aquifers by hydrocarbons, heavy metals, sewage, and other pollutants, and even the filling of caverns with explosive or toxic gases are the real features of interest. Jennings mentions the importance of this very practical aspect of karst geomorphology in the preface of the book, but he does not discuss it at length on the grounds that a satisfactory exposition would require too much space.

Jennings died of a heart attack while skiing in 1984. This book is his last statement on the subject of karst. It communicates much of his love of landscape and is highly recommended as an introduction to the subject.

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A Reunion in Physics

Shelter Island II. Proceedings of the 1983 Shelter Island Conference on Quantum Field Theory and the Fundamental Problems of Physics. ROMAN JACKIW, NICOLA N. KHURI, STEVEN WEINBERG, and EDWARD WITTEN, Eds. MIT Press, Cambridge, MA, 1985. xii, 369 pp., illus. $37.50.

In early June of 1947, a group of 24 physicists gathered at the Ram's Head Inn on Shelter Island, a remote, sparsely populated island located about 100 miles east of Manhattan near the end of Long Island. Their 2½-day meeting was the first major postwar theoretical physics conference in the United States. Its purpose was to bring together leading researchers to discuss some of the outstanding problems in quantum theory. (The list of participants reads like a Who's Who in Physics.) The impact of that meeting is now part of history. Indeed, as a direct consequence, Hans Bethe produced his famous Lamb-shift calculation and Robert Marshak proposed the two-meson hypothesis. Even more important, the seeds were sown for Richard Feynman's and Julian Schwinger's classic works on quantum electrodynamics and later more formal developments in renormalization theory. Those breakthroughs laid the foundation for our present-day theories of elementary particle physics.

To commemorate that historical meeting, a second Shelter Island Conference was held in June of 1983 at the same Ram's Head Inn. Besides providing a reunion for the class of 1947 (ten of the original 24 participants returned), Shelter Island II was organized in the same spirit as the earlier meeting, to bring together a relatively small group of researchers who would survey the state of elementary particle physics and discuss future directions. Some of the proceedings of that meeting have been edited and collected in *Shelter Island II*.

The first part of the book contains scientific talks by some of the world's leading physicists. It begins with a kind of state-of-theory address by Murray Gell-Mann. As always Gell-Mann is comprehensive and entertaining. (I was particularly amused by his linguistic anecdote that the *f* in O'Raifertaigh, the name of a well-known Irish physicist that I always have trouble spelling, should really be *thbh*.) Gell-Mann provides a nice perspective on how far theoretical physics has advanced and what problems remain. One of those problems—how gravity can be unified with the other fundamental forces—sets the theme for most of the meeting. Subsequent talks range from technical discussions by Steven Weinberg, Michael Duff, and Edward Witten of Kaluza-Klein theories, in which gravity is fundamental and the other forces are a result of compact extra space dimensions, to Stephen Adler's description of gravity as an effect induced by embedding the other fundamental forces in curved space-time. Advances in supersymmetry, an important ingredient in attempts to tame the short-distance infinities of quantum gravity, are discussed by Bruno Zumino and P. C. West. There are also survey talks less (in some cases, not at all) concerned with gravity by T. D. Lee, Roman Jackiw, Alan Guth, A. D. Linde, S. W. Hawking, and Toichiro Kinoshita, who discuss their current research efforts. All of these talks are clear and well written, but I particularly appreciated those on the new inflationary universe cosmology by Guth and Linde, two of the pioneers in that field. However, if Shelter Island II is to have a scientific legacy, I would guess that it might stem from a talk by John Schwarz, "a brief survey of superstring theory." Schwarz and his collaborators have argued for more than a decade that we must abandon our point particle approach to physics at short distances and reformulate theories in terms of string variables. Not long after Shelter Island II, a technical breakthrough by Michael Green and Schwarz led to a viable superstring theory of all interactions found in nature. As a result, during the past two years superstring research has dominated elementary particle theory. Indeed, some superstring enthusiasts have likened the present situation to the exciting early days of quantum mechanics. If this is true, it would make for an interesting Shelter Island III meeting.

