environments, even though many are completely terrestrial.

All too often comparative physiologists document obvious differences among organisms and then tell stories about the adaptive significance of these differences. Randall *et al.*, by contrast, align seemingly disparate aspects of vertebrate physiology into a cohesive whole and suggest novel consequences of this alignment. This book raises important issues and may well shape future research efforts in comparative vertebrate physiology.

MARTIN E. FEDER
Department of Anatomy and
Committee on Evolutionary Biology,
University of Chicago,
Chicago, Illinois 60637

Mechanisms of a Response

Estrogens and Brain Function. Neural Analysis of a Hormone-Controlled Mammalian Reproductive Behavior. DONALD W. PFAFF. Springer-Verlag, New York, 1980. x, 282 pp., illus. $24.90.

Behavioral biology is one of the most fragmented of all scientific disciplines because most behavioral scientists restrict themselves to a single level of analysis. However, the most significant advances in our understanding of the biological bases of behavior have come about when several levels of analysis are combined into a single research program. Donald W. Pfaff is one of the foremost practitioners of this approach.

In *Estrogens and Brain Function*, Pfaff moves effortlessly from the organismal to the molecular in an analysis of the lordosis behavior of the female rat. Using the analogy of the reflex arc, he guides the reader through an extraordinary research program that has traced the sequence of events underlying this hormone-dependent behavioral response, including the manner in which stimuli are perceived and integrated in the central nervous system and the way in which this information is influenced by the female's hormonal milieu.

Beginning with a description of the dynamics of the sexual encounter, Pfaff shows how the behavior of the male elicits postural changes in the female, ultimately resulting in the exhibition of lordosis. Stimulation of specific areas of the female's body, particularly the flanks, tail base, and perineum, are crucial for the occurrence of lordosis. The sensory nerves supplying the perineal skin enter the spinal cord, converging onto spinal interneurons. Recordings of single units in the dorsal-root ganglion indicate that each hair or hair-skin unit is activated by one type of hair, whereas at the level of the spinal gray many units respond to both hair movement and skin deformation and other combinations of cutaneous stimulation. Transection of different regions of the spinal cord demonstrates that the anterolateral columns are the critical ascending neural pathway, projecting into the central gray of the midbrain.

Estrogen has profound effects on both the peripheral and the central nervous systems. The sensitivity of the peripheral mechanoreceptors and the receptive field size of the pudendal nerve increase with estrogen treatment in ovariectomized females. Further, estrogen is taken up and bound in specific regions of the brain, including the medial preoptic area (POA), the medial anterior and basal hypothalamus, the limbic system, and the mesencephalon.

The hypothalamus is a major integra-