Wireless communications came out of the laboratory into the commercial sphere in the 1890's. Several spark systems, based on the work of Heinrich Hertz, were developed to send signals across the airways. By 1910, they were effective transmission systems for long-distance radio messages. (The development of these systems and the industry that grew around them was described in Aitken's 1976 book *Syntony and Spark*.) But with spark systems sharp tuning and transmission of voice were impossible. As the number of stations increased, the elimination of interference through better tuning became critical; voice transmission would make the system accessible to those without specialized training.

Over the first two decades of the 1900's, radio men searched for a continuous-wave system that would allow them to overcome the weaknesses of spark systems. Three devices developed were the oscillating arc, the alternator, and the vacuum-tube oscillator. In the United States the oscillating arc had an exciting history. Sponsored by the Federal Telegraph Company of California, the arc became the basic unit in a chain of U.S. naval stations for global communications. The arc came from nowhere to compete successfully with the spark systems of the National Electric Signaling Company (NESCO) and the Marconi companies. NESCO was one of several companies to develop the alternator, a design modified and constructed by General Electric (GE). Before the end of World War I, alternators were operating in several stations, all taken over by the U.S. Navy for use in war communications. Both the arc and the alternator technologies were mature upon installation. Their immature cousin, the vacuum tube, was not used in continuous-wave systems until after the war.

In these days of the transistor, it is difficult to appreciate the versatility of the vacuum tube that came before. Engineers investigated several kinds of use for the tube, patenting each along the way. By the time an effective transmission system using tubes became available, patents for tube design and use were numerous and widespread among companies. And with the advent of commercial broadcasting transmitters and receivers and test instruments in the 1920's, the market for tubes—small, simple-to-manufacture devices—grew dramatically as compared to the market for arcs and alternators.

While these tube developments were in progress, nationalistic concerns about control of global communications led to actions that shifted control of the airways from one corporate group to another. On the part of the Navy there was a perception that the British Marconi Company, and hence the British government, had the capacity to control global communications. Negotiations between Marconi and Federal and between Marconi and GE offered the Navy an opportunity to step in. Naval officers asked GE to form a new company that would become the "American radio company" and would "advance and protect American national interests in world communications." This they did, with the help of AT&T, American Marconi, and Westinghouse, by forming the Radio Corporation of America. These facts essentially formed the basis for the views of radio developments presented in most histories and congressional and Federal Communications Commission hearings since the mid 1920's.

What we have in Aitken's book is a new treatment of the problem faced by the radio men and the industrialists. This history illuminates how the technical feasibility of the new technologies was proved, how the new technologies, beginning as laboratory devices managed by technical personnel, came to be supervised and managed by corporate-level authorities, and how, through politicization, they became early instruments of telecommunications policy. Moreover, Aitken describes how "broadcasting" was impossible without the previous development in continuous-wave technologies. This was not obvious, because these technologies emerged from undertakings with different objectives.

Aitken has made use of a wider range of sources, many of them unavailable until recently, than any previous investigator. Moreover, he has used his sources in more effective ways. Documents isolated in small archival collections become important evidence for the larger picture. Large corporate collections, such as those of Owen D. Young, a principal actor in the RCA drama, provide vital new perspectives and facts. The story of RCA's formation is told and assessed better and more accurately here than elsewhere. In fact, Aitken's research provides a challenge to previous writing on this subject. He demonstrates that GE management's assessment of the needs of the industry might very well have led them to a path similar to that proposed by the Navy. In addition, he presents some evidence that the Navy's view may have been manipulated by GE to achieve the company's own ends.

Those who know the model of interaction of science, technology, and the economy and the concept of "translators"—individuals who act at the interfaces of these sectors—from Aitken's *Syntony and Spark* will find that the model has undergone considerable modification in this book. In the more complex case of continuous-wave development, it was necessary to consider perspectives developed in formal, bureaucratic organizations. Since the later phase of radio development involves business and government at least as much as technical people, Aitken has been forced to soften the boundaries so sharply defined in the earlier book. The dramatic tension in the story itself and the broadening of the analysis make the book interesting and useful to a broad range of historians, economists, technical managers, and policy-makers.

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Animal Behavior

Experimental Behavioral Ecology and Sociobiology. In Memoriam Karl von Frisch 1886–1982. BERT HÖLLDOBLER and MARTIN LINDAUER, Eds. Sinauer, Sunderland, MA, 1985. xiv, 488 pp., illus. $55; paper, $30. From a symposium, Mainz, Germany, Oct. 1983.

It is difficult to think of a concise title that would capture the essence of this book. Its given title does not, somehow, do it justice. Although about half its 28 chapters are primarily experimental, many are based on observational field studies, theoretical models, or reviews of literature. Nor is the content of the book restricted to the particular interpretative slant suggested by "behavioral ecology and sociobiology," although that field is well represented here by some of its most distinguished practitioners (Wilson, Krebs, Markl, Bradbury, Emlen and Vehrenkamp, Sherman and Holmes). The contributions are in fact highly varied in style, from a warm biographical essay on von Frisch by Lindauer, through accounts of ingenious laboratory and field studies of army ants (Franks), desert isopods (Linsenmair), and ground squirrels (Sherman and Holmes), to reports of remarkable detailed laboratory research on the mechanism of orientation in honeybees (Wehner and Rossel) and their complementary opposite—ruminations (Griffin) on "cognitive dimensions of animal communication." The book is a memorial tribute to Karl von Frisch, who revolutionized the public image of insects with his ingenious work on the sensory physiology and dance-communication of honeybees. Perhaps it could have been titled "Modern, Exemplary Studies of Animal Behavior that Karl von Frisch Would Have Liked." Keywords indicating its primary content and emphasis (number of chapters in parentheses) are: honeybees (nine), communication (nine), behavior evolution (nine), social insects (15), forag-

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-