ing (three), kin recognition (three), and learning (four).

Certainly von Frisch could not have failed to enjoy reading this book for the sheer pleasure of learning a lot of newly discovered things about the lives of a diversity of animals. For example, the chapter on desert isopods by Linsenmair reveals that woodlice not only can distinguish their relatives from non-kin but can recognize their elaborately selected monogamous mates by means of chemical "badges." And Franks's study of Panamanian army ants shows, among other things, that the disproportionately long-legged submajor workers are "porters" specialized in carrying prey, and that, although speed of running is generally an exponential function of leg length, all colony members run at approximately the same speed—perhaps to prevent traffic jams on their crowded highways.

Von Frisch's stature and influence on the study of insect behavior and sensory physiology were so great that his pioneer role is sometimes exaggerated in relation to earlier work by others. Although this can perhaps be forgiven in a memorial volume, it seems only fair to point out that von Frisch was not the first to introduce "the powerful method of training animals by 'associative learning' in the study of sensory physiology" so that "experimental behavioral ecology can be said to have begun around 1911, when the young Karl von Frisch wondered why flowers are colorful" (p. 1). The credit for those accomplishments should go to the black American insect ethologist C. H. Turner (1867–1923), who not only used trained honeybees to demonstrate that honeybees can distinguish colors and the fine details of color patterns but also experimentally demonstrated sound frequency discrimination and associative learning in moths. Turner's careful and extensive work on honeybees was published (in the *Biological Bulletin* of the Marine Biological Laboratory in 1910 and 1911) just as von Frisch was beginning his first field studies (which appeared in print in 1915).

In a chapter entitled "The principles of caste evolution" Wilson calls for a revival of the superorganism concept in studies of social insects. His eloquent myrmecocentric argument may lead some readers to overlook 20 years of discussion and observation showing (if nothing else) that intragroup genetic heterogeneity (existent in most eusocial species) can lead to individual selfishness and conflicts of interest within colonies—so that the superorganism is expected to be achieved only in special circumstances (for example, in the particular highly eusocial ants discussed by Wilson) or for certain behaviors (those for which there is no reproductive conflict of interest or its effects have been completely suppressed). A partial antidote is found in the chapter by Heinrich, who attempts to see how far he can explain honeybee colony thermoregulation in terms of individual responses without "superorganismic" colony-level coordination. There too, however, the controversy regarding ultimate (evolutionary) causation remains: since selection can operate simultaneously on many levels (genic, individual, colony, species) knowing the mechanism alone (for example, the responses of an individual) does not eliminate the possibility that it has been shaped by selection at another level (for example, that of the group). Persistent traits must survive selection at both the individual and the colony level. As Velthuis (p. 344) points out, even in the case of a highly eusocial species such as the honeybee one often ends up contemplating "the intriguing interweaving of cooperation and competition, so apparent in many features of social insects."

Several authors (Markl, Griffin, Marler) take up the question of cognition and other "higher" mental feats of non-human animals. It is a sign of progress in what Griffin calls "cognitive ethology" that these formerly taboo subjects are so extensively discussed in the eminently respectable scientific forum represented by this symposium. Griffin seems to have won his point, summarized in the epilogue to this book, that the mental lives of animals deserve scientific investigation. He has undoubtedly been aided in this by recent discoveries greatly expanding our estimation of the humanlike capacities of other animals, a perfect example being the widespread ability to distinguish different degrees of genetic kinship and to adjust social interactions accordingly (reviewed in this volume by Sherman and Holmes, and discussed by Linsenmair). Two decades ago most biologists would have deemed kin recognition highly unlikely—especially among sweat bees, tadpoles, and isopods—and no one bothered to investigate it. Especially telling for Griffin's argument is the fact that it was a strong theoretical conviction that kin recognition might occur that finally led to its discovery; our ignorance of animal mental processes is undoubtedly largely a product of a collective mental block against thinking about them. However, cognitive ethology will not emerge as a science until it has some testable hypotheses, at the very least in the form of operational definitions of terms like "awareness," "mental experiences," and "conscious thought"—suggestive ideations of a nascent discipline that, as Griffin admits, are not yet amenable to precise definition.

As would any specialist reading a book of this length, I found shortcomings alongside exciting findings in the areas I know best. However, they are unimportant given the overall excellence of the chapters in question. The standard of work included is consistently high, and the book gives a sense of where different endeavors in research on animal behavior are headed. It would make a good companion volume for Wilson's now ten-year-old *Sociobiology* in terms of the concepts discussed and the breadth and fascination of the findings described.