Although the scientific proceedings are enjoyable, I prefer the part of the book devoted to historical perspectives. Personal recollections by participants in Shelter Island I make captivating reading. Even more fascinating is a history of Shelter Island I by Silvan Schweber. Schweber chronicles the organization of the meeting, the meeting itself, and subsequent meetings in the Pocono Mountains and Peekskill, New York, at which quantum electrodynamics was reformulated. Schweber's description of a police-escorted bus ride by the conference participants from Manhattan to Shelter Island, dinner hosted by a proud local chamber of commerce, newspaper coverage, and the like combined with a splendid group photograph bring the conference to life and contrast it sharply with today's very different style of conferences. I strongly recommend the section of historical perspectives, particularly Schweber's contribution, to any physicist or student of history. It distinguishes this book from the far too many conference proceedings one regularly receives and earns for it a treasured place in one's permanent library.

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Life in the Universe

The Search for Extraterrestrial Life. Recent Developments. MICHAEL D. PAPAGIANNIS, Ed. Reidel, Dordrecht, 1985 (U.S. distributor, Kluwer, Hingham, MA). xxvi, 579 pp., illus. $64; paper, $29.50. IAU Symposium no. 112. From a symposium, Boston, June 1984.

Three topics in astronomy seem to hold endless fascination for scientists and layfolk: black holes, the origin and structure of the universe, and extraterrestrial life. Of the three, extraterrestrial life is easiest to visualize and even to identify with. Following a considerable period of marginal legitimacy, the search for extraterrestrial life has attained respectability, and the International Astronomical Union recently established a new commission, Bioastronomy, to deal with the subject. The book under review is the proceedings of the commission's first official scientific meeting, held in 1984. The most recent proceedings of previous meetings on

extraterrestrial life appeared in 1980 and 1982, and when I was approached by *Science* to review the proceedings of the 1984 meeting it seemed inconceivable that sufficient new material could have accumulated in only three years to justify yet another volume. I must confess, however, that I was rather pleasantly surprised. After the wheat is separated from the chaff (in this field there is usually a surplus of the latter), something substantial still remains.

The most substantive sections are those on recent technological progress in radio searches for extraterrestrial intelligence (ETI) and on optical and infrared searches for other planetary systems. The next few decades of radio searches are likely to be dominated by a program at NASA Ames and the Jet Propulsion Laboratory that is currently funded at a level of $1.5 million per year. Detailed discussions of the hardware and software now under development and the planned search strategy are presented by most of the leading workers at Ames, JPL, and Stanford University. In addition, there is an excellent review by Jill Tarter of recent radio searches and a delightful description by Paul Horowitz and John Forster of the novel Harvard-Smithsonian narrowband (now 8.4 million-channel) search project.

These ambitious radio searches for ETI may never discover anything of interest. The same is not likely to be true of searches for other planetary systems. Indeed, tantalizing hints already have begun to emerge, beginning in 1983 with infrared discoveries by NASA's Infrared Astronomy Satellite (IRAS) and by ground-based observers. Hartmut Aumann reviews the exciting IRAS discovery of clouds of tiny dust particles in orbit about a substantial fraction of all nearby main-sequence stars that are somewhat more luminous than our sun. A noteworthy connection between the IRAS discoveries and the radio searches for ETI is the star ϵ Eri, which was one of the two sunlike stars first examined for radio signals by Frank Drake in 1959 and is the lowest-luminosity star that IRAS discovered to be surrounded by a dust cloud. Steven Beckwith describes the ground-based discovery of even more massive dust clouds near a few newly formed, sunlike stars. All the dust clouds discussed by Aumann and by Beckwith have dimensions comparable to or somewhat larger than our solar system. Nonetheless, these discoveries only hint at the existence of other solar systems. A pessimist could argue that the reason that there is so much dust in orbit about these stars is because planets have not formed and never will. Other contributors consider various techniques that eventually may detect large planets in orbit about nearby stars. However, these papers are distinctly less satisfying than those of Aumann and Beckwith since they describe only what the future may bring. There is still no confirmed example of a planet-like extrasolar object.

