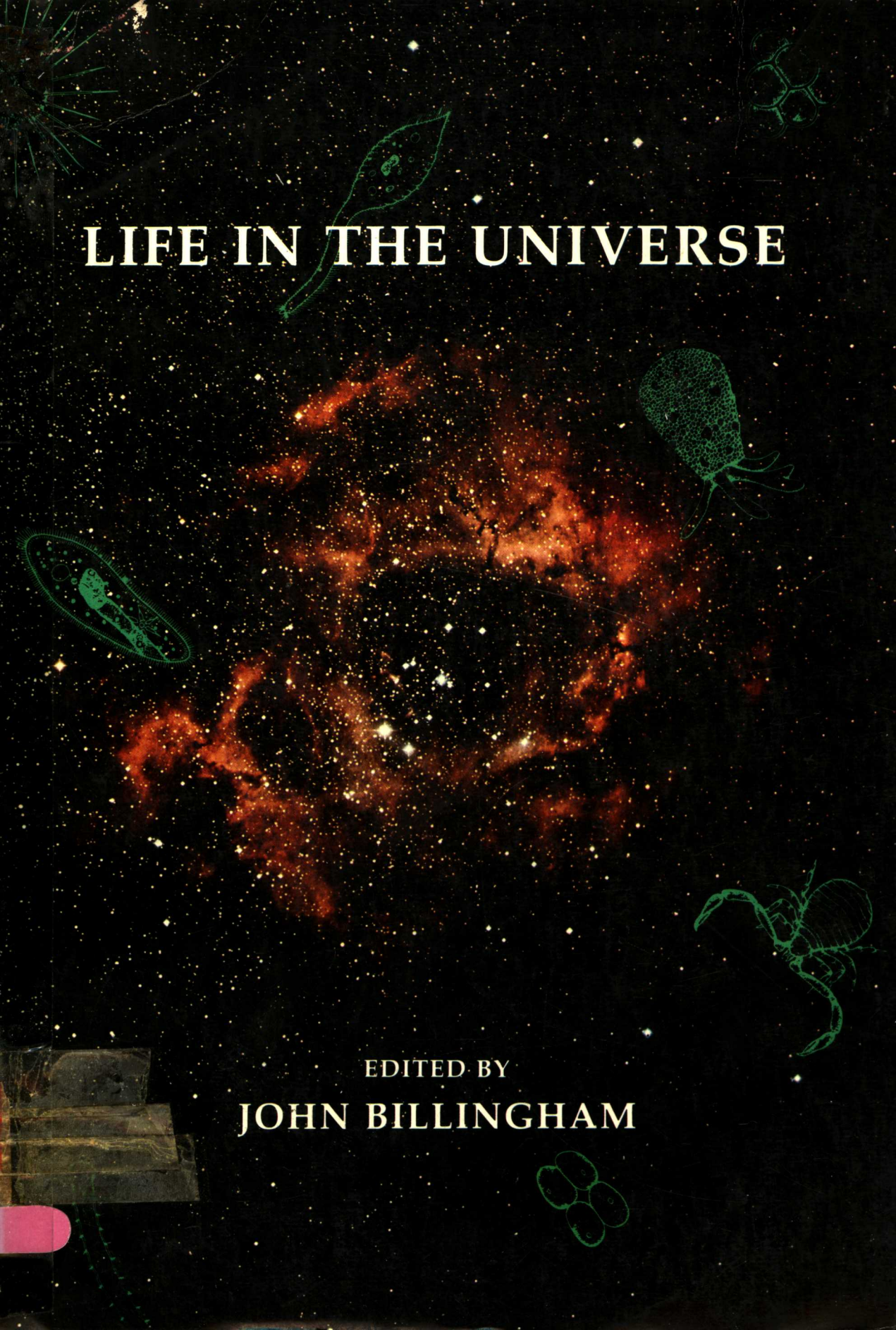
LIFE IN THE UNIVERSE



EDITED BY

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LIFE IN THE UNIVERSE

John Billingham, Editor

The MIT Press
Cambridge, Massachusetts
London, England

Preface

Over the past twenty years, there has emerged a new direction in science, that of the study of life outside the Earth, or exobiology. Stimulated by the advent of space programs, this fledgling science has now evolved to a stage of reasonable maturity and respectability. Its central tenet, based on a wide range of studies in a score or more of scientific disciplines, is that it is probable that life has emerged and evolved not only on Earth, but in many other places in the Universe. We do not yet have any evidence of the existence of extraterrestrial life, but its existence is predicted from the following arguments.

Modern astrophysical theory predicts that planets are the rule rather than the exception. Planets are therefore likely to number in the hundreds of billions in our Galaxy alone. Given a suitable location and environment for any single planet, current theories of chemical evolution and the origin of life predict that life will begin. And given a period of billions of years of comparative stability on the planetary surface, life will sometimes evolve to the stage of intelligence. The next step may be the emergence of a technological civilization, and it is possible that civilizations may be in communication with each other. It is relevant to ask whether we are now in a position to detect them.

