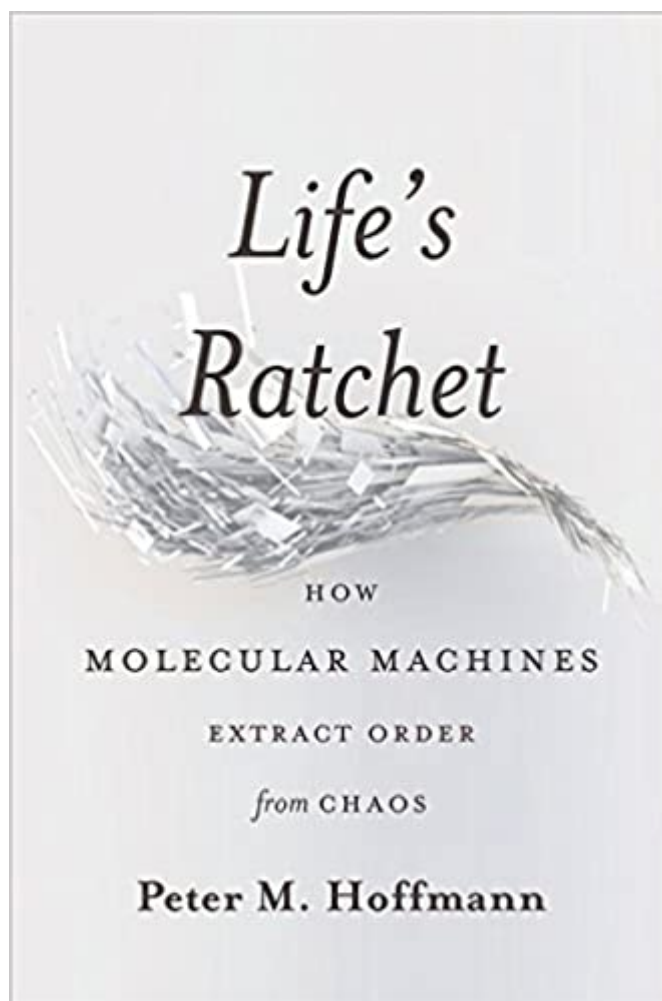


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Life's Ratchet: How Molecular Machines Extract Order From Chaos



Synopsis

Life is an enduring mystery. Yet, science tells us that living beings are merely sophisticated structures of lifeless molecules. If this view is correct, where do the seemingly purposeful motions of cells and organisms originate? In *Life's Ratchet*, physicist Peter M. Hoffmann locates the answer to this age-old question at the nanoscale. Below the calm, ordered exterior of a living organism lies microscopic chaos, or what Hoffmann calls the molecular storm—specialized molecules immersed in a whirlwind of colliding water molecules. Our cells are filled with molecular machines, which, like tiny ratchets, transform random motion into ordered activity, and create the “purpose”—that is the hallmark of life. Tiny electrical motors turn electrical voltage into motion, nanoscale factories custom-build other molecular machines, and mechanical machines twist, untwist, separate and package strands of DNA. The cell is like a city—an unfathomable, complex collection of molecular workers working together to create something greater than themselves. Life, Hoffman argues, emerges from the random motions of atoms filtered through these sophisticated structures of our evolved machinery. We are agglomerations of interacting nanoscale machines more amazing than anything in science fiction. Rather than relying on some mysterious “life force” to drive them—as people believed for centuries—life’s ratchets harness instead the second law of thermodynamics and the disorder of the molecular storm. Grounded in Hoffmann’s own cutting-edge research, *Life’s Ratchet* reveals the incredible findings of modern nanotechnology to tell the story of how the noisy world of atoms gives rise to life itself.

Book Information

Hardcover: 288 pages

Publisher: Basic Books; 1 edition (October 30, 2012)

Language: English

ISBN-10: 0465022537

ISBN-13: 978-0465022533

Product Dimensions: 6.4 x 1 x 9.5 inches

Shipping Weight: 1 pounds (View shipping rates and policies)

Average Customer Review: 4.4 out of 5 stars 75 customer reviews

Best Sellers Rank: #139,289 in Books (See Top 100 in Books) #24 in [Books > Science & Math > Biological Sciences > Biophysics](#) #26 in [Books > Science & Math > Physics > Molecular Physics](#) #26 in [Books > Science & Math > Physics > Nanostructures](#)

Customer Reviews

Physics Today;[A] fascinating glimpse into recent research on molecular machines, research that lies at the intersection of biology, chemistry, and physics.... Life's Ratchet does an excellent job of conveying the tension between mechanical descriptions of molecular machines...and the chemical perspective.... I highly recommend this book to scientists in the fields of biophysics and nanoscience as a readable introduction to a broad variety of topics in those areas.

•The Scientist;What distinguishes life from its nonliving ingredients? How could life arise from the lifeless? These questions have vexed philosophers and scientists for more than 2,500 years. Bio-besotted physicist Peter Hoffmann wrote Life's Ratchet to get to the beating heart of the matter. After a lively, lucid grand tour of the controversy's history...Hoffmann arrives at modern molecular biology and the technological breakthroughs, such as atomic force microscopy, that enable us to see the very atoms of a cell.... A masterwork of making the complex comprehensible, this book would make a smashing freshman biology textbook;and that's a compliment.

•City Book Review;Life's Ratchet is nothing short of brilliant. With wit and literary prowess, author Peter M. Hoffmann delivers a profound message about the nature of the life within our lives. He writes with a grace and careful thoughtfulness;the Shakespeare of scientific literacy.

