



Science of Aging
Knowledge Environment



SCIENCE ONLINE SCIENCE MAGAZINE HOME SCIENCE NOW NEXT WAVE STKE/AIDS/SAGE SCIENCE CAREERS E-MARKETPLACE

Institution: UNIV OF CALIFORNIA - BERKELEY | [Sign In as Individual](#) | [FAQ](#) | [Access Rights](#) | [Join AAAS](#)

Science magazine

HELP SUBSCRIPTIONS FEEDBACK SIGN IN AAAS

SEARCH

BROWSE

▶ ORDER THIS ARTICLE

ASTROBIOLOGY:

All Alone After All?

A review by Christopher P. McKay*

Rare Earth Why Complex Life Is Uncommon in the Universe
Peter D. Ward and Donald Brownlee
Copernicus (Springer-Verlag), New York, 2000. 361 pp. ISBN 0-387-98701-0.

Are we alone? This question guides the fundamental quest of **astrobiology**. Certainly interest in the field has surged in recent years, and there is an eager expectation in both the scientific community and the public that somehow we will soon obtain an answer. Lacking data, we guess at where to look and what we might find. But, as geologist Peter Ward and astronomer Donald Brownlee point out, it's important to clarify the "we" in the target of our search. "We" could refer to any life, to animal life, or to intelligent communicative beings. For each target, our search strategy and the expected results might be very different. The rare Earth hypothesis put forward in *Rare Earth* posits that microbial life is common but complex (animal) life is rare. The authors comb through all the aspects of what makes Earth a home for complex life: from deep within its interior, to the solar system, and beyond to the galaxy itself. For each factor they make the case (if not always convincingly) that the situation of our Earth is optimal for the development of complex life. It seems we do live in the best of all possible worlds after all.

For the first three billion years of Earth's history, our planet was populated only by simple microbial life. This pattern, we all agree, is the one most likely to be repeated on other planets. Maybe a shortened version of it even occurred next door, during Mars' early history. Why are we so confident that microbial life is widespread? The arguments in *Rare Earth* are the standard ones: Organic matter is common in the universe. The formation of many biologically important molecules is easily achieved in chemical reactions. The catalytic RNA molecule appears to be a suitable halfway point between proteins and DNA. And, most importantly, it all happened so quickly here on Earth, why not elsewhere as well.

Much has been made recently about microbial life in extreme environments, and *Rare Earth* follows

▶ [Summary of this Article](#)

▶ **dEBates:** [Submit a response to this article](#)

▶ [Download to Citation Manager](#)

▶ Alert me when: [new articles cite this article](#)

▶ Search for similar articles in:

[Science Online](#)
[ISI Web of Science](#)

▶ Search Medline for articles by: [McKay, C. P.](#)

▶ This article appears in the following Subject Collections:

[Evolution](#)
[Microbiology](#)
[Astronomy](#)

suit. But that emphasis is mistaken. Life on Earth is not very tough at all. No life form has yet been found that can grow or reproduce without liquid water. This restricts life to a fairly narrow range of temperatures, -20° to 120°C . By cosmic standards, that's a narrow habitable zone. Despite the rhetoric, recent work in extremophiles has not changed our understanding of the limits to life. The list of life's boundaries from 20 years ago is identical to the current one except that the upper temperature limit has moved from 100° to 113°C . What has expanded is our understanding of the ecology of life in environments difficult for humans to access. Accompanying this has been an increased comprehension of possible liquid water environments on early Mars, subsurface Mars, and Europa.

Nevertheless, I too believe microbial life is widespread. But in the back of my mind there are two uncomfortable facts. The first is that we have only one example of life, evolution, and intelligence. From this we can conclude that such events are not impossible, but any assessment of their probability is uncertain at best. The second is that we currently have no good evidence of any life beyond Earth. The infamous martian meteorite has whetted our appetite for evidence of life but not satisfied it.

The transition from microbial life to complex life (animals) is the key step. Factors that could influence this include a long-lived stable star, a Jupiter to scatter planetesimals throughout the solar system in just the right way, a Mars to perhaps provide the initial seed for life, a large Moon to stabilize the climate, just the right amount of water and carbon to provide for a stable biosphere but not overwhelm it, and, most importantly, plate tectonics. Plate tectonics emerges as the hero in the life story of Earth: "It may be that plate tectonics is the central requirement for life on a planet...." Subduction, volcanism, and plate motions recycle the planet both biologically and chemically and control the temperature. (It is sobering to remember that just 40 years ago plate tectonics was an unbelievable hypothesis.) If plate tectonics is the hero in the epic Ward and Brownlee recount, then meteor and comet impacts, which threaten to wipe out complex life at regular intervals, are the villains.

How do we discover how common life is? how common complex life is? how common intelligence is? By searching as widely as we can. Searching the skies for signals or artifacts of intelligent beings, searching the nearby planets for evidence of a second genesis of microbial life, and searching the nearby stars for habitable planets. We should let our quest be guided by our theories of life and evolution, but we should try not to be constrained by them--they may be wrong. In this spirit, *Rare Earth* provides a sobering and valuable perspective in just how difficult it might be for complex life and intelligence to arise.

The author is in the Space Science Division, Mail Stop 245-3, Moffett Field, CA 94035, USA. E-mail: cmckay@arc.nasa.gov

- ▶ [Summary of this Article](#)
- ▶ **dEbates: [Submit a response to this article](#)**

-
- ▶ [Download to Citation Manager](#)
 - ▶ Alert me when: [new articles cite this article](#)
-



Search for similar articles
in:

[Science Online](#)

[ISI Web of Science](#)

▶ Search Medline for articles

by:

[McKay, C. P.](#)

▶ This article appears in the
following Subject

Collections:

[Evolution](#)

▶ [Microbiology](#)

▶ [Astronomy](#)

Volume 288, Number 5466, Issue of 28 Apr 2000, p. 625.

Copyright © 2000 by The American Association for the Advancement of Science. All rights reserved.



Science of Aging
Knowledge Environment



▲ PAGE TOP