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Approaching the Topic

How do you write a book about things, life and language on planets outside our own Solar System, when you do not even know if they exist or not? The only sensible answer is by looking at how life developed on Earth[1] and then considering how this could manifest itself on exoplanets, those beyond the planets which orbit our star, the Sun. This is because when considering possible Earth-like planets (see Section 8.8 for 10 criteria) we have, at our present state of knowledge, a set consisting of only one member, our Earth; this is the 'set of one' issue (Figure 1.1).

All you can do in this situation is assess likelihoods on the basis of what we know about how life evolved here on Earth. For that reason, this book is concerned with key aspects of the evolution of terrestrial life and how parallel aspects might manifest themselves on exoplanets (see Section 2.7 for a classification of different types). Equally, any consideration of language beyond Earth must start by considering how we came to have such a successful system for thought and communication – our language

1 In this book 'Earth' with a capital first letter is the planet on which we live. The Solar System is the system of planets with the Sun, our parent star, at its centre. The names of our planets and their moons are also written in capitals. By analogy, the word Moon, with a capital M, refers to the single moon orbiting our Earth. All lowercase spellings refer to objects and systems beyond our Solar System.

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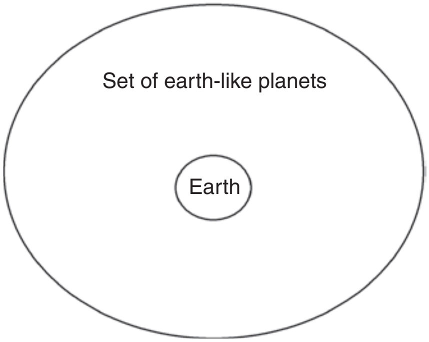

Figure 1.1 Our Earth as a set of one

faculty and its many realisations as languages in our world (see Chapter 32). It is this language faculty which enables us to acquire and speak language, so its evolution on Earth should be considered in detail when speculating about how a similar ability could arise with comparably intelligent beings on other planets.

This book is not about estimating the probability of life and language beyond Earth – we simply know too little at present to do that – but about the conditions under which life and language might arise, and the manner in which they might manifest themselves, based on careful consideration of all the factors which we can identify as relevant. It is up to readers themselves to reflect on how likely life and language may be beyond our Solar System. At the moment this question is only theoretical, and is likely to remain so for some time to come unless, and this is a big proviso, the efforts of scientists suddenly yield results, either by discovering an artificial signal from somewhere in our section of the galaxy (a technosignature) or by telescope observations showing beyond reasonable doubt that life forms exist on an exoplanet (a biosignature). Again, we do not know whether such a discovery is just around the corner or in the distant future or, indeed, will ever be made. But there is a huge body of investigative scientific work on the structure of our universe, the laws of physics, the nature of chemistry, possible biology beyond our Earth (the concern of astrobiology) and, above all, on the nature of planets outside our Solar

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System. This body of research is growing daily. And it is within the framework of this research that the present book is to be understood.[2]

1.1 Four Basic Questions

Whether the present book is justified depends on how one views the consideration of four basic questions, each more specific in an ascending order.

Four basic questions about life and language beyond Earth

1. Is there any life beyond Earth?
2. Is there intelligent life beyond Earth?
3. Is this life technologically advanced enough to communicate with us?
4. Does such life have a communication system which we would recognise as language?

The first question is the most basic and may well be answered in the near future by scientists examining planets and moons within our Solar System, assuming that such life does not have the same source as that on Earth. For instance, studying Mars may provide evidence of previous life on Mars in its distant past when conditions were similar to those on Earth, with liquid water and a thicker oxygen-bearing atmosphere. The question of just what constitutes life is discussed in detail in Part III.

The second question above concerns intelligent life, which here refers to sentient beings on an exoplanet with cognitive abilities comparable to those

2 It should be said that this book is not connected in any way with science fiction or Hollywood space movies. These are genres of writing and film, valid in their respective realms, but which have precious little to do with the subject matter of this book. For that reason, the term ‘alien’ is not used anywhere in this book.

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of humans on Earth. The physical substrate for their intelligence would have to be something functionally similar to our brains, similar in the amount of internal structure, and capable of complex computations. Whether the physical substrate of their intelligence would consist of tens of billions of neurons and trillions of connections linked to a nervous system controlling the body, as with us humans, is something we simply do not know.

