has recently shown that tree shrews get along just fine in the trees using Gambaryan's "primitive ricocheting jump," leaping primates ordinarily land with the hind feet touching down first, and I doubt very much that the quadrupedal ricochet is primitive for marsupials, as Gambaryan says at the end of the book. Whether or not one accepts Gambaryan's arguments of this sort, his efforts to reconstruct the phylogeny and adaptive meaning of different sorts of quadrupedal gait give data of this kind a new significance, and provide us with a model for incorporating such data into our reconstructions of the past.

In the body of the text, Gambaryan attempts to relate habitat and food-getting to movements of the limbs in running, and to explain muscular morphology in terms of the ranges of joint motion that various locomotor habits require. An extraordinary quantity of data on gaits, limb lengths, muscle weights and attachments, and joint mobility is brought together in successive chapters on ungulates, elephants, carnivores, lagomorphs, rodents, and kangaroos.

Some of Gambaryan's remarks on carnivores will convey an idea of the scope of these analyses. In both carnivores and ungulates, the forelimbs play an important propulsive role in running; but carnivores differ from ungulates in having a more flexible vertebral column (increasing the length of the stride) and thus having greater mobility between the forelimb and the trunk. This mobility correlates with a locomotor cycle in which the humerus is further protracted at the shoulder joint; therefore, increasing specialization for speed tends to produce enlargement of the pectoral muscles in carnivores, but not in ungulates. The typical fast locomotor pattern of felids is a bounding run, in which both hind limbs move together, whereas canids specialize in a lateral gallop less suited to bursts of speed and more to prolonged running. This obviously reflects typical differences in hunting behavior, and the resulting differences in locomotor pattern are in turn reflected in differences in limb proportions and in joint angulations. Bears have powerful forelimbs used in characteristic foraging behaviors, and their power is utilized in locomotion to produce a distinctive form of gallop in which the phase of "crossed flight" (between forelimb pushoff and hind-limb touchdown) is prolonged. The propulsive functions of the vertebral musculature, which distinguish carnivores from ungulates, are peculiarly exaggerated in the weasel family, whose distinctively long and mobile vertebral column is interpreted by Gambaryan as part of a supposed ancestral adaptation for hunting burrowing prey. The familiar "humping" gait of mustelids results from these vertebral specializations, which are also reflected in increase in the relative weights of the vertebral extensors, reduction of the interspinous ligaments and spinous processes, and virtual elimination of the "crossed flight" phase of the gait cycle.

Here as elsewhere, objections can be raised to much of what Gambaryan says. For instance, many of his interpretations of muscle functions are based on his electromyographic studies of decerebrate cats going through reflex locomotor movements induced by electrical stimulation of the brain stem. This bizarre procedure simplifies the experimenter's job by allowing him to switch his animal on at the same time as the recording apparatus, but its relevance to normal locomotion is obscure, and I hope that the method will not be imitated by other electromyographers.

Yet for all of that, Gambaryan has collected and synthesized here a vast amount of useful and suggestive information about carnivore locomotion, and his chapters on other orders are equally informative and stimulating. Hardin's translation is lucid and readable, and even corrects a few errors made in the original Russian edition—for example, the use of *Procyon* instead of *Lycaon* for the African wild dog. It would also have been helpful to have some of Gambaryan's anatomical terminology brought into line with Western usage, so that the reader would not have to figure out for himself that "anconeus" means "triceps" and that "talocrural extension" means volar flexion of the ankle joint. Despite these difficulties, and despite the objections that everyone will have to some of Gambaryan's arguments and conclusions, this is an impressive synthesis that needs to be read by anyone with an interest in the evolution of mammalian locomotion.

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Ethological Diversion

Animal Architecture. KARL VON FRISCH with the collaboration of Otto von Frisch. Translated from the German by Lisbeth Gombrich. Harcourt Brace Jovanovich, New York, 1974. viii, 306 pp., illus. $12.95. A Helen and Kurt Wolff Book.

Animal Architecture, written by Karl von Frisch in collaboration with his son Otto von Frisch, is the modern-day counterpart of a remarkably similar book written by J. G. Wood called *Homes without Hands* published in England in 1884, just two years before the elder von Frisch was born. It is an informal, affectionate, oh-my book of animal behavior. Written "for light diversion," it is not so much a comprehensive scientific survey of structures produced by animals as an excuse to describe selected, often spectacular, aspects of natural history. Experts will be aware of occasional small inaccuracies, impressed with the amount of specialized literature reviewed, and frustrated at the complete absence of bibliographic references. But the book contains a large collection of generally reliable information about the biology of diverse species, rather casually fitted to the theme of animal architecture and softly stamped with the author's gentle philosophy of nature. Beginning with the sand-grain shells of certain amoebas, it proceeds "up" through the animal kingdom to the loosely woven sleeping nests of chimpanzees. Some of the classic figures of European ethology are included—the feisty three-spined sticklebacks with their releasers and sign stimuli, the slender *Ammophila* wasp, and Kohler's problem-solving apes. There is a conspicuous absence of any mention of von Frisch's own famous work on communication in bees, even though other notable nonarchitectural capacities are freely discussed for various species. Almost every example cited is illustrated by one or more of the 114 excellent photographic plates (many of which are in color) and 105 drawings (some excellent, others mediocre but adequately illustrating the text).

