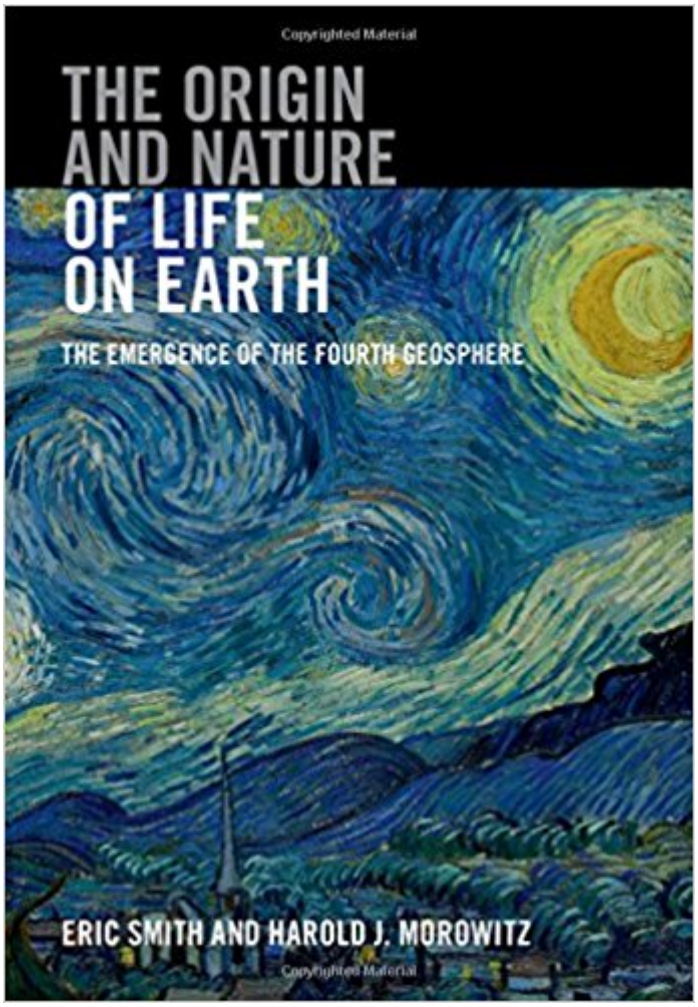
The Origin And Nature Of Life On Earth: The Emergence Of The Fourth Geosphere



Synopsis

Uniting the conceptual foundations of the physical sciences and biology, this groundbreaking multidisciplinary book explores the origin of life as a planetary process. Combining geology, geochemistry, biochemistry, microbiology, evolution and statistical physics to create an inclusive picture of the living state, the authors develop the argument that the emergence of life was a necessary cascade of non-equilibrium phase transitions that opened new channels for chemical energy flow on Earth. This full colour and logically structured book introduces the main areas of significance and provides a well-ordered and accessible introduction to multiple literatures outside the confines of disciplinary specializations, as well as including an extensive bibliography to provide context and further reading. For researchers, professionals entering the field or specialists looking for a coherent overview, this text brings together diverse perspectives to form a unified picture of the origin of life and the ongoing organization of the biosphere.

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Customer Reviews

"... the most significant book on the origin of life hitherto written." Walter Fontana, Harvard Medical School"This is a truly unusual work of scholarship, which offers both novel perspectives on a huge range of disciplines and a model of scientific synthesis. This is a remarkable, and remarkably impressive, book." Cosma Shalizi, Carnegie Mellon University"... an exceptionally important, highly original, unique scientific contribution ..." Elbert Branscomb, University of Illinois

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multidisciplinary book explores the origin of life as a planetary process. For researchers, professionals entering the field or specialists looking for a coherent overview, this text brings together geochemistry, biochemistry, microbiology and physics, and includes an extensive bibliography.

The best, most eloquent book I've read in 30 years -- better even than classics like Guns Germs and Steel. Brilliantly thought out and expressed in a clear, accessible, informative style. A special delight are the side-bars in chapter 7, which introduce a multitude of pertinent topics from adjacent disciplines that I've always wanted to learn more about, a valuable quantitative interlude. Magnificent bibliography.

Good product, prompt delivery.