The third question above has more facets to it than might appear at first sight. To be able to communicate across the vast distances of interstellar space, exobeings would have to have developed a technology which allowed them to manipulate radio or light waves for this purpose. Such technology would imply a whole raft of further facts about exobeings (see Section 1.2) and their lives on exoplanets.

The fourth question above can only be considered if at least the first two are answered positively. Allowing for extraterrestrial intelligence one can then ask whether exobeings would also have language like humans. For most of the discussion in this book I will refer to exobeings as if there were only one group of them from one exoplanet speaking one exolanguage. Reality may prove to be very different. If we continue to discover exoplanets at the current rate (over 5,000 confirmed, mid-2022), we may well find more than one planet which might harbour intelligent life (though this has not happened yet). And, indeed, there may be exoplanets with exolanguages spoken by beings with differing degrees and types of intelligence, which we on Earth are not aware of.

1.2 Working Backwards for a Moment

There are many ways by which we could learn of exobeings on an exoplanet (see the detailed discussion of possible scenarios in the final chapter of the book). Consider the following situation, which is probably the most likely of the diverse options. We discover an artificial signal, apparently emanating from a planet in another solar system, what conclusions would we be justified in making then?

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WHAT ARE 'EXOBEINGS'?

A number of terms are essential regardless of how one reads this book. Each of these begins with the prefix *exo-*, which in the present context means 'beyond our Solar System'. Apart from *exoplanet*, a planet outside our Solar System, the most important is *exobeings*, used throughout this book with a very specific meaning. It is a shorthand for intelligent forms of life on an Earth-like planet beyond our Solar System, which are technologically advanced enough to engage, in principle, in interstellar communication. This implies that exobeings would use a system of communication in their social interactions, an *exolanguage*, which is functionally comparable to human language. This also means that they would be, again in principle, in a position to communicate with the inhabitants of different planets, either by sending and possibly receiving meaningful signals to and/or from others.

Possible conclusions to be drawn about exobeings on discovering an artificial signal from a different solar system

1. They would have to be able to construct objects and so have considerable cognitive abilities and dexterous limbs, functionally comparable to our hands.
2. They would have to produce metals and alloys out of which to make their artefacts.
3. They would have to know electricity and be able to generate it at will as a source of energy for their artefacts.
4. They would need to understand the science of wave transmission in order to undertake interstellar communication.
5. They would need language to interact with each other when constructing and operating their complex instruments; and, of course, in order to pass on accumulated knowledge down through the generations.

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It should be remembered that there may well be exoplanets with societies which are culturally and artistically advanced but without science and technology to match. Here one can recognise that the term 'advanced' is open to a multitude of interpretations and its use has to do with the assumptions and expectations of those who employ the term. In this book, I am using 'advanced' specifically to refer to a society of exobeings who would possess technology allowing them to manipulate waves of the electromagnetic spectrum for the purposes of potential communication with beings on other planets. So, for this book, 'advanced' implies complex technology. Any exobeings on an exoplanet without such technology would remain hidden from us, at least given our current level of science and engineering. Needless to say, the term 'advanced' is not intended in any evaluative sense.

1.3 Questions, Questions, Questions

Would exobeings have a carbon-based biology like our own, would their sensory organs be similar to ours, would they have eyes, ears, noses, mouths and a sense of touch like ours? What would their physical form be like, what intake of energy would they have? Would they breathe and eat like we do? Would exobeings come in two flavours, comparable with our male and female, using sexual reproduction in which half of the genetic material in offspring comes from the mother and half from the father?

What about other characteristics of intelligent forms of life elsewhere. Would they be curious and continually seek answers to things they do not understand? Would they show great mobility, a high degree of self-awareness and reflection, the ability to think logically, solve problems and design artefacts? Would they have mastered digital[3] technology, indeed nanotechnology, in a manner similar to the way we have and are striving to do right now?

3 The term 'digital' is used here somewhat in the popular sense, that is to say, more as a shorthand for 'scientifically advanced and using computer technology'. This could also include sophisticated analogue equipment, but that is not the point in this general use of 'digital'.

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Would they behave in ways which we could understand and feel an affinity with? Would their societies be comparable to ours? Would there be a similar stratification and division of labour on their planet? Would the transmission of accumulated knowledge across the generations be comparable to our own? Intelligent forms of life are likely to be organised into entities comparable to societies, and the complexity of the latter would be a consequence of the intricate communication system they use. Without a complex communication system, a complex society cannot exist. The latter presupposes the former.

