on the new science of astrobiology (formerly known as exobiology). Although these terms may evoke images of little green men and other aliens portrayed in science fiction novels, astrobiology uses a variety of disciplines, such as biology, chemistry, and geology, to provide information about the origins, evolution, and distribution of life in the universe.

The author, who is a faculty member at an astrobiology institute at the University of Washington, begins with a discussion of what life is. The discovery in the 1970s of a vast community based on the deep sea vents powered by geothermal energy challenged the notion of the definition and the limits of life on Earth (a topic avidly pursued by astrobiologists). Ward points out that the scientists working on this project did not even immediately recognize life from the area of these vents because they did not expect to find it. Thus, he raises the issue of "life as we do not know it."

Several chapters consider obstacles in our limited point of view of what actually constitutes life. For example, the author explores the concept of silicon-based rather than carbon-based life in the colder parts of the solar system. Other possibilities include a change in molecular chirality, a change in solvent from water to ammonia or methane, and RNA-based rather than DNA-based life.

The second part of the book considers the candidate planets and moons that may harbor life in the solar system. At first glance, Venus may not appear to be hospitable to life since the surface temperature is about 900°F because of the dense atmosphere. Earlier in the history of the solar system, however, Venus may have had a more favorable environment with a less dense atmosphere when there was a dimmer sun. At the present moment, life could exist in the water droplets found in Venus's upper atmosphere, and some astrobiologists have even hypothesized that there are photosynthetic microbes in the atmosphere. In fact, the European Space Agency has a mission planned to return samples from the upper part of the atmosphere of Venus.

Mars has been the source of fascination throughout history. Recently, a flotilla of spacecraft successfully landed on the surface and orbited the planet. Is there life on Mars? Some astrobiologists argue that we already have found life on Mars because of the discoveries made in 2004, which showed the existence of ammonia in the atmosphere. These scientists suggest that since ammonia is a byproduct of some types of metabolism, we can make an inference about the existence of life on this planet. The author contends that we need to send humans to Mars because, in addition to the likely microbial life on the red planet, there may have been complex life that would be revealed in a fossil record.

Europa is one of the four large moons of Jupiter, and the Voyager spacecraft took photographs that suggest an ice surface on this moon. This exciting discovery has led to numerous proposals of life on Europa. However, the nature of the ice and its thickness is not known. Ward explores possibilities for life on the ice surface, within the ocean, and at the sea bottom (analogous to geothermal vents on Earth?). He is decidedly more pessimistic about life on Europa than many other astrobiologists, mainly because of the huge amounts of ionizing radiation emitted from Jupiter.

In addition to Mars, Ward is most optimistic about finding life on Titan, the largest moon of Saturn and the only moon in our solar system that has an atmosphere. He also believes that Titan can give clues on the nature of prebiotic Earth. In January 2005, the Cassini spacecraft released the Huygens probe that descended through Titan's atmosphere and then landed on its surface. During the descent, the probe collected data for two and a half hours, including information about surface features and cloud formations. One potentially significant result is that Huygens detected methane, which may be a sign of microbial activity. Titan certainly is an interesting moon that merits further investigation for the quest of life in the solar system.

This will be a fascinating read for both biologists and the general public. There are a few flaws—such as the overemphasis on the work from the author's own institute at the University of Washington and the lack of the most up-to-date results from the Cassini/Huygens mission to Titan. Nevertheless, the book provides a great overview of the new and exciting field of astrobiology.

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MODULARITY: UNDERSTANDING THE DEVELOPMENT AND EVOLUTION OF NATURAL COMPLEX SYSTEMS. *The Vienna Series in Theoretical Biology.*

Edited by Werner Callebaut and Diego Rasskin-Gutman; Foreword by Herbert A Simon. Cambridge (Massachusetts): MIT Press. $55.00. xvi + 455 p; ill.; index. ISBN: 0–262–03326–7. 2005.