Although the book jacket rather loudly advertises the author's Nobel laureateship, it is a relief to find the text free of the kind of high-flown philosophizing that sometimes emanates from grand old men of science. An unexpected and valuable feature of the book is its incidentally autobiographical quality. Clearly von Frisch has watched and loved all kinds of animals since he was a small boy. Much of the book is based on firsthand observations, and the most inspired parts deal with personal experiences, such as his own discovery of parthenogenesis in some pet bagworm moths. He was an insect collector, who, instead of instantly killing a captive mason bee, released it and followed it to its home "in a fifty-yard sprint." The book reflects a wide-ranging scholarly interest in animals; it also shows that von Frisch does not always view them with strict scientific detachment. He empathizes with animals, for example (p. 225) expressing sympathy for kingfishers who have to pass through the "stench" of a flight tube coated with excrement from their young and (p. 252) supposing that badgers wall off portions of their tunnels occupied by foxes because

"Nest of a harvest mouse in an oat field. An oat stem nearby has been bent and incorporated into the nest for extra support." The nest "is a breeding nest made by a pregnant female for her young . . . Sleeping nests are simpler and less dense." [From *Animal Architecture*]

"apparently they do not like the smell of fox." Whatever critics may justifiably say about the pitfalls of anthropomorphism in the study of animal behavior, being able to identify with an animal—to imagine oneself in its different perceptual, and possibly even emotional, world—is undoubtedly a common and valuable trait among working ethologists.

Von Frisch expresses a humble, almost pessimistic attitude about the efficacy of science. Biologists who believe that "the key to life in all its manifestations" can ultimately be found through research "are to be pitied," he says, "for they have never experienced that sense of profound awe in the face of the workings of nature, some of which will forever elude comprehension, even by the mind of man" (p. 287). But such philosophizing is rare in the book. It is clearly intended mainly for entertainment, and as such can be recommended to both amateur and professional students of biology and behavior. It does a good job of immersing the reader, even if only momentarily, in the lives of other animals (the section on birds is particularly vivid). With this book von Frisch seems to be saying: "Here are some of the most striking true animal stories I know. Look at how beautiful and amazing these creatures are. Think of how they must feel, and be kind to them."

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Bioacoustics

Ultrasonic Communication by Animals. GILLIAN SALES and DAVID PYE. Chapman and Hall, London, and Halsted (Wiley), New York, 1974. xii, 282 pp. + plates. $15.75.

Important discoveries in biology have often arisen from the application to biological problems of new techniques or instrumentation developed in other disciplines. It was, for example, the invention of the crystal-controlled oscillator in the physics laboratory of G. W. Pierce that enabled Pierce and D. R. Griffin to first detect the ultrasonic vocalizations of bats in 1938 and subsequently led to the discovery of echolocation. Instruments for studying ultrasound have undergone vast improvements since those early days, and there is now a rapidly growing body of research in ultrasonic bioacoustics. It is now realized that many groups of organisms use sound frequencies above our hearing range for social communication or acoustic orientation.

This book provides a welcome, relatively compact survey of the rapidly growing literature in ultrasonic bioacoustics. It should be of interest to the layman as well as to the scientist. A brief introduction on the properties of sound and methods for studying ultrasound is followed by one chapter on bats, three on insects, one on rodents, and one covering birds, marine mammals, and insectivores. There is also a short appendix in which some of the equations from radar theory are applied to echolocation.

The authors discuss, in so far as is possible, the characteristics and biological functions of ultrasounds emitted by each group of animals, the mechanism of sound production, the nature of the auditory organs, and, to varying extents, the neural processing of auditory information. The distinction between sonic and ultrasonic frequencies is biologically arbitrary, and many of the organisms discussed emit sounds containing frequencies in both of these categories. In at least one case a group of organisms (mole crickets) that has not been demonstrated to produce ultrasound is included for the sake of completeness.

The assets of the book include the application of fundamentals of information theory to illuminate the possible functional significance of different types of sonar pulses used in echolocation, a worthwhile discussion of the physics and mechanisms of insect strigilation, and the first comprehensive review of the literature (most of which has appeared in the last ten years) on ultrasonic communication in rodents. It