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Prices of Books

Average per volume prices of books reviewed in *Science* 1980–1985. Data are for hard-cover books except where books were available only in paperback; books priced only in foreign currencies were excluded from the calculations. The average prices per page for the technical books in the natural sciences for the years covered were 9.0¢, 11.3¢, 11.1¢, 11.1¢, 12.0¢, and 12.7¢.

Category	Price (dollars)					
	1980	1981	1982	1983	1984	1985
All books	35.52	42.22	44.05	41.93	45.38	47.02
Technical books in natural sciences	42.61	52.76	51.70	51.18	55.29	49.66

Gibbons

The Lesser Apes. Evolutionary and Behavioural Biology. HOLGER PREUSCHOFT, DAVID J. CHIVERS, WARREN Y. BROCKELMAN, and NORMAN CREEL, Eds. Edinburgh University Press, Edinburgh, 1984 (U.S. distributor, Columbia University Press, New York). xiv, 709 pp., illus. $56. Based on a conference, Ulm, Germany, July 1980.

The lesser apes (Hylobatidae) include several species of medium-sized (5 to 7 kilograms), highly frugivorous animals, traditionally called gibbons, and one species of larger (11 kilograms), more folivorous siamang. Nowadays all are referred to as gib-

bons, and they inhabit tropical forests of continental Southeast Asia and some islands (Borneo, Java, Sumatra, and the Mentawai Islands). During the 20th century they have attracted scientific interest for two major reasons. First, their locomotor behavior of brachiation and their postcranial morphology are very different from those of quadrupedal primates and have been interpreted by some as preadaptive for the evolution of orthograde posture and associated morphological features in humans. Second, gibbons are remarkable for a complex of social traits that are rare in mammals: monogamy, territoriality, and elaborate songs, including duets by members of mated pairs.

The present volume is a largely successful attempt to make the latest results of specialized research available in a convenient form for diverse users. Most of its 46 chapters are by participants in a 1980 conference. Others were solicited by the editors after the conference to fill gaps in the coverage. The contributions are arranged in five groups: Conservation, Functional Morphology, Ecology, Social Behavior, and Evolutionary Biology.

The biomechanics of brachiation is elucidated in a mathematical analysis by H. Preuschoft and B. Demes, who demonstrate that brachiation at moderate speeds corresponds well to a pendulum model and that the long forelimbs of gibbons thus serve to increase velocity. Tail-arm brachiation of New World spider monkeys (*Ateles*) has a more irregular rhythm owing to movements of the tail, so one might infer that Preuschoft and Demes's conclusion that moderate-speed gibbon brachiation conserves energy is not necessarily contradicted by the frequently cited results of P. E. Parsons and C. R. Taylor (1977) showing that brachiation of *Ateles* is energetically more expensive than quadrupedal movement by the same animal.

W. L. Jungers and J. T. Stern, Jr., contribute what will undoubtedly become a classic, on kinesiological aspects of brachiation. They used simultaneous video recording and telemetered electromyography of forelimb muscles to analyze with admirable lucidity just what a gibbon is doing with its limb segments and muscles throughout the different phases of brachiation. The forelimb muscles used in brachiation are more active in vertical climbing, when the animal cannot use gravity to its advantage, and Jungers and Stern conclude that "given the relatively great demands placed on these muscles during climbing, an animal that is well adapted for scansorial behaviours is probably preadapted for some degree of arm-swinging as well" (p. 134).

Progress in understanding gibbon sociality does not come easily. This is demonstrated in a comprehensive discussion by W. Y. Brockelman and S. Srikosamatara, starting with the important point that clarification of selective factors operating on social systems requires knowledge of the proximate behavioral mechanisms that maintain the systems. Brockelman and Srikosamatara attempt to elucidate proximate causes by comparing intergroup behaviors across gibbon species, but this proves unsuccessful for a variety of reasons, including the small intraspecific sample sizes imposed by various aspects of gibbon biology. With respect to vocal behavior, which is undoubtedly extremely important in regulating social relations, experimental playbacks are a promising approach, and it is unfortunate that this book was completed too early to include J. C. Mitani's rigorously designed field experiments with Bornean gibbons. After a thorough review of the available (albeit inadequate) evidence, Brockelman and Srikosamatara suggest that in hylobatids females are the more important sex in maintaining monogamy and that the degree of dietary specialization seen in these primates may favor their form of social life by reducing the importance of interspecific competition, thereby increasing the benefits of intraspecific defense of resources. Finally, Brockelman and Srikosamatara's own fieldwork in a *Hylobates lar–H. pileatus* hybrid zone in Thailand has revealed some interesting *lar-pileatus* trios containing one adult male and two adult females; in such groups only one female is reproductively active.

