

Griffin D R. *Listening in the dark: the acoustic orientation of bats and men.*
New Haven, CT: Yale University Press, 1958. 413 p.
[Biological Laboratories, Harvard University, Cambridge, MA]

I reviewed available evidence for echolocation in bats, whales, birds, and blind people, including comparisons with those "artificial bats" called radar and sonar. Background material included natural history, behavior, and physiology, especially metabolic adaptations and migrations. Opportunities for future research were emphasized. [The *SC*® and *SSC*® indicate that this book has been cited in over 385 publications.]

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This book, the title of which was suggested by my father, Henry F. Griffin, grew out of three Trumbull lectures on animal navigation given at Yale University in December of 1955. I hoped to stimulate more interest in echolocation, the ability of animals and men to locate objects at a distance by the echoes they return from probing signals.

Biologists had accepted with interest the 1940 discovery by Robert Galambos and me (at Harvard University) that bats avoided obstacles by hearing echoes of sounds above the range of human hearing.¹ Later, while at Cornell University, I found that bats also detect their insect prey by echolocation. In collaboration with a few students and colleagues at Harvard, notably Alan D. Grinnell² and Alvin Novick,³ I began to appreciate the range of specializations for echolocation among the diverse groups of bats and other animals. But I felt intellectually lonesome because so few other scientists had become actively involved in the investigation of these fascinating adaptations of behavior and physiology.

The book helped stimulate extensive and significant investigations, thus assuring its own technical obsolescence. When the original edition of about 3,000 copies was exhausted, I started a revision, but progress in the field was so extensive that I could not keep up with it. Dover reprinted the book in 1974, and in 1986 Cornell University Press reprinted it again, with a preface by James A. Simmons, whose own extensive and ingenious experiments were among the most important in extending our understanding of echolocation far beyond anything I even imagined in my most speculative dreams of the 1950s. The book was also honored by the Eliot Medal of the National Academy of Sciences.

So much has since been learned about bats and echolocation that only two chapters remain as pertinent as they were in 1958. Chapter 3 reviews a fascinating and thought-provoking history that has timeless lessons concerning the interplay of critical caution based on familiar concepts and the enterprising imagination that leads to revolutionary discoveries. Chapter 12 is unfortunately *not* obsolete, for aside from the quantitative measurements of C.E. Rice,⁴ very little has been added during the past 30 years to our understanding of human echolocation, despite its great importance for the blind.

Recent symposia and reviews can bring an interested reader up to date on bats and echolocation, especially the books by M.B. Fenton,⁵ J.E. Hill and J.D. Smith,⁶ and Simmons.⁷ An encyclopedic symposium volume⁸ will cover the whole field and its many fascinating ramifications. Of all these new discoveries I am most impressed and intrigued by the mounting evidence that not only can some species of bats detect and capture flying insects by means of echolocation, but they also can discriminate between the echoes of different kinds of insects despite the great fluctuations of echo intensity and frequency spectrum as an insect turns and moves its wings.

Finally, I should confess that the study of bats and echolocation has been great fun, and I only hope that my many successors will enjoy the fruitful interaction between field and laboratory investigations as much as I have.

1. Griffin D R & Galambos R. The sensory basis of obstacle avoidance by flying bats. *J. Exp. Zool.* 86:481-506, 1941.
2. Grinnell A D & Griffin D R. The sensitivity of echolocation in bats. *Biol. Bull.* 114:10-22, 1958.
3. Griffin D R & Novick A. Acoustic orientation of neotropical bats. *J. Exp. Zool.* 130:251-300, 1955. (Cited 60 times.)
4. Rice C E. Human echo perception. *Science* 155:656-64, 1967.
5. Fenton M B. *Communication in the Chiroptera.* Bloomington, IN: Indiana University Press, 1985. 161 p.
6. Hill J E & Smith J D. *Bats, a natural history.* Austin, TX: University of Texas Press, 1984. 243 p.
7. Simmons J A. *The sonar of bats.* Princeton, NJ: Princeton University Press. (In press.)
8. Nachtigal P, ed. *Animal sonar systems.* New York: Plenum. (In press.)

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