When speculating about exobeings and their language, other questions arise. Would they have a language faculty similar to ours enabling them to acquire and process language? Would they use sounds within our hearing range for communication? Would they breathe and have similar vocal organs to us with vocal folds to generate voice when exhaling air from their lungs? Would their languages be similarly structured to ours, making them – in principle – comprehensible to us? Could we learn them, or could exobeings learn any of our languages?

Other broader issues would depend on the precise nature of an exoplanet and how exobeings evolved there. For instance, would exobeings have a day–night biological rhythm like humans do? Not if their planet were tidally locked to their star, like our Moon is to Earth, always showing the same side to us.[4] A further question concerns rest and sleep: humans use sleep for essential memory filtering and consolidation, a process which could be just as essential for exobeings as it is for us.

These questions are all worthy of consideration but there are no definitive answers, rather probabilities and likelihoods. So, this book is not to be interpreted as a claim for the existence of exobeings – there is no evidence for this as yet. The book is about considering the possibility that they

4 In this case, exobeings would probably not have a waking–sleeping cycle like we do. But for a planet to be in the habitable zone of its solar system it has to be some distance from its star (assuming that the star is fairly hot) and at this distance the star's gravity would probably not be strong enough to prevent the planet from rotating around its own axis, which means the star would not keep it tidally locked.

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might exist and the possible nature of the system(s) of communication they would use amongst themselves. Of course, if there is no life beyond Earth then there are no languages beyond it either, and this book would be pointless. But we simply do not know if there are exobeings comparable to ourselves on other planets. Unless we have evidence to the contrary, it is legitimate to think about their possible existence and the kinds of language they might have.

From the above, it is immediately apparent that even the simplest question about life on exoplanets involves a whole series of further questions which need to be considered. These are addressed in more detail throughout this book as part of a realistic consideration of possible life on exoplanets. In addition, the conceivable evolutionary paths which might have been taken by exobeings are looked at in detail.

The Issue of Bias

For some readers, the approach I have adopted might appear too anthropocentric, showing a bias towards life forms similar to us Earthlings. But we need to bear in mind that life forms on an exoplanet will have arisen through Darwinian evolution over hundreds of millions of years and, in this long process, organisms will have developed which are functionally comparable to those on Earth. And if there are planets with exobeings then the latter will also have evolved structures which are functionally comparable to our brains. And for any planet with societies complex enough to develop advanced technology, language is an absolute precondition.

Just how life and language might be manifested on an exoplanet is unknown to us but, in terms of structural and functional organisation, exolife on exoplanets will most probably share basic similarities with life on Earth. To assume otherwise, to assume that exolife would be completely different from terrestrial life, both in principle and in realisation, would shift the burden of proof. Then it would be necessary to show what these differences might be like and how they would engender intelligent life capable of mastering complex technology.

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1.4 An Unlikely Story

Imagine the following scenario. It is completely unrealistic but bear with me for a moment. A fleet of 10 interstellar spacecraft are sent out from Earth for one year to investigate various planets in star systems around our galaxy, the Milky Way. The teams have decided in advance which planets they are going to see: only those which have a mixture of land and sea, an atmosphere with about a fifth to a quarter of oxygen and surface temperatures comparable to those on Earth, say on average around 20 °C in the more temperate zones. Now each spacecraft can manage to visit two planets per week, gathering essential data, taking samples along with some videos into the bargain. This means that in their year zipping across the galaxy to their stellar destinations they collect data from 1,000 Earth-like exoplanets (those beyond our Solar System).

When the teams return home there is an international press conference where they present summaries of their findings. A select group of journalists are invited to the exclusive presentation and the astronauts reveal the results of their missions:

Finding 1: On all planets there were microorganisms in the sea and on the land there were tiny tough plants hanging out in crevices.

Finding 2: On most planets there were fish-like creatures in the sea, really strange shapes and sizes, but they were sea animals able to move around independently and react to stimuli from the environment.

Finding 3: On some planets there was complex vegetation with atmospheres of water clouds and rain. There were creatures moving around on land, some big, some small. Again, a great variety. Some of the animals were herbivores and others were carnivores.

Finding 4: On two planets there were creatures who seemed fairly intelligent and dexterous with hand-like limbs. They had built simple huts and used raft-like structures for moving on water.

