

As more specialists enter the debate, there is a growing need for a comprehensive and succinct survey of the field. This Resource Letter proposes to serve that function. It has been organized into several parts. Section II is a scientific and historical overview. Sections III and IV cover specific issues in the debate over whether other civilizations exist in the universe. Section V deals with experimental and observational studies pertinent to this question, including past and planned work, and possible alternate approaches.

In selecting citations, we attempted to satisfy three criteria. First, the material aims to provide exposure to all the important ideas and investigations in the field. Generally, we preferred the original articles, but sometimes chose major review papers for succinctness and clarity. Second, we did not want to overwhelm the reader with a discouraging bulk of selections. (Bibliographies cited at the end will assist the energetic in locating more material.) Books were generally avoided. Third, the material ought to be suitable for tutorial purposes. By these criteria, some excellent papers may not have been judged suitable for inclusion. We crave the indulgence of the authors of excluded works.

In selecting articles for the Reprint Book, we have emphasized those which are hard to locate, and which would not be expected to be found in a typical university research library. The reader's attention also is drawn to the following collection of papers.

1. *The Quest for Extraterrestrial Life, A Book of Readings*, D. Goldsmith (University Science Books, Mill Valley, CA, 1980). (E), (I)

## II. BACKGROUND

### A. Major review works

If the reader has time to look over only a few works on this subject, the following provide a succinct overview. See also Sec. VI.

2. *Intelligent Life in the Universe*, I. S. Shklovskii and C. Sagan (Holt-Day, New York, 1966). This work brought widespread attention to the modern debate. (I)
3. *Interstellar Communication: Scientific Perspectives*, edited by C. Ponnamperna and A. G. W. Cameron (Houghton-Mifflin, Boston, 1974). These edited versions of lectures presented at the NASA Ames Research Center during the summer of 1970 effectively summarize the scientific rationale that motivated NASA's first involvement with the search for extraterrestrial intelligent life. The chapter by Oliver presents Project Cyclops, which evolved during the subsequent study carried out at Ames in the summer of 1971. (I)
4. *Life in the Universe*, edited by J. Billingham (MIT, Cambridge, MA, 1981). Proceedings of a NASA 1979 conference. (I)
- \*5. "The 'Great Silence': The Controversy Concerning Extraterrestrial Life," G. D. Brin, *Q. J. R. Astron. Soc.* **24**, 283-309 (1983). Surveys explanations for the absence of evidence of extraterrestrial civilizations and arranges them in a framework, outlining the full dimensions of the problem. Demonstrates that present approaches may be simplistic. (I)
6. *The Search for Extraterrestrial Intelligence*, T. R. McDonough (Wiley, New York, 1987). Any astronomer will sooner or later be asked about extraterrestrial life by relatives or friends who have little or no technical education. This book anyone can enjoy. (E)
7. "Extraterrestrial Intelligence: The Debate Goes On," *Phys. Today* **35** (3), 26-38 (1982). A lively debate featuring letters from many prominent and opinionated scientists. (I)

### B. Ancient philosophy and myths

In a field with as few hard facts as this one, speculation and debate are strongly influenced by cultural biases. Often, a protagonist for a particular viewpoint is unaware that he or she is continuing a long tradition. Understanding the

origins of these biases may encourage less passionate argumentation.

8. "Extraterrestrial Intelligent Life" (parts I and II), L. E. Beck, in *Extraterrestrials: Science and Alien Intelligence*, edited by E. Regis, Jr. (Cambridge U. P., Cambridge, MA, 1985), pp. 3-9. A succinct summary of the history of the idea of extraterrestrial life and its modern legacy. (E)

The above may be considered an appetizer. Unfortunately, there are few short works on this subject. Interested readers are referred to the following books.

9. *Plurality of Worlds*, S. J. Dick (Cambridge U. P., Cambridge, 1982). Presents the history of the extraterrestrial life debate from Democritus to Kant, illustrating its role in the development of philosophy and science. (I)
10. *The Extraterrestrial Life Debate 1750-1900*, M. J. Crowe (Cambridge U. P., Cambridge, 1986). Covers the most vigorous period in the history of the extraterrestrial life debate. (I)

### C. Modern principles

Those contemplating extraterrestrial life are generally influenced by deep assumptions about how the universe works. For instance, since Copernicus, most astronomers have adhered to the "mediocrity principle"—that the Earth is not a unique place—which implies the likelihood of other abodes of life. The "anthropic principle" counters this, suggesting we may be unique, after all. This philosophical debate has obvious implications for possible evolution elsewhere in the universe.

11. "The Anthropic Principle," *G. Gale, Sci. Am.* **245** (6), 154-171 (1981). A popularized account. (E)
12. "Redefining the Cosmos," H. T. Simmons, *Mosaic Magazine* (National Science Foundation), March (1982), pp. 16-22. The Cosmological Principle, or assumption of mediocrity, is taught as almost religious canon to students of astronomy. (I)
13. "The Anthropic Principle and the Structure of the Physical World," B. J. Carr and M. J. Rees, *Nature* **278**, 605-612 (1979). Surveys the apparently fortuitous values of the physical constants that permit life to exist in the universe. Is this a coincidence or somehow related to the existence of "observers"? (A)
14. "Kantian Epistemology as an Alternative to Heroic Astronomy," W. I. McLaughlin, *Vistas Astron.* **28**, 611-639 (1985). Our universe of perceived and understood phenomena is a mental construct limited by our ability to perceive and reason about a larger, real universe that lies beyond our perception and understanding. Thus we have created our universe, but in our minds, not in reality. (I)
15. "Particle Physics and Inflationary Cosmology," A. Linde, *Phys. Today* **40** (9), 61-68 (1987). A very clear introductory exposition of inflationary cosmology, which shows how this theory removes in an uncontrived way any need for anthropic principles. (I)

### D. Evolution

A thorough understanding of evolutionary processes would enable us to judge better how likely it is that mankind's level of intelligence and technology is unique in the universe.

16. "Thermodynamics of Evolution," I. Prigogine, G. Nicolis, and A. Babloyantz, *Phys. Today* **25** (11), 23-28, and **25** (12) 38-44 (1972). Evolution is a cosmic process that creates order out of disorder, based on thermodynamically open systems far from equilibrium. (A)
17. *The Search for Universal Ancestors*, edited by H. Hartman, J. G. Lawless, and P. Morrison (NASA SP-477, U. S. Gov. Printing Office, 1985). The reading public is not generally aware of the little monograph gems that are published by NASA. This one, a mere 126-pages long, presents the search for the origin of life in a delightful style. Only one chapter, "The Laboratory Experience," is somewhat technical. Unfortunately, it lacks an index. (I)
18. "Galactic-Scale Civilization," T. B. H. Kuiper, in *Strategies for the*