suming that different aspects of understanding of time are more closely related than, say, understanding of how to infer temporal duration and how to do arithmetic problems. Second, and related, at what level can we most profitably model conceptual understanding? The chapters in this volume include a few promising leads in this direction. For example, Bullock, Gelman, and Baillargeon divide children's knowledge into the principles that define understanding, the stimulus relations such as contiguity that suggest likely connections, and the knowledge about objects and events that inform us as to the plausibility of possible causal connections. Presumably each type of understanding would need to be included in a comprehensive model of conceptual knowledge. At present, however, these promising leads remain just that. None of the contributions in the book provide detailed models that integrate different aspects of understanding of time. Few authors even present detailed models of understanding of individual aspects of time. *The Developmental Psychology of Time* documents the progress that has been made in describing children's conceptual understanding since Piaget's initial efforts. It also documents the tasks that still remain.

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Life in the Universe

Extraterrestrials: Where Are They? Papers from a symposium, College Park, Md., Nov. 1979. MICHAEL H. HART and BEN ZUCKERMAN, Eds. Pergamon, New York, 1982. x, 182 pp., illus. Cloth, $22.50; paper, $9.50.

The pendulum of opinion on the probability of extraterrestrial life has swung several times. Classical civilization was willing to populate the moon and other heavenly bodies. But medieval views of the earth as the only material object in the universe rendered the question rather moot. The Copernican revolution led to acceptance of the reality of other planets, also to very widespread belief in life on them—for some early astronomers, even on the sun. This wave crested with Percival Lowell's claims around 1900 to have found evidence of intelligent life on Mars. Furthermore, in the 19th century Laplace's nebular hypothesis of solar system formation led to the supposition that other stars probably had planetary systems and hence could be havens for life.

The first major counterattack came around the turn of the century. The nebular hypothesis in its primitive form could not adequately explain the degree of angular momentum in the planets, so T. C. Chamberlin and F. R. Moulton proposed that the solar system formed through a close encounter of two stars, tearing out mutual tidal filaments that condensed to form the planets. Stars are so awesomely far apart in relation to their sizes that such a near miss should practically never have occurred in the history of the galaxy. Our solar system would thus be essentially unique. Widespread acceptance of this cosmogony gave an entire generation, up to the 1940's, little reason to think very seriously about life elsewhere in the galaxy. Anti-extraterrestrialists took solid comfort from the U.S. space probes in the 1960's and '70's, which scotched the idea that there were canals on Mars and showed that life on Mars, if present at all, must be very well concealed, for example in moist subsurface regions. Nor have probes to the other objects in the solar system given much encouragement to the search for life.

On the other hand, over the last 30 or 40 years the nebular hypothesis has not only revived but has been shown by several lines of evidence to be essentially correct. Planetary systems are thus presumably quite commonly associated with other stars, although to be sure no case has yet been unambiguously detected. Further evidence includes the generally uniform chemical compositions throughout space, the vast spans of time available, and the overwhelming numbers of stars, and hence of potential solar systems, in our galaxy alone. This evidence led, after the Second World War, to an almost euphoric acceptance by most astronomers that life could well be a ubiquitous phenomenon in the universe. This belief has been encouraged by the explosive progress in biochemistry, probing toward mechanisms of origin of life, and in paleontology, showing that life apparently appeared on earth rather soon after it became physically possible. It is difficult to imagine life without evolution and natural to suppose that senses of growing power, the organization of such senses into brains, and the ultimate development of intelligence leading to science and technology would also occur widely throughout the universe. The highly publicized project Ozma and a number of other searches for radio transmissions from such hypothetical civilizations were accordingly undertaken.

Some skeptics of course always remained. Michael Hart was the first to crystallize a number of the counterarguments in an important 1975 paper. He and several like-minded colleagues organized a conference in 1979 to explore these ideas more fully. Publication of the proceedings is belated but welcome. The title of the book stems from Fermi's famous question: "Where are they?" The argument, as fleshed out by Hart in the opening paper, is simple and somewhat spine-tingling. After only one or two centuries of what might truly be called science, the human race has already learned how to travel through the solar system. Another century or two should see our descendants forging out to the nearby stars. Colonies planted around these stars would be expected soon to expand further in a wave that should result in descendants from this planet spreading through the entire galaxy in less than a hundred million years. But our galaxy is more than a hundred times older than that. If other intelligent civilizations are so ubiquitous, surely some, if not even a vast number, must have gotten a head start on us and should long since have filled the galaxy. Yet to quote from Ben Zuckerman's splendid preface: "To astronomers who work with giant optical and radio telescopes the Universe appears to be a gigantic wilderness area untouched by the hand of intelligence (with the possible exception of God's)."

Where are they, indeed? A series of fascinating papers explores various facets of the question. Hart begins by throwing down the challenge: We observe no extraterrestrial intelligence because there *are* no other advanced civilizations in our galaxy. Zuckerman briefly reviews the half-dozen sensitive searches so far made by radio techniques. Robert Sheaffer examines claims that extraterrestrial visitors are being observed, giving good evidence for rejecting any such claim as a viable scientific hypothesis. Michael Papagiannis points out reasons why the asteroid belt should be examined carefully for evidence of any tampering by extraterrestrials. Sebastian von Hoerner reviews the likelihood of interstellar colonization. Ronald Bracewell stresses that the first advanced civilization could indeed preempt the galaxy. Freeman Dyson takes issue with statements occasionally made by distinguished scientists that interstellar travel is impossible by outlining no fewer than nine ways in which advanced civilizations might accomplish it. Half a dozen other interesting papers elaborate on the ideas sketched above. Hart concludes the volume with a second paper, pointing out the fantastically lucky and improbable path that life on the earth has trod through four billion years of potential disasters quite capable of wiping it out—either forcing evolution to begin again from scratch or totally precluding any future life. In other words, even though havens for life in the universe may be abundant, and even though life may indeed start in many places, the chance of life hanging in there long enough to evolve intelligence and technology may be very slight indeed for any given planet.