What are modules, and how do they facilitate understanding complexity as examined by scientists, artists, economists, and psychologists, among others? Slightly to dramatically different definitions of modules (and often modularity) are presented by each author, but they are appropriate to their theses. In some fields, more than one working definition is the norm—psychologists offer three to three and one-half, each appropriate to a different mode of analysis. The editors brought together experts from an unusual diversity of fields to survey "modular thinking" in different disciplinary contexts, to clarify the characteristics of modules and how their use influences research agendas, and finally, to effect acquaintance among diverse practitioners of the definitions, uses, and implications of modularity as part of the search for similarities and differences as well as their implications for a general concept or theory.

The book commences with a foreword on complexity and decomposability by Herbert Simon and a preface by the editors that explains their goals for the Konrad Lorenz Institute Altenberg Workshop that sponsored the symposium/discussion and for the volume that emerged. The book includes three sections—Evo-Devo: The Making of a Modular World, Evo-patterns: Working Toward a Grammar of Forms, and Modularity of Mind and Culture. Callebaut's introductory chapter, The Ubiquity of Modularity, sets the stage for examination of definitions and uses of modules and modularity. The editors introduce each of the sections of the book by characterizing approaches to the kinds of complexity that the various authors consider in detail.

Did the editors and authors meet their goals? Yes and no—the volume is a great read; the content of each chapter provides definition, examples, and analysis so that the *implications* of "modular thinking" are profound. Many commonalities, similarities, and a number of differences in definition and usage are revealed. For example, I found the discussion of "impossible figures" in art, based on the nature of recognized and repeated modules, to be strongly reminiscent of the discussions by evolutionary morphologists about why "morphospace" is not occupied by all the possible forms of organisms that can be postulated. A common definition and a common research agenda did not result; that would be too much to expect. If the consequence of digesting this book is a greater precision of definitions used and more focused discussion of the relevance of the concepts, this volume will have achieved successful stimulation of forward thinking communication across disciplines.

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Branching Processes: Variation, Growth, and Extinction of Populations. *Cambridge Studies in Adaptive Dynamics, Volume 5.*

By Patsy Haccou, Peter Jagers, and Vladimir A Vatutin. Cambridge and New York: Cambridge University Press. $95.00. xii + 316 p; ill.; index. ISBN: 0–521–83220–9. 2005.

This book has an unusual structure, with neither a fixed set of authors throughout, nor different authors for separate chapters, as in an edited volume. Chapters 1 through 3, 5, and 6 have mainly been written by Haccou, Jagers, and Vatutin. Other chapters contain substantial contributions by additional authors. Chapters 1 to 3 set out basic ideas of branching process theory. Most attention is given to standard haploid models whose properties were well known by the early 1970s, but one section is devoted to a more recently developed model that explicitly incorporates two sexes and couples. Chapter 5 discusses extinction probabilities of lineages descended from single ancestors and distributions of times to extinction. Chapter 6 examines stochastic analogs of the theory of population growth when the time parameter is continuous. Concepts such as the Malthusian parameter and reproductive values are introduced and discussed.

Chapters 4 and 7 deal with recent developments, the former being on necessary generalizations of the mathematics that allow analysis of models for populations with properties such as density dependence and complicated structures. Specific models are discussed in Chapter 7. Among these are models for recently discovered phenomena such as the polymerase chain reaction and telomere shortening. Another section examines epidemiology and two discuss coalescent theory.

For the most part, the mathematics is kept relatively simple and theorems are illustrated by easily workable special cases, where possible. I have a slight quibble because calculations involving linear fractional offspring distributions, which are not discussed, are just as easy as for the special case of geometric distributions that are presented.

The range of topics covered is broad. Proofs are given if they entail simple mathematics. Theorems are quoted without proof otherwise. The writing is clear and careful, and I have found very few misprints. Biologists should find this book to be of interest because of its forceful arguments for insights to be gained by expressing biological theories in mathematical terms. It should also be attractive to mathematicians because of the numerous biological examples that can lead to interesting mathematics.

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