•Physics World, Best Books of 2012;[A] clearly written book about molecular motors and other nanoscale structures.... It does a very good job of capturing the excitement driving current research on this increasingly important topic.

•Nature;Life's Ratchet engagingly tells the story of how science has begun to realize the potential for matter to spontaneously construct complex processes, such as those inherent to living systems. The book is a good mix of history and the latest concepts, straightforwardly explained;. The book's important message is that there is a revolution brewing. This revolution will not tell us what matter is made of. Instead, as described in Life's Ratchet, it will tell us how matter and energy combine to make me and you.

•New Scientist;In Life's Ratchet, biophysicist Peter Hoffmann reveals that the secret to life isn't some mysterious force. Rather, it is chaos itself. Hoffmann provides a ringside perspective on life at its most fundamental level, gained through his work on imaging and manipulating molecules.

•Kirkus Reviews, starred review;A fascinating mix of cutting-edge science with philosophy and theology.

•Werner R. Loewenstein, author of The Touchstone of Life and Physics in Mind;Peter Hoffmann brings the universe of the very small to life. Life's Ratchet is an exciting guide to the wondrous strange nanoworld of molecules driving the machinery of life. Engaging, provocative, and profound.

Peter M. Hoffmann is a professor of physics and materials science at Wayne State University in Michigan and the founder and director of the university's Biomedical Physics program. He lives in Saint Clair Shores, Michigan.

Having taught cell and molecular biology at the college-freshman level for several years, I thought I had a pretty fair mental image of the conditions and metabolic activities that exist within various living cells. Truth is however, I had never imagined the magnitude of the random thermal motion (or 'molecular storm' as Hoffmann calls it) that is a constant feature of the cell interior, and that Hoffmann describes--and quantifies--in an entirely captivating manner. Even less did I ever entertain the possibility that such random thermal motion is exploited by enzymes and molecular motors within the cell to help them execute their vital functions--without violating the second law of thermodynamics. But Hoffmann constructs a pretty compelling argument that this is the case! After reading this book I even find myself half-wishing that I could un-retire and go back to the class room to share Hoffmann's insights with students. Hoffmann employs surprisingly few mathematical formulas to convey his ideas, and illustrates certain of them with simple but instructive diagrams. But although parts of this book read like a novel, it is not all easy reading. It probably is not essential to be well grounded in biochemistry and thermodynamics in order to appreciate Hoffmann's insights, it sure wouldn't hurt!

As a scientist I can say that this is without a doubt one of the best and most lucid books I have ever seen about sub-cellular processes, the energy that drives them, and their evolution. The book is not meant to be an in-depth look at specific processes. Instead, the author explains in general terms how these processes work, where they derive their energy, and how they evolve. Incredibly, this talented writer was able to accomplish this without resorting to mathematics or plunging into a deep discussion of thermodynamics, making the subject accessible to scientists and non-scientists alike. This book should be required reading for every high school and college biology and chemistry student as an introduction to their coursework. I recommend this book enthusiastically, even for those readers who are already well versed in this field!

A marvelous explanation of what science knows about the molecular and cellular world and stimulating, informed speculation about how the amazing machinery and processes of life got started and continues to evolve. The author is the first to "see" some of these processes and the

reader shares the awe as he writes about his experiences.

The book was well written and entertaining. Anyone who has seen the DNA, RNA, or other walking nano biology animations should read this clear written description. The animations are wonderful to see but can't include the molecular soup and storm that these reactions take place in. Read about the folding and shapes of proteins that allow these and other enzymatic actions. The book explains the scientific tools used to discover how these machines work. I know little about the field of subject matter this book was written about but found myself gaining a lot of understanding.

I really enjoyed this book. I read it back in 2012, but never seemed to get around to writing a review. It discusses how life takes advantage of physical law to function. Even in the modern world, many people seem to believe in a vital spirit that makes life metaphysically distinct from non-life. I read this alongside several other books to familiarize myself with some of the basics of biology. I was in college studying experimental psychology (with a focus on cognitive neuroscience) with a philosophy minor and was quite interested (and still am) in the debates in philosophy of mind over physicalism. I am a physicalist, so I wanted to really be familiar with some of the bare basics of how life works to make sure I wasn't on shaky grounds. Below are listed a couple other books I read alongside it that those who are interested in this book might also want to read: *Wetware: A Computer in Every Living Cell* (discusses how single celled organisms process information) *What is Life?* by Addy Pross (discusses the chemical principles by which life could emerge without getting much into specifics) *The Machinery of Life* by David S. Goodsell I didn't read it alongside this, but *The Extended Phenotype* by Richard Dawkins would probably be of interest.

Wants to know how life began and where organic chemistry becomes purposeful life. This is the book. When I was done, I put it down and said to myself "Well there you have it, now I know how it got this way" . I have spent the last 20 years reading every science book I could find to try to really understand what it is that I'm looking at every day, how the hell did this happen? Well now I know. I may never have to pick up another book again in my life. The author writes in such a pleasant way as to avoid any kind of condescending undercurrent, he knows some stuff would be impossible for guys like me to truly understand without a Phd. in molecular biology or some such discipline, so he does his best to make the incomprehensible engaging. I'd like to have a beer or 6 with this guy - oh, that's right I quit drinking a while back. Somehow, having a window into the line between organic chemistry and self perpetuating living things makes me feel, at long last, that the universe I have

been pondering for the last 60 years does make sense, and that this line, like deep time and such concepts, can't be felt at a gut level. But it can be revealed, slowly, to guys like me over time.

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