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During question time, one of the journalists asks the scientists, "So, you didn't find any planet with life like on Earth, right?" The spokesperson concedes this, however adds: "But we only looked at 1,000 planets and there are at least 50 billion of the right type in our galaxy alone". Then one of the younger astronauts asks for the microphone: "Sure, we still have to keep looking. However, when on our mission we did some time-travel experiments as well, and one of these yielded interesting results".

Here's what happened: when their spacecraft was passing one of the stellar systems, they saw it contained a planet about the size of the Earth. It was not on their list of planets to investigate, but they thought it was worth taking a look at anyway. However, it turned out to be a hot ball of molten rock, constantly bombarded by meteorites and asteroids. One of the seniors on board the spacecraft saw that a young astronaut wasn't occupied at that moment and said that they should do a time-travel test on the planet. Sitting at a screen and scrolling on a dial, the scientists could cycle through millions, even hundreds of millions of years into the planet's future, in a matter of seconds. They could see that the planet eventually cooled down and the bombardment stopped. The atmosphere contained water and, on the surface, there was also a lot of water, apparently delivered by comet strikes in the planet's early years. Scrolling through nearly two billion years, the scientists just saw green slime all over the place, but nothing else. "That planet ain't in a hurry to go anywhere", the younger scientist said, "will we keeping scrolling on?". "Okay, give it another few billion years, just to be sure", the other replied. They saw that there was a change in atmosphere: oxygen turned up and, zooming in on the planet to microscopic levels, they saw that cells had moved from simple structures to more complex things. A bit later creatures appeared in the sea and, after about four billion years, life forms suddenly got more complex with predation becoming a means of gaining food. Later again, some creatures moved onto land and they began to proliferate. The younger scientist was getting impatient, "Still nothing to write home about on this planet, let's go for a coffee break". The senior scientist replied, "Just a few more minutes, to see if these animals are getting up to anything interesting". Nothing turned up, but the moment before the two scientists were going to turn off the time-travel computer,

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the planet suddenly came alive with cracks and pops from all sorts of radio signals, and small objects could be seen orbiting the planet. "Wow, what's happening down there? Zoom in on that place again". Zooming down to the surface, a vista of large artefacts, apparently clustered at various points across the surface of the planet, could be seen. Objects were moving across the land and the sea along certain routes. In the air, craft could be seen going from one place in the planet to another. But the time-travel program was having difficulties moving further forward or displaying more detail. The computer was beginning to falter: it was already 4.5 billion years into the future of the nascent planet and that seemed to be the limit of what the time-travel software could manage.

1.5 Back to Reality

The above is pure fantasy. There is no such thing as time travel into the future and you cannot zip around the galaxy from one solar system to the next in a matter of days. To give you a flavour for distances in the Milky Way galaxy, consider this: the nearest star to us is Alpha Centauri (actually a three-star system) and, travelling at the rate of our present fastest spacecraft (*c.* 60,000 kilometres per hour), it would take about 75,000 years to get there. You cannot travel faster than light (according to Einstein's theory of relativity), not even at a considerable fraction of this. There are some theoretical options, such as using wormholes or Alcubierre drives, but they are just that: theoretical ideas far removed from present reality.

However, the above anecdote illustrates two important points: the first is that the aim of much exoplanet research – investigating planets beyond our Solar System – is to find planets similar to Earth. Following on that is the further aim of many scientists, which at present is beyond our investigative potential, namely, to find out whether they might harbour intelligent life forms. The second point, made by the fictitious time-travel experiment, is that finding life on other planets depends crucially on biological evolution there being roughly in sync with our own human evolution. The planet being described in the little story is, of course, our Earth: 4.55 billion years ago it was a ball of molten rock constantly hit by objects around it. From the perspective of human beings (and only from that vantage point) not much happened during most of Earth's history. The rise of humans occurred only at the very end, in the last few hundred thousand years. When searching for exoplanets, astronomers will find many barren, inhospitable worlds but, given how tenacious life forms are, some of these worlds may well come to harbour intelligent beings in their distant futures, times completely outside our reach. And, of course, there may have been similar situations in the opposite direction: maybe planets exist on which complex civilisations flourished but which are long since gone, either because of self-destruction or through some untoward external event such as an asteroid strike, a nearby supernova explosion or a direct hit by a gamma-ray burst.