In this stunning, magisterial, and surprisingly wide-ranging book, Eric Smith and Harold Morowitz approach the origin of life from first principles and bring together knowledge from astrophysics, geochemistry, biochemistry, information theory and statistical mechanics to show how all the hints and constraints we know so far about lifeÃ¢Â Â™s start and the universal patterns of life weÃ¢Â Â™ve found compel us to adopt a new framework to understand life: life is a complex series of non-equilibrium phase transitions driven by a persistent geochemical redox potential.First, Smith and Morowitz argue that the ecosystem is the correct level to view the phenomenon of life and how it integrates with the rest of the planetÃ¢Â Â™s geochemistry. It is only there that one can see the closed, robust nature of life. In every ecosystem from hydrothermal vents to rainforests, the ecosystem as a whole takes in inorganic inputs and free energy and builds biomass using a conserved core set of metabolic reactions. These core reactions give us many hints to the context of where and how life began suggesting the primary role of hydrothermal vents and of autocatalytic chemical networks.Next, Smith and Morowitz examine the physical conditions that were present before life began and ask the question: what stress was present in the non-living world that could have compelled the phenomenon of life into existence? Any non-equilibrium process (of which life is the most complex example) requires energy and a barrier to keep that energy from dissipating away too quickly. Smith and Morowitz take the physicistÃ¢Â Â™s view and list many possible energy sources present on or around the early Earth and the barriers that could have maintained them. For example, they point out that the sun uses gravitational potential energy to drive nuclear fusion and the barrier to dissipation is the low probability of having a fusion collision which is set by the weak

force!They then review the geophysical and geochemical processes that take place in the mantle, the crust and the atmosphere and describe the redox states of minerals in the mantle and how the atmosphere on the surface is held at a more oxidized state by hydrogen escape. (This chapter is the most in-depth and best introduction to the field of geochemistry that IÃ¢Â Â™ve ever read.) The reduced state of the mantle and the oxidized state of the atmosphere turns the Earth into a giant redox battery (which has precisely the right energy difference to run the organic reactions of life) with the barrier being the crust itself and hydrothermal vents acting to concentrate this diffuse redox energy to specific points on Earth.Smith and Morowitz then present the core metabolic reactions that are universal to all life. This set of reactions creates a closed feedback loop and the whole loop (and most of the steps) are energetically favorable in a reduced hydrothermal vent environment. The core processes of life want to happen spontaneously at vents! Patterns and structure in core metabolism also reveal many more hints as to the key steps life needed to pass through on its journey to Ã¢Â Âœlift itself off the rocksÃ¢Â Â•. The evidence is fascinating and compelling, but thereÃ¢Â Â™s too much to adequately summarize here.Throughout the book, Smith and Morowitz argue that the most important question is not how were the organic precursors to life synthesized, but instead how was the selectivity of chemical reactions robustly maintained? There are many proposed reaction pathways to produce the building blocks of life, but the problem is that these pathways make many more products than the ones life uses and these unwanted products would starve the early reactions of life from getting enough input material. Bringing the questions of selectivity and robustness to center stage immediately suggests that one could use the tools of information theory and phase transitions to make progress.Information theory studies the storage and communication of information and deals with things like error-correcting codes that help you preserve information if youÃ¢Â Â™re sending it through a noisy channel. Studying phases of matter has yielded a mathematical framework to understand how qualitatively different macroscale behavior (like ice or water) can result from the same fundamental building blocks and interactions (H_2O molecules and electromagnetic interactions). Error correction in message transmission and the maintenance of some system in a particular phase require that only certain configurations of message or system can be selected. Furthermore, we know that the stability of a phase and the efficacy of message transmission mean that such selectivity can be robust.The authors then give an introduction to the broad and successful field of phase transitions and describe how ideas from information theory fit into understanding what a phase really is. This introduction leads to the math necessary to understand dynamic phase transitions in out of equilibrium chemical networks (which is close to what weÃ¢Â Â™d want to understand life!) and includes a fantastic introduction to the

modern viewpoint of how the universe formed as a cascade of phase transitions starting with the quark-gluon plasma right after the Big Bang to nucleons to neutral atoms to chemistry to eventually, after every symmetry has been frozen, superconductivity.Finally, Smith and Morowitz bring all these ideas together and describe how they conceptualize Ã¢Â Âœthe nature of the living stateÃ¢Â Â•. Central are the ideas of robustness and modularity. They recount a parable about two watchmakers who are trying to build complex watches and are both interrupted every few minutes. One builds the watch in a very complex way so that it only works if all the pieces are in place and falls apart if the watchmaker leaves halfway through. The other watchmaker builds his watch out of self-contained modules which are each stable on their own. His progress remains when he is interrupted. The second watchmaker is able to finish his watch much faster than the first. We can see that modularity gives us a way of preserving a complex system against perturbations and of building more complex structures without the whole system becoming unmanageable or unstable. The modularity of life is evident everywhere one looks and is returned to again and again throughout the book.Modularity links with another idea that Smith and Morowitz emphasize: why can physics theories work at all if we donÃ¢Â Â™t know the underlying building blocks of the world? The answer actually comes from the study of phases and is closely related to modularity. Matter in a certain phase can be described by an Ã¢Â Âœeffective theoryÃ¢Â Â• within that phase that allows us to ignore laws of the universe that act outside the regime of that phase. For example, the laws of chemistry donÃ¢Â Â™t really apply when the world is too hot and atoms are ionized into plasma. The cascade of freezing transitions that matter undergoes itself represents a type of modularity and robustness. One phase lets us have molecules, we can then use molecules as the building blocks for minerals, which can then be used as the building blocks for more complex structures. Although much work remains, Smith and Morowitz see similar ideas present in how life self-organized into such a hierarchical and modular form (although in lifeÃ¢Â Â™s case, it remained fully out-of-equilibrium unlike the phase transitions for matter mentioned above).Overall, this was one of the most profound and thought-provoking books IÃ¢Â Â™ve ever read. It provides a solid foundation for those who are sufficiently motivated to reach the forefront of the current discussions on the origin of life. It also provides tools and ideas that have shaped how I understand the world more generally. I learned so much from this book! As a warning, the book assumes comfort with several branches of science (geology, chemistry and physics) and is rather dense at parts, but the book is laid out in a modular enough way that one should be able to find those parts of the book they are most interested in. ItÃ¢Â Â™s not light reading, but the insights in this book are totally worth the effort for those interested in the origin of life!

