chapter moves onto planet formation, building on the earlier discussion of accretion disks in the context of star formation to discuss planet formation in the Solar nebula and planet migration; it then focuses on the Earth–Moon system, the heavy bombardment of the early Solar System and the differentiation of the Earth. The third chapter on the search for extrasolar planets discusses the different search methods and includes a section on circumstellar disk observations. The fourth chapter discusses habitable zones around different spectral classes of stars and atmospheric gas retention, and gives a good account of the concept of the continuous habitable zone, the carbon cycle, greenhouse/glaciation climates, the stabilization of the Earth's inclination by the Moon and the Drake equation. The fifth chapter, the first of the second section, on life and its origin on earth, discusses the basics of biochemistry and biochemical processes, the molecular clock and the tripartite division of life. A short section (which I felt could have been longer) on the last common ancestor, the origin of the genetic code, Urey–Miller experiments and the RNA world concludes the chapter. The sixth chapter on evolution was the best chapter of the book – following a brief foray into evolution, endosymbiosis and the emergence of eukaryotes were covered well, including the oxygen catastrophe, mitosis/meiosis, multicelluarity and a rapid discourse on the evolution of multicellular creatures. Mammalian evolution was covered including the evolution of primates and its climatic context. From this followed a brief description of the emergence of australopethicines and hominids, brain evolution, and tool use. In particular, the Gould/Conway Morris debate is covered, the author leaving the last word to Conway Morris. I personally do not agree that this argument is settled – indeed, I would suggest that evolutionary convergence is applicable only to physical morphologies and not to behavioural repertoires. Behavioural repertoires are not subject to the same physical constraints as morphology and behavioural strategies often evolve despite physical constraints, for example sexual selection. The seventh chapter on the search for extraterrestrial life considers the possibility of life within our and other solar systems, with an emphasis on Mars concluding with a short critique of UFO sightings (which I think was unnecessary). The eighth chapter on the future of mankind envisages the future development of space flight and humanity's expansion through the Solar System, including O'Neill colonies, interstellar voyages, the creation of artificial life forms and the development of intelligent robots. The chapter concludes with showstoppers to this vision such as bolide impacts, climatic change, astronomical catastrophes and, of course, humanity's greatest enemy, itself. The ninth and final chapter considers the Fermi paradox in relation to the Drake equation and the SETI quest.

I had mixed feelings about this book. In one respect, it encapsulated a quick survey of relevant fields relating to the question posed in the title. Although a laudible attempt, the vast expanse of coverage inevitably meant some significantly sketchy treatment. I felt that the author was so severely constrained by the page limit that a scalpel had been ruthlessly applied. Often, something tantalizing would crop up and very little indication was given as to where more information could be sought. Furthermore, things appeared where I did not expect them or things were covered more than once, for example Drake equation was covered in two separate places. There was nothing particularly novel about the book either – in many respects it was similar in coverage to so many popular science and first-year textbooks in astrobiology. My feeling was of a book that could not figure out its target audience – a hybrid between a popular science book and a technical tract, satisfying neither. That said, I liked the coverage of some of the biological aspects, particularly multicellularity and the evolution of mammals/primates, and felt that this could have been expanded further as these aspects could have added a stamp of uniqueness to an astrobiology text that generally covered microbiology. The book included a reference list that could have been larger given the coverage (and it contained too many Internet references – an academic bugbear of mine). However, I do not wish to give the reader a false impression – despite my reservations, this is a good book with some interesting tit-bits but it hovers uncertainly between popular and professional science. It could potentially fill a niche as a supporting text to an undergraduate astrobiology course, rather than as a primary text.

Alex Ellery
Surrey Space Centre, University of Surrey,
Guildford, UK

Life in the Universe: Expectations & Constraints

Dirk Schultze-Makuch and Louis Irwin

Springer Advances in Astrobiology & Biogeophysics Series, Berlin Heidelberg, Germany (*2004*)
172 pages · *ISBN 3-540-20627-2*
10.1017/S1473550407003667

This book is an extremely useful addition to astrobiology lore. By focusing on the four prerequisites for life (energy, chemistry, solvent and habitat), the authors embark on a carefully constructed examination of the possibilities of the forms that life might take, ruthlessly slaying Earth-centrism that is so dominant in astrobiology. Each chapter is concluded with a useful summary and an extensive reference list. The first introductory chapter defines the book as a whole, presenting a short summary of their approach and rationale. The second chapter, on the definition of life, goes beyond the traditional notions of life, and re-examines its properties and overturns conventional thinking. In the process, the authors are armed with cases – many new to me – to support their approach. Of particular note is their emphasis on the primacy of biomembranes to maintain thermodynamic disequilibrium. They then outline the implications of their definition of life for the origin of life adding biomembrane formation to the metabolism/replication-first debate. The third chapter, on lessons from the history of life, attempts to generalize from the specifics of our own biosphere through a number of

observations, for example life tends to stay small and simple; complexity inevitably increases but as the exception rather than the rule, etc. These first three chapters set the scene with the following chapters delving into their analysis in more detail. The fourth chapter, on energy sources and life, starts off with the known redox reactions and then examines a number of different possibilities for powering life, from thermal gradients to osmotic gradients to magnetic fields and others, in a remarkably succinct assessment of what may be possible. In the fifth chapter, on building blocks of life, the authors initially consider carbon compounds, and then expand to alternatives such as silicon and variations thereof, and other possibilities such as boron. The sixth chapter, on life and the need for a solvent, begins with water and then expands to other polar solvents such as ammonia, hydrazine, acids, etc. Even non-polar solvents are considered. The seventh chapter, on habitats for life, considers surface, subsurface, atmospheric and space environments as potential habitats. The eighth chapter, on ideas of exotic forms of life, expands the consideration of life to spin configurations, the Black Cloud (from Fred Hoyle), the neutron star (from Robert Forward) and brown dwarf habitats. The ninth chapter, on signatures of life and the question of detection, examines the notion of biosignatures, geosignatures and geomindicators, concluding that instruments should be attempting to detect energy gradients as one of several different approaches. This last chapter was the left-field chapter in that it did not seem to conclude what I expected – that the variations of life forms might be so vast and different that we might not recognize them. More importantly, we find what we seek, and if we ask the wrong questions we will not get the right answers. However, that said, the authors have highlighted that we need to be very careful about how we design instruments for life detection if the shades of Viking are not to be repeated.

This is very much a book for the specialist and it is a major contribution to the science of astrobiology. It is rich with information and its thoroughness is delightful. It is mind-expanding and I know of no other book that re-assesses the fundamentals of astrobiology in such a way. This book is a tacit lesson in open-mindedness tempered with thorough scientific analysis. This is a very important book for all professional astrobiologists.

Alex Ellery
Surrey Space Centre, University of Surrey,
Guildford, UK

https://doi.org/10.1017/S1473550407003667 Published online by Cambridge University Press