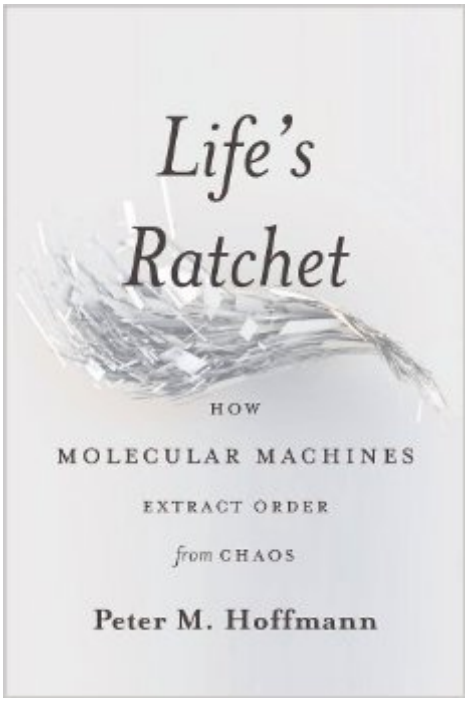
Life's Ratchet: How Molecular Machines Extract Order From Chaos



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 Lifeâ ™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 “purposeâ • 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 forceâ • to drive them—as people believed for centuries—lifeâ ™s ratchets harness instead the second law of thermodynamics and the disorder of the molecular storm.Grounded in Hoffmannâ ™s own cutting-edge research, Lifeâ ™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.

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Customer Reviews

This is an absolutely amazing book.For millennia, there has been a sense that living matter is somehow different from ordinary matter. There had to be some kind of vital force, something outside the well understood laws of physics and chemistry. For centuries, the challenge stood, even as scientists discovered cells, organic synthesis, genes and protein structure.Then science reached the nanoscale. In the late 1980s and early 1990s a new class of microscope opened up the world of the nanometer. Individual molecules could be viewed, first statically, then in motion. New techniques could mark individual molecules and tweezers made of light beams opened a new area to experimentation and measurement. At the nanoscale biology, chemistry and physics converge. Living creatures are made of tiny machines.These machines are made of molecules. They operate in a veritable storm of random motion and random collisions, and it is this storm that provides the energy for living motion - cellular motion, genetic manipulation and chemical transport. The second law of thermodynamics has this random motion effectively useless, unable to drive directed activity, but there is a loophole. Energy can be used to destroy information, to forget and reset molecular state. In cells, this energy is provided by ATP losing a phosphorous atom and converting to ADP. It seems insignificant, but at the nanoscale this minuscule jump burns at 7000 degrees. It is these fiery sparks of forgetfulness that drive life’s ratchet and make life possible.This book is a biophysicists manifesto. There has been a critical convergence in our understanding of living systems. We can look at the mysterious vital force up close and understand it.

One of the enduring mysteries of life -- how we moved from a cold inanimate world to one teeming with life and purpose - at least in principle, finally has been solved.In this book by a physicist (who admits to having no biological training), Peter Hoffman finds the answer to this most forbidding of all of mankind’s questions. According to him, the answer lies not in deep philosophical or religious speculation, but in Darwin’s natural selection and the intricacies of the second law of thermodynamics as they combine and work together at the atomic, molecular and cellular levels. He discovered that amid the storm of chaos that goes on at the atomic level, there emerges from colliding water molecules, machine-like components capable of spontaneously converting one form of energy into another.These components are tiny machines (nano-machines, as it were) that act like nano-scale electrical motors, operating on electrical voltages found in water, and which, in addition to being able to change one form of energy into another, are also capable of rendering order to the chaos we find at the atomic level. Our cells are filled with these tiny molecular machines that ratchet up the process of transforming random motion into hierarchically ordered cellular

activity.They do this by first operating on electrical voltages, and then by turning those voltages into collections of machines (like themselves), and them into hierarchies of nano-scale factories. These factories go on to custom build other molecular level machinery that together have proceeded down a long evolutionary path, and through many very complicated processes involving natural selection, to produce and package enzymes, peptides, amino acids, and even strains of DNA.