As exobiology developed, it was only reasonable that the early work should concentrate on our Solar System. Studies of chemical evolution and the origin of life were complemented by the search for life and life-related chemistry on the planets of the Solar System. These investigations, of course, continue and are the essence of exobiology today. They draw heavily and inevitably on the story of the origin and evolution of life on Earth.

More recently, it has become apparent that our horizons should properly be enlarged to begin to look beyond the Solar System, to the Galaxy, and to the Universe. What is the nature and distribution of Life in the Universe? – a simple question, even bold, and clearly a question whose answers will be most difficult to achieve. But it is a question that surely should be asked. And it is the question that stimulated us to convene a Conference on Life in the Universe.

This volume records the proceedings of that conference. The meeting was held at NASA Ames Research Center, June 19-20, 1979. It was designed to address the broad questions of life in a roughly chronological sequence, dealing in turn with present theories of the physical and chemical events in the story of cosmic evolution, with the environments in which life can originate and evolve, to the evolutionary patterns which allow the emergence of complex biological systems, including intelligent beings, and finally to the possibility that we may now be able to detect the existence of extraterrestrial intelligent life.

The Conference on Life in the Universe was made possible only through the efforts of many people. It is not possible to acknowledge everyone, but special recognition should go to Bob Frosch, Administrator of NASA, who gave the Introduction at the meeting and who has encouraged us in this venture; to Sy Syvertson and Tom Young, Director and Deputy Director at Ames Research Center, who have equally lent their support; to our Chairmen, Harold Klein, George Herbig, Mark Stull, and Frank Drake, whose remarks appear at the front of the four sections of this volume; to the many Ames scientists who have helped me with editing this volume; to Larry Cohen and Charles Seeger for editing the manuscripts and preparing the Glossary; to the Ames people, particularly Mark Stull, who organized and arranged the meeting; to Paul Bennett and his colleagues in the Technical Information Division at Ames – Beulah Gossett for editing the manuscript and Ken Atchley and Marianne Rudolf for their work on the illustrations; to Charlotte Barton, Mary Jessup Young, and Al McCahon of Management Systems Associates for preparing the camera-ready copy; to Vera Buescher and Lorraine Bendik for pulling everything together at every stage; and last but not least to the authors of the wide range of presentations given at this meeting, whose papers are presented here and whose interest in life in the Universe was responsible, sine qua non, for the success of the Conference.

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Conference Overview

LIFE IN THE UNIVERSE as a title for a conference is both suggestive and debatable. We know of only one existence of life in the Universe – that being ourselves on planet Earth. We know that our Earth is an enormously small part of our Universe. A perplexing question evolves as to whether life abounds or are we unique. Attacking this question is not easy, and we are left with two distinctly different, though complementary, approaches.

The first is indirect and deals with developing an understanding of the origin of life and environments necessary to support life. Armed with some understanding in these areas, one looks to the Universe to study chemical characteristics and physical conditions. Combining our knowledge concerning the origin of life, life supporting environments, and the chemical character and physical nature of our Universe, we can develop theories concerning the evolution of complex life in our Universe. The first three sessions of this Conference focused on the indirect approach. This approach has strengths which were effectively illustrated by the Conference. There is a constant feedback as we stretch ourselves to consider life in the Universe, to further develop our views on the origin of life and the characteristics of life supporting environments. Additionally, we are continually striving to better understand our Universe. While we recognize the indirect approach will never uniquely determine the existence of life in the Universe beyond Earth, the pursuit will result in enormous growth in our understanding of life, its origin, and the necessary conditions for its existence.

The fourth session reviewed the direct search approach, referred to as the Search for Extraterrestrial Intelligence (SETI). It involves listening for potential radio transmissions from intelligent life somewhere in the Universe. The approach includes both a survey and the examination of suitable stars as targets. A research program has been established to begin a modest, direct search for life in the Universe.

The Conference very effectively dealt with the indirect and direct approaches to studying life in the Universe. Some people ask why such studies should be performed. The answers are numerous, varying from the

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scientific contributions that will result from the pursuit to the more intangible benefits derived from pondering our place in the vastness that surrounds us. The idea of a conference on life in the Universe is a tribute to the future. It demonstrates a faith, confidence, and concern about the future that is critically needed as we face the demands of the present.

A. Thomas Young
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(now Director of Goddard
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Introduction

When I was invited to attend this meeting, I decided to come for two reasons, one being to demonstrate by coming to talk to you that I think this subject is of central importance to the NASA job. My second reason, which is always a problem to the formal system, is that I wanted to come to the meeting to hear the papers because of my interest in the subject. As it happens, the system will not let me escape completely, so I will get to hear papers today, but not tomorrow.