Two interesting papers concern the existence of bacteria in interstellar space. J. Mayo Greenberg and Peter Weber describe their experiments on the viability of spores at 10 K subjected to a flux of ultraviolet radiation. The results may be relevant to the idea of panspermia. R. E. Davies and colleagues compare their new laboratory ultraviolet spectra of various proteins, viruses, bacteria, and so on with interstellar spectra and conclude that there is no spectral evidence for the existence of any biological cells like those on Earth in interstellar space.

A most unusual feature of the volume is that it contains 14 chapters of various sorts by the editor. This may be compared with a total of 63 contributions by everyone else. Given this imbalance it is unfortunate that the editor's contributions are not always error-free. For example, in the "historical introduction," the date of the launch of the first Sputnik is given, incorrectly, as 4 October 1959. (This error is clearly not merely a typo.) Ironically, 550 pages later, in another chapter by the editor, the correct launch year, 1957, appears.

This volume clearly deserves a place on our bookshelves. If the commission on bioastronomy has a major meeting every three years, as it is intimated on p. 555 that it will, I wonder if this will be true of subsequent proceedings.

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Teleological Cosmology

The Anthropic Cosmological Principle. JOHN D. BARROW and FRANK J. TIPLER. Clarendon (Oxford University Press), New York, 1986. xxii, 706 pp., illus. $29.95.

Do you prefer the proof of the existence of God by St. Thomas Aquinas? Or do you defer to the derivation of the wave function of the universe by Stephen Hawking and James Hartle? How about the creation myth of the Boshongo, a Bantu tribe? Or does evolution in an 11-dimensional Kaluza-Klein universe more accurately describe the origins of space and time? The unprejudiced observer may find it difficult to choose between these options. His or her task will be greatly aided, however, by the appearance of *The Anthropic Cosmological Principle*, which presents a unique blend of modern and ancient cosmology.

The book is devoted to a resurrection of teleology, the notion that the universe was shaped not by chance but by a grand design. After Darwinian evolution had destroyed much of traditional teleology, cosmology developed into a physical science during the 20th century, with the introduction of the tensor calculus helping to drive the philosophers and theologians out of the field, much to its subsequent loss. But the pendulum does swing in science, and we now have Barrow and Tipler making much of the idea that our presence is indispensable to the existence of the observed universe. Even more, our presence requires a unique universe, thereby coupling the largest observable horizons of tens of billions of light-years to our puny solar system a mere light-hour across. Even the infinite horizons that the future holds in store for us are uniquely constrained by our mere act of existence.

One of the book's central themes is creation whether it concerns the matter content of the universe, the size of the universe, the dimensionality of the universe, or life itself. Biological application of the anthropic argument in a form that originated with Brandon Carter leads to a relation between the number of improbable steps that have enabled humans to evolve and the future length of time during which the biosphere will continue to evolve. Remarkably, we learn that intelligent life on earth may only be destined to evolve for another 40,000 years. It is not difficult to think of a mechanism by which life could be extinguished, but how seriously do we take, for example, the inevitability of nuclear winter? Carter's hypothesis relies on the improbability of the evolution of intelligent life. Should our galaxy turn out to be teeming with intelligent extraterrestrials, all bets are off. Barrow and Tipler argue, however, that space colonization by such extraterrestrials would have been inevitable and that any such species would have revealed itself over the billions of years available for its self-replicating technology to have developed.

It is such arguments that may justifiably lose the reader's confidence in his or her guides on this cosmic journey through space and time. Obviously, a truly intelligent species could have developed a plethora of means to hide all trace of extraterrestrial contact. But this is a quibble with a marvelous treasure trove, a novel guide to our bizarre universe. The book will be a joy to all cosmologists and would-be cosmologists, whether their background is in quantum physics or philosophy. Much of the book is original and explains with clarity and wit ideas that are otherwise almost inaccessible.