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.

It is a unique potpourri of historical anecdotes, philosophical arguments, mathematical derivations, and physics jargon. And it is a great bargain.

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Star Formation

Protostars and Planets II. DAVID C. BLACK and MILDRED SHAPLEY MATTHEWS, Eds. University of Arizona Press, Tucson, 1985. xx, 1293 pp., illus. $45. From a meeting, Tucson, Jan. 1984.

The transformation of an interstellar cloud to a star or a planet involves an increase in gas density by a factor 10^{25}. The range of physical problems faced by astronomers trying to understand this transformation covers a correspondingly broad spectrum, ranging from instabilities caused by galactic shock waves 10^{22} centimeters long to the coalescence of dust particles 10^{-4} centimeter in diameter. This book is a courageous attempt to bring together all the main threads in a single volume of 43 review chapters based on papers presented at a conference. Major themes discussed in the book include the instability and fragmentation of molecular clouds, the dynamics of disks and jets discovered around young stellar objects, the chemistry of meteorites and of the interstellar medium, and the origin and evolution of the giant planets and of the protoplanetary nebula.

Broadly speaking, the contributors to this volume can be identified either as astrophysicists interested in the signs of recent and incipient star formation in interstellar gas clouds 10^{20} centimeters or more distant or as planetary scientists looking within the confines of our own 10^{15} centimeter diameter solar system for clues to the origin of the sun and planets. The gap between these approaches is wide and is largely attributable to the enormous technical difficulty of detecting or studying planetary systems around any star apart from the sun. Can the gulf between the disciplines be effectively bridged in a single volume such as this? An encouraging answer comes from an examination of the differences between this volume and the proceedings of the first Protostars and Planets conference held in 1978. There are signs that the gap has narrowed considerably in the intervening six years. Because of improvements in the sensitivities of infrared and millimeter-wave telescopes, galactic astronomers are now able to study the progenitors of sunlike as well as high-luminosity stars. The success of the Voyager flybys, meanwhile, has drawn the main attention of planetary astronomers away from the terrestrial and toward the giant planets, the evolution of which bears strong resemblances to those of stars. Both groups of astronomers are faced with new problems involving the dynamics of flattened rotating systems; planetary astronomers are addressing the newly discovered complexities of Saturn's rings, while galactic astronomers are exploring the connections between collimated outflows and circumstellar disks around young stellar objects.

The editors of *Protostars and Planets II* have produced a thick volume that will be of considerably greater durability than the average collection of conference proceedings. Authors have been allowed, if not encouraged, to expand their papers into full-length reviews, which in two cases are over 90 pages long. The book is elegantly typeset and includes an extensive index, a glossary, and an 85-page list of references. A penalty for this approach is that the book has been two years in preparation. These two years have been eventful: the IRAS satellite has found dust rings around the sun and signs of planetary material around Vega, there have been flybys of Uranus and Comet Halley, and a large planet-like companion to the star van Biesbrock 8 has been discovered. It will soon be time for Protostars and Planets III.

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Precision Measurement

The Fundamental Physical Constants and the Frontier of Measurement. B. W. PETLEY. Hilger, Bristol, England, 1985 (U.S. distributor, International Publishers Service, Accord, MA). x, 346 pp., illus. $49.

Metrology and the determination of the fundamental constants are an important but little recognized field of science to which all scientists are indebted. The major participants in the field are a few individuals located principally in national standards laboratories and university laboratories who have been seduced by the "romance of the next decimal place" and who enjoy the challenge of measuring physical quantities to a higher precision with a stated uncertainty. Occasionally new science is found in the next decimal place.

Brian Petley, whose home is the National Physical Laboratory in England, is a long-time participant in this endeavor who has worked on many different metrological problems. In this book he has provided a broad survey of the field that will be useful to participants, to students, and to curious bystanders.

The first part of the book provides a historical summary discussing what is meant by a fundamental constant, the evolution of what have been regarded as fundamental constants, and the increased role in metrology of measurements of time, frequency, and wavelength. Familiar examples of fundamental constants are the speed of light, the Boltzmann constant, the Planck constant, the charge of the electron, the Rydberg constant, and the Faraday constant. The major advances in this century have been in the measurement of time and frequency and the replacement of arbitrary prototype standards, such as the distance between two scratches on a platinum-iridium bar, by standards based on the properties of simple physical systems. The second, for example, is now defined in terms of a cesium atomic clock rather than the somewhat variable rate of rotation of the earth.

Coupled with the issue of measurement is the issue of units and standards for measurement. To measure the velocity of light requires a unit for measuring length and a unit for measuring time. To measure voltage requires some form of voltmeter that has been calibrated against a standard for voltage. One shortcoming of the book is that it does not summarize the original definitions of such Standard International units as the meter, the kilogram, the second, and the ampere or provide a description of the techniques initially used to realize them. One problem that has plagued metrologists is that during this century the standards for the volt, the ampere, and the ohm have changed.

In the view of many scientists the most important constants are dimensionless constants or dimensionless combinations of constants. The most well-known example of these is the fine-structure constant that is a measure of the strength of the electromagnetic interaction. The most famous constant is the speed of light. It has been the subject of increasingly precise measurements since Galileo's first attempt to measure it using lanterns on adjacent hills. The theory of relativity elevated the speed of light to a particularly high status in that it has the same value in all inertial frames. The availability of the laser has made it possible to define the meter as the distance traveled by light in a time period measured with respect to a cesium clock. Thus the velocity of light is no longer a constant to be measured but an ingredient in the definition of the unit of