We are in a unique time and in a unique situation. All generations feel that is the case. I think we can make the statement that for the first time we can see what the sketch of the connection between the origin of the universe and ourselves may be. As I understand the situation, it is only a sketch. There are lots of gaps in the chain of connection between the first instants of the universe, the formation of matter, the whole evolution of the universe, the galaxies, the stars, the solar system, the planets, the organic molecules and so on to ourselves. But at least we can say we have a sketch. We have pieces that we think we understand and there are pieces that we do not understand.

There are perhaps two gigantic missing pieces in this chain where I think it is fair to say we have hardly a clue. One is at the end nearest ourselves when we contemplate the nature of consciousness; the other is at the very other end where we contemplate the first instants of the universe. At best we may simply have reduced the whole problem to a lack of understanding of the beginning, which I suppose could be described as reducing it to a previously unsolved problem.

At least we have the satisfaction of knowing that a quest for understanding of ourselves has now become more than a blind groping for ideas. It has become a matter of connecting ideas from a distant past through a set of processes of which we have a glimmering and some knowledge to a present, and looking on beyond that into some distant future that we can only imagine. Our job now is to begin to test this chain of logic by looking at the universe and to ask seriously: "If the chain of logic is correct, is it only us?" If it is not only us – and that is what the chain of logic implies – then how can we not seek our siblings? How can we not find out who else is part of the

same chain of logic? If it should turn out that it is only us, then a very much greater problem is posed for us — how come? And what does that mean for the tasks that we have to set ourselves next? If the task is to find an understanding of ourselves, and if our understanding of origins implies others, surely we must find the others; but if there are no others, then we have the problem of generating our own next tasks.

All of this understanding comes at a very difficult time for attempts to understand. It comes at a time in which we seem to have a faltering in global and national interest in knowledge for its own sake. We have become hyperpractical and are expected to explain the use of things we do not understand, before we understand them.

It is a time of the "golden fleece" for SETI, and I presume it will be a time of golden fleeces for other things we try to do. The "golden fleece" idea, the idea that searches, gropings for knowledge whose purpose we do not understand are silly and some kind of a ripoff, results from sheer lack of understanding, lack of imagination, and lack of perception of the meaning of the history of the human race.

It is a lack of understanding of the nature of the increase of knowledge, whether immediately practical knowledge or not, and a lack of understanding of the intellectual risk-taking which is an essential part of any groping for knowledge. In any noisy system the only way in which we can be sure of making no false alarm errors is to turn the system off. There can be no detections if there is no possibility of false alarm. To grope we must have the possibility of error, the whole game is making errors, finding them, and disposing of them.

The second strain of trouble with which we battle in doing this work is the idea that the universe has been around for a long time, so let us postpone the expensive effort to understand it until we have saved the human race. The question is again backward — a misinterpretation of the nature of our history as a race. The question is not "how can we pursue knowledge until we have saved the race?" The historical question is more "how and why should we bother to save the race unless we seek to understand where we came from, who we are, and what the universe around us is about?"

The very process of saving ourselves is imbedded in and indissolubly tangled up with the process of understanding ourselves and what is around us. The cathedral of knowledge of self cannot be built only from the inside. It must also be built by testing what is built inside against what is outside. Our inner perception must somehow be congruent with the outer fact of the universe in which we are imbedded. What we are doing is not seeking, as is sometimes suggested, only power, technological capability, and what is sometimes described as bloodless scientific knowledge. Scientific knowledge is tied up intimately with our internal attempts to search for ourselves and

to understand ourselves because it provides the true context for what we are trying to understand.

I look forward to participating in this meeting because I think it is of profound importance scientifically, socially, and philosophically to pursue this subject. I think we are at the point where we must seriously talk about how we do experiments and seek success; we are beyond the point where we can only talk about how we grope. I look forward to the next steps.

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LIFE IN THE UNIVERSE

Contents

Three Eras of Cosmic Evolution

ERIC J. CHAISSON

This conference-opening paper sketches the global hypothesis that permeated the discussions at this interdisciplinary meeting, the purpose of which was to explore prospects for research into the nature and distribution of life in the Universe.

A friend who is a high-energy physicist once suggested that everything of importance happened within the first few minutes of the Universe. All subsequent events, he claimed, can be regarded as mere detail. Many scientists would regard my friend's view as provincial. The relatively simple subatomic matter may have been created in the first moments of the Universe, but the more complex organized matter now surrounding us must have formed well after its start. Every dating technique developed by post-Renaissance science suggests that complexity steadily arises from simplicity, order from chaos.

Granted, the initial coagulation of matter from otherwise chaotic radiation shortly after the Universe flashed into existence was an event of incomparable significance. This emergence of matter as the dominant constituent is the first great transformation in the history of the Universe. But a second great transformation occurs when technologically competent, intelligent life emerges from that matter. Our civilization on Earth is now on the threshold of this second transformation.

EARLY UNIVERSE

To place the construction of all matter into perspective, consider figure 1, which summarizes the run of density and temperature throughout all time for a Big-Bang Universe. It represents the consensus of contemporary

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