10 Extraterrestrial Intelligent Life

Having laid some extensive groundwork, we are finally ready to address the central questions of the existence and possible nature of extraterrestrial intelligent life. Although no trace of such life has so far been found, there are clearly compelling reasons for its existence. In Chap. 5 we estimated that Earth-like planets should occur quite frequently in our galaxy, and in Chaps. 6 and 7 it was shown how life, and intelligent life, have formed on Earth. Using the Drake formula, these results will now be combined to estimate the expected number of extraterrestrial intelligent societies. Since many probability factors entering this equation are controversial, the opinions of various authors will be discussed.

Because the first Earth-like planets were born about 10 billion years ago, and assuming that they have developed in a similar way to the Earth, extraterrestrial intelligent societies should already have been around for many billions of years. This raises the so-called *Fermi paradox*: "Where are they, and why don't we have contact with them?" Because advanced extraterrestrials would have gone through our stages of development, possible answers to these difficult questions should be attainable from our discussion of the foreseeable future of mankind in Chap. 9. Although the present chapter is very speculative, it will permit us to see the Fermi paradox, the search efforts for extraterrestrial intelligence (SETI), and even the future of our own civilization, in an entirely new light.

10.1 Does Extraterrestrial Intelligent Life Exist?

If the emergence of intelligent life were a unique chance event that has practically never occurred anywhere else, then estimates of the number of communicating intelligent societies, as attempted by the Drake formula (Chap. 5), would be pointless. Many of my colleagues and I believe, however, that reasonable arguments can be made that life, and intelligent life, should be quite common on other Earth-like planets. That the formation of life might be seen as the predictable result of chemical evolution has already been pointed out in Chap. 6, where Christian de Duve (1991) was quoted with his opinion that it is almost certain that the origin of life came about by a sequence of small steps, each with a plausible probability. He argued that this suggests that life will also occur on other planets if the chemical and environmental reasons for its development are not much different. Can a similar case be made for the appearance of human-type intelligence on other planets?

In Chap. 7 it was noted that the evolution of life is governed by Darwin's theory of mutation and natural selection, in which the mutations are chance events while the selection is directional, leading to the evolution of new organisms. It was also mentioned that there is a dispute over whether Darwin's theory only determines short-range evolution or whether it also governs the long-range development of the biological world. It was concluded that the phenomenon of convergence demonstrates that Darwin's theory must also hold for long-range evolution, because the survival of the fittest is due to the specific environment and the laws of nature that severely constrain the inhabitants of the biosphere.

The situation in biology, as suggested in Chap. 7, is not very different from that in astronomy, where one has the evolution of celestial bodies, which is also governed by chance events, by the properties of the environment, and by the laws of nature. If the evolution of interstellar clouds can be successfully modeled up to the formation of stars and from there to the final stages of white dwarfs or supernovae, it should also be possible to model biological evolution.

Certainly such simulations of the biophysics of cells, of organisms, of geophysical and climatological environments on terrestrial planets, and of ecological interactions between fauna and flora will be vastly more complex than that governing the evolution of the relatively simple astronomical objects, but there is no reason why this modeling should not be possible with future computational power. While such efforts so far represent as yet unrealized challenges, I attempted in Chap. 7 to show that there are definite reasons why long-range biological evolution eventually led to humans and intelligence.

Chapter 7 described how bacteria employ different strategies and how the strategy of eukaryotic cells rests on the accumulation of information. Large numbers of genes, which constitute blueprints for battle tools, enabled an ever more sophisticated fight for survival. By incorporating endosymbionts and using them as organelles, the eukaryotic cells became particularly efficient. This strategy of using massive amounts of information to fight the battle for survival continued with the creation of multicellular organisms, which allowed the formation of organs, and culminated in man with about 30 000 genes. As the laws of nature are the same everywhere in the universe, we can assume that Darwin's theory will result in similar strategies of nature on other Earth-like planets, and that the method to fight successfully by accumulating information will be a possibility that nature would not neglect elsewhere.

Does that lead to the development of human-type intelligence? Here we must note that intelligence is not a singular property that only happens in man, but that it also occurs in various degrees in animals. Intelligent behavior has always improved the chances of survival. That there is a noticeable growth of intelligent behavior from fish to amphibians, and from reptiles to mammals, has been pointed out in Chap. 7. Primates typically have twice the brain volume compared to other mammals of similar body weight, and the intellectual capabilities of the great apes far surpasses those of lower monkeys.