For those interested in questions on the grand scale, this slender book is one of the most interesting and important of the decade. Though few of the ideas are original with the volume, to have them collected in one place and so forcefully stated cannot fail to have a profound effect. The pendulum has been given a very hard push back toward at least a neutral point.

Nevertheless the book is quite one-sided. It does not include a single defender, such as Carl Sagan or Frank Drake, of the opposite point of view. Powerful counterarguments *can* be made. For example, there are a group of counterarguments that fall under the heading "absence of evidence is not evidence of absence." Galactic civilizations, of the type that survive suicidal tendencies and develop interstellar travel, may feel no need whatever to latch onto all the real estate in the galaxy, or any more desire to interfere with indigenous life forms than we have to catch every butterfly. Or our science may still be truly embryonic—we may be no more aware of the real currents of interstellar communication than Amazon natives are of the radio waves in which their bodies are bathed.

The recently published survey, *Astronomy for the 1980's*, sponsored by the National Academy of Sciences, considers these questions closely and recommends a modest but long-term program of listening and looking for evidences of intelligent extraterrestrial life, initially mainly in the high-frequency radio band. The survey recognizes that the probabilities of any early detection are small indeed but that the importance of such a discovery would be incalculably great. A further important factor is that low-cost technology now exists to improve over previous searches by factors of a million or more.

Are we alone? We just don't know. We are unlikely to know unless we look long and hard—and maybe not even then. But either way the implications are utterly profound. If we are not alone in the galaxy, can we hope someday to qualify as members of the galactic club despite our human frailties and foolishnesses? If we are alone, we are responsible for keeping this fragile spark alive and offering what should be the blessing of sentient life to countless descendants down through the eons.

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Martian Landforms

The Channels of Mars. VICTOR R. BAKER. University of Texas Press, Austin, 1982. xiv, 198 pp., illus. $39.95.

Perhaps one of the most enigmatic results of the recent exploration missions to Mars has been the discovery of massive and ubiquitous examples of fluid erosion on a planet that currently appears to be bone dry, with an atmospheric pressure typically less than 1 percent that of the earth. Ancient thousand-kilometer-long channels, dwarfing by orders of magnitude any conceivable terrestrial analog, suggest almost unimaginably large flows of water. Even older, widely scattered valley networks, equal in size to or larger than terrestrial canyon networks and of similar morphology, suggest persistent groundwater erosion.

Baker presents a comprehensive review of the controversy surrounding the seeming contradiction between the existence of channels and valleys, which strongly suggest water flow, and the dry and airless surface of Mars. He begins with historical controversies surrounding the study of Mars and takes the reader through the current ones, which concern the origin of the Martian channels. Baker is among those who favor an explanation of the channels that posits a catastrophic flood.

As he points out, 80 years ago another controversy involving a diluvialist hypothesis raged when J. Harlen Bretz suggested that the curious ragged morphology of the Scablands in eastern Washington could be explained by the occurrence of huge catastrophic Pleistocene floods. The Bretz hypothesis was severely criticized by leading geological figures of the day, particularly for its failure to suggest a source for the hypothesized floods. Critics of the hypothesis that catastrophic floods caused the large Martian channels also point to the lack of an apparent source for the floods as a weakness in the argument. In the earlier controversy ice-dammed Pleistocene Lake Missoula was eventually identified as the source of water, and the Bretz hypothesis was recognized as remarkably prescient, considering that synoptic spaceborne imaging was not available to him. Whether the proponents of Martian diluvialism will similarly triumph is still far from clear, as Baker readily admits.

Because Baker's previous comprehensive work on the Scabland problem (*Geol. Soc. Am. Spec. Paper 144* [1973]) was strongly in concert with the work of Bretz, it is not surprising to find him favoring a catastrophic flood as the source of the Martian channels. Nevertheless, his exposition of competing hypotheses, primarily eolian and glacial scouring, is fair and thorough, and his reference to parallel work of colleagues is generous.

Beyond the catastrophic flood controversy, Baker deals competently and completely with the general subject of climatic change on Mars and with the evidence bearing on it that a variety of other landforms may or may not provide. His approach is refreshingly that of an experienced geomorphologist, and the book is distinctly data-oriented, with a profusion of detailed geomorphic maps of Martian and Scabland channels and many page-sized photographs of Martian channels and terrestrial analog features. The only real criticism that can be leveled at the book is that a few pictures are upside down and the labels on some of the illustrations are not polished.

Recently, as a result of the Viking missions to Mars and the Voyager missions to Jupiter and Saturn, there have appeared a spate of popular and technical books of uneven quality that have surveyed the results of the missions generally. In contrast, *The Channels of Mars* is a well-focused and well-illustrated monograph about a fascinating morphological problem written in a lively style by an expert in fluvial geomorphology. Baker's book is a comprehensive summary and a stimulant for those of us studying Martian channels, valleys, and