Astrobiology: A Very Short Introduction

by David C. Catling

Questions for Thought and Discussion

- Chapter 1 addresses the question of "What is Life?" by considering what we know from terrestrial life, our one example. Members of the public often wonder if scientists are failing to consider "life as we don't know it", which is an idea popularized in science fiction. Is the concept of "life as we don't know it" useful in factual science? How would we define "life as we don't know it" and how would we look for it?
- In the formation of the Earth, to what degree did chance events allow the Earth to become a habitable environment and what does that mean for the likelihood of Earth-like planets elsewhere?
- What is an acceptable level of proof that a geological or geochemical trace found in ancient rocks is a sign that there were once living organisms?
- What are the various possibilities for where life originated and their relative merits, and how will it be possible for future science to decide amongst these options?
- If an asteroid had never hit the Earth and ushered in the age of the mammals with the Cretaceous-Palaeogene mass extinction 65 million years ago, do you think technological civilization would have evolved in some other animal lineage, perhaps even the dinosaurs? What are arguments for and against such evolution?
- Our civilization is heading towards a point in the future where it can genetically engineer individuals and also greatly slow an individual's aging process. If and when this happens, how do you think it will alter the future evolution of the human species? Are there potential implications for the evolution of advanced life and civilizations elsewhere in the universe, if they exist?
- In Chapter 5, the book takes the point of view that viruses are not alive. But are there arguments for considering viruses as living entities?
- Could some viruses be remnants of the "RNA World" and if so, how would we find out?
- In Chapter 6, Table 1 gives a list of bodies in the Solar System where life might exist. What kind of extremophiles (listed in Box 1, p.81) might exist on each of these celestial bodies and how would we detect such life in space missions?
- Which icy moon should be a higher priority for a space mission to look for life: Enceladus or Europa? Why?
- A scientific debate that has been raging for at least thirty years is whether early Mars was predominantly cold with periodic wetness or whether it was "warm and wet" for long intervals of geologic time. What do you think about the validity of the arguments used by both sides of this debate? What are the ways in which future missions to Mars could help to resolve the debate?
- In general, the search for life in the Solar System is the exploration of places where liquid water was present in the past or is present today. Could there be plenty of liquid water on a body without life ever originating? Is it possible to imagine a subsurface ocean on Europa that has no life? If so, why might a dead body of water occur?
- Is the conventional "habitable zone" concept too restrictive, bearing in mind its limitation to liquid water, Earth-like habitats? Are there good scientific arguments for looking more widely for inhabited exoplanets?
- In viewing a spectrum of light from an exoplanet to find biosignatures, how would we ever be sure that we are seeing life rather than some purely chemical process

that mimics life? Would we be able to determine the presence of life on an exoplanet similar to the Archaean Earth, which had a biosphere but with an atmosphere devoid of oxygen?

- In “Fermi’s Paradox”, how realistic is Fermi’s assumption that technological civilizations on planets elsewhere would be spacefaring and be able to spread throughout the galaxy? An interstellar spacecraft moving at a substantial fraction of the speed of light would face many problems such as the huge amount of energy required and, because of great speed, the potential for explosive collisions with even tiny pieces of debris. If such a spacecraft had to move more slowly, would interstellar travellers be organic beings or robots? In fact, is Fermi’s idea of spacefaring extraterrestrials merely a projection of human beliefs (given a human history of conquest and exploration) that may have no relevance for unknown extraterrestrial culture with unknown motivations?
- If efforts in the Search for Extraterrestrial Intelligence (SETI) succeed in picking up a message transmitted by an alien civilization, what do you think are the chances that we would understand such a message? If we understood a message, what might be its cultural impact on humankind? Would receiving such a transmission have the same importance for humankind even if we don’t understand the message?
- Should humans beam messages into space describing Earth’s location and our civilization or is it dangerous to make other civilizations in the galaxy (if they exist) aware of us? “Messaging to Extraterrestrial Intelligence” (METI) has recently been pursued by private organizations such as *Lone Signal*. Some argue that advanced civilizations will be altruistic by virtue of their longevity and high intelligence. Alternatively, the American scientist Jared Diamond has argued that an advanced civilization elsewhere would treat us brutally like we treat simple animals. See Chapter 12, ‘Alone in Crowded Universe’ of J. Diamond (1993) *The Third Chimpanzee*, Harper Collins, New York.

Further Reading

Further reading is given on p.131-133 of *Astrobiology: A Very Short Introduction*