Stunning. Even if you are only able to read a portion of it. The title makes clear at least three things Ã¢Â Â“ it is about the nature of life more than about species; it is very closely tied to Earth processes; and it could be self-consciously aware of its possible future stature with its slight contrast to The Origin of Species. The "magisterial" label is correct. This strongly heralds a new era in biology. As powerful as the insights it brings, it was nice to see that they treat much of the exciting current origin-of-life research as an ongoing, collective project while showcasing their own work. This is the best biology book I have ever seen.

The two authors accomplished a great task of bringing together several pieces of scattered information throughout the domains of specialized science that evolved independently, so to say, and which within their respective domains can somehow contribute to the study of the origin of life. Even those that are apparently unrelated to this kind of study, in a first moment. But a synthesis uniting this body of knowledge was missing, until now. And by tying up these areas the authors provide a solid guideline that will likely conduct research within this particular field and will possibly bring insight to other fields of science as well in the years to come.This is not a popular science book, and the authors certainly didn’t mean it to be. Their point is made following evidence and grounded on solid and rigorous theoretical principles. But it is a book that should be read by anyone working in the field, and those deeply curious about the subject. It is certainly worth the effort.

Harold Morowitz and Eric Smith argue that life is a non-equilibrium phase transition coalescing around the interfaces of air/water, water/rock, and rock/air, wherever a chemical energy potential exists. They use this to further argue that metabolic processes in all organisms are extremely conserved and reflect primordial energy flows through the early earth systems. They paint a clear picture of how ecologies are the relevant biological units, how evolution plays a role in this view, and how to think about variability vs. conserved motifs in biology.An extremely enlightening read that will, in my view, bring bioenergetics back to the forefront of etiology of disease, and hopefully make biology as a whole shift away from the cell-molecular / gene computational metaphors that lack cohesive explanatory power, and toward a more holistic understanding of the organism. One of the best intros to physiology. Changed how I think about these problems.

It’s good book, but you need a good background on biochemistry. I have a Ph.D. in chemistry but understand only 50-60% of the content. This book, however, teaches me importance of geology and

geobiology.

The Origin and Nature of Life on Earth: The Emergence of the Fourth Geosphere The Annotated Origin: A Facsimile of the First Edition of On the Origin of Species Fourth Grade Science Volume 1: Topics: Earth's History through Rocks, Fossils and Tree Rings, Earth's Structure, Rocks and the Rock Cycle, Plate Tectonics The Worship Of The Dead Or The Origin And Nature Of Pagan Idolatry And Its Bearing Upon The Early History Of Egypt And Babylonia Georgia Nature Weekends: 52 Adventures in Nature (Nature Weekend Series) Peeling The Earth Like An Onion : Earth Composition - Geology Books for Kids | Children's Earth Sciences Books The Emergence Of Folklore In Everyday Life: A Fieldguide And Sourcebook The Social Life of Coffee: The Emergence of the British Coffeehouse Oceans of Wine: Madeira and the Emergence of American Trade and Taste (The Lewis Walpole Series in Eighteenth-Century Culture and History) The Emergence of Rock and Roll: Music and the Rise of American Youth Culture (Critical Moments in American History) Colored Men And Hombres AquÃ- : Hernandez V. Texas and the Emergence of Mexican American Lawyering (Hispanic Civil Rights Series) Emergence of the Theory of Lie Groups: An Essay in the History of Mathematics 1869â "1926 (Sources and Studies in the History of Mathematics and Physical Sciences) Fighting The Second Civil War: History of Battlefield Preservation and the Emergence of the Civil War Trust Gypsies and Flamenco: The Emergence of the Art of Flamenco in Andalusia, Interface Collection Volume 6 A History of Psychology: The Emergence of Science and Applications Dancing On Our Turtle's Back: Stories of Nishnaabeg Re-Creation, Resurgence, and a New Emergence Power and Sexuality: Emergence of Canon Law at the Synod of Elvira Oman and the World: The Emergence of an Independent Foreign Policy The Emergence of Total War (Civil War Campaigns and Commanders Series) Emergence of the Modern Mexican Woman (Women and Modern Revolution)