The evolutionary history of gibbons is murky. Although in recent years many fossil apes have been dubbed ancestral gibbons, J. G. Fleagle concludes that "aside from the dental remains of extant species from the last million years or so in China and south-east Asia, there are no convincing fossil gibbons" (p. 443). Possible candidates are early Miocene *Micropithecus* from East Africa and *Dionysopithecus* from China, but more fossils are needed.

The goal of the 1980 conference to stimulate fruitful debate was clearly realized with respect to classification and phylogenetic reconstruction. There is general agreement that extant hylobatids can be divided into three groups (subgenera): *H. syndactylus* (the siamang), *H. concolor*, and the rest (including the problematical lar group of species or populations). Molecular clock methods are used by J. E. Cronin, V. M. Sarich, and O. Ryder to suggest that the three groups split apart about 4 to 5 million years ago, whereas the lar group differentiated much more recently, probably within the last million years. Cronin *et al.* suggest that speciation by chromosomal evolution may have been involved in the initial tripartite split, but not within the lar group. In the lar group, characters of pelage, song, and cranial morphology do not covary consistently, leading to different numbers of species (one, four, or five in this volume) according to which characters are considered most important by the investigator. The comprehensive and diverse chapters of this section convince one that gibbon phylogeny and classification constitute one of the really exciting topics in primate biology and mammalian systematics, and a final brief summary by the book's editors provides a useful list of topics worthy of further research in this area.

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Books Received

Cloning of Frogs, Mice, and Other Animals. Robert Gilmore McKinnell. University of Minnesota Press, Minneapolis, 1985. xii, 127 pp., illus. $12.95. Revision of *Cloning: A Biologist Reports* (1979).

Clustering Aspects of Nuclear Structure. J. S. Lilley and M. A. Nagarajan, Eds. Reidel, Boston, 1985 (distributor, Kluwer Boston, Hingham, MA). xii, 420 pp., illus. $54. From a conference, Chester, United Kingdom, July 1984.

The Cognitive Computer. On Language, Learning, and Artificial Intelligence. Roger C. Schank with Peter Childers. Addison-Wesley, Reading, MA, 1985. xiv, 268 pp. Paper, $12.95. Reprint, 1984 edition.

Common Seaweeds of China. C. K. Tseng, Ed. Science Press, Beijing, and Kugler, Berkeley, CA, 1984. x, 316 pp., illus. $125.

Explanation, Causation and Deduction. Fred Wilson. Reidel, Boston, 1985 (distributor, Kluwer, Hingham, MA). xviii, 385 pp. $49. University of Western Ontario Series in Philosophy of Science, vol. 26.

Exploitation of Physiological and Genetic Variability to Enhance Crop Productivity. James E. Harper, Lawrence E. Schrader, and Robert W. Howell, Eds. American Society of Plant Physiologists, Rockville, MD, 1985. viii, 92 pp., illus. Paper, $12. From a symposium, Champaign-Urbana, IL, Oct. 1984.

Explosive Remnants of War. Mitigating the Environmental Effects. Arthur H. Westing, Ed. Published for the Stockholm International Peace Research Institute and the United Nations Environment Programme by Taylor and Francis, Philadelphia, 1985. xvi, 141 pp. $25. From a meeting, Geneva, July 1983.

Fiber Optics. Technology and Applications. Stewart D. Personick. Plenum, New York, 1985. xii, 257 pp. illus. $45. Applications of Communications Theory.

Flying Squirrels. Gliders in the Dark. Nancy Wells-Gosling. Smithsonian Institution Press, Washington, DC, 1985. 128 pp., illus. $24.95; paper, $9.95. A Smithsonian Nature Book.

Forest Trees of Australia. D. J. Boland *et al.*, 4th ed. Nelson, Melbourne, Australia, and CSIRO, East Melbourne, Australia, 1984 (U.S. distributor, ISBS, Beaverton, OR). xvi, 687 pp., illus. $49.95.

Formaldehyde. Analytical Chemistry and Toxicology. Victor Turoski, Ed. American Chemical Society, Washington, DC, 1985. xiv, 393 pp., illus. $89.95. Advances in Chemistry Series, 210. From a symposium, St. Louis, April 1984.

From Invention to Innovation. Long-Distance Telephone Transmission at the Turn of the Century. Neil H. Wasserman. Johns Hopkins University Press, Baltimore, 1985. xxvi, 162 pp., illus. $17.50. The Johns Hopkins/AT&T Series in Telephone History.

From Maxwell to Microphysics. Aspects of Electromagnetic Theory in the Last Quarter of the Nineteenth Century. Jed Z. Buchwald. University of Chicago Press, Chicago, 1985. xvi, 339 pp., illus. $70.