The development of high intelligence in corvid type birds, on a level with that of monkeys, represents a particularly fine example of convergent evolution. Finally the fabulous growth of brain volume (Fig. 7.33) from the australopithecines, *H. habilis*, *H. erectus* to *H. sapiens* implies great leaps in the level of intelligence. Here a lot of research must be done in the future to understand these fundamental leaps and in what way we differ, for instance, from *H. erectus* who already used fire as a tool, 1–1.5 million years ago. Clearly, more intelligent behavior, employing tool use and group communication, gave our ancestors a higher chance of survival.

We can speculate that human-type intelligence might have developed from the dinosaurs, had the K/T boundary event not happened. From the logic of the human body plan, discussed in Chap. 7, we can even assume that these hypothetical intelligent beings would not have looked too different from us, and this argument should also hold for intelligent extraterrestrials in the state when they first appeared on their own planets.

Certainly, intelligence came about on the basis of Darwin's theory, by mutations and the relentless fight for survival. The cultural evolution associated with the accumulation of information in the form of "software" due to learning can be viewed as a natural continuation of the ancient survival strategy of eukaryotic cells, of amassing knowledge in the form of genes. In summary, therefore, it appears reasonable that intelligent life will also be an outcome of the biological evolution on other Earth-like planets.

10.2 What is the Hypothetical Nature of the Extraterrestrials?

What can be said about the nature of the extraterrestrials? In Chap. 5 it was argued that Earth-like planets that orbit in a continuously habitable zone are essentially found only around G-stars of the metal-rich population I. As the first population I stars appeared around 10 billion years ago, and assuming that the development time for human-type intelligence is about 4.6 billion years (as on Earth), the first intelligent societies could have appeared about 5 billion years ago. We thus have to face the possibility that there are intelligent societies billions of years older than ours.

Is there a way of visualizing these much more advanced life forms? As will be demonstrated below, there is absolutely no hope that our imagination is capable of providing an even approximately adequate picture of such beings, who are billions of years more advanced. Fortunately, however, as these societies must, at some distant time, have gone through our stage of technological development, we might gain some vague glimpse of their nature by considering our own future. In Chap. 9 we have already discussed some of the staggering changes that are expected in only the next few centuries due to the conquest of space and the mastering of the biological world, combined with the advances in information technology. We have speculated about humans with greatly superior mental capabilities, tiny artificial self-conscious androids, and connected societies. But I think that even our most daring futuristic views constitute a very poor preview of the true development of the next millennia, and will certainly be completely inadequate to predict the nature of our descendents, millions or billions of years in the future. There may well be qualitative changes. In addition, as mentioned above, nature may have more fundamental steps in store than the three basic steps of life already identified by Aristotle: vegetative, sensitive, and conscious life. To foresee the possible development of mankind over such time-spans is truly beyond imagination.

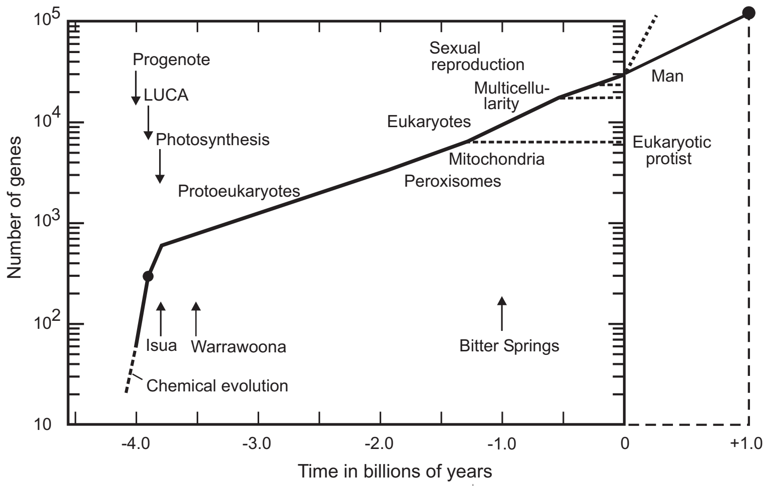

Fig. 10.1. Extrapolation of the number of genes of hypothetical organisms 1 billion years into the future

Yet there is an analogy that may help us to gain some appreciation of the magnitude and quality of the difference between these advanced stages and us. This method, called linear extrapolation, is often used with good results in science. In Fig. 7.7 the growth with time of the number of nonidentical genes of the most advanced life forms on Earth is displayed. Figure 10.1 shows a 1 billion year extrapolation of this curve into the future (solid line). Clearly, such an extrapolation is possible and likely, because molecular biochemistry has recently acquired the capability to artificially add and modify genes.