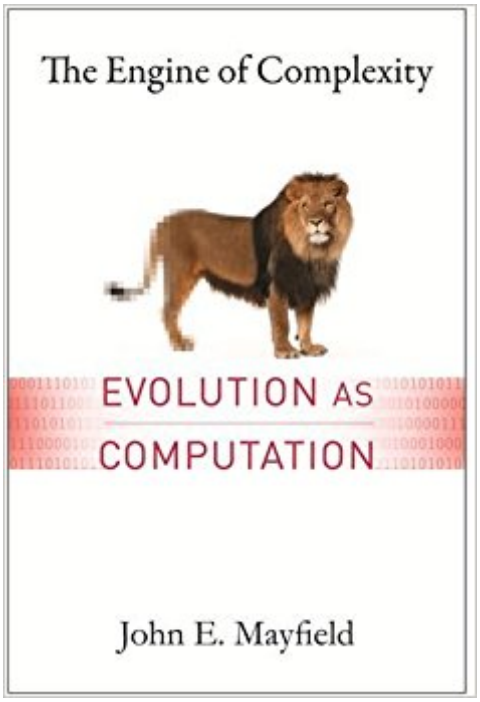
The Engine Of Complexity: Evolution As Computation



Synopsis

The concepts of evolution and complexity theory have become part of the intellectual ether permeating the life sciences, the social and behavioral sciences, and, more recently, management science and economics. In this book, John E. Mayfield elegantly synthesizes core concepts from multiple disciplines to offer a new approach to understanding how evolution works and how complex organisms, structures, organizations, and social orders can and do arise based on information theory and computational science. Intended for the intellectually adventuresome, this book challenges and rewards readers with a nuanced understanding of evolution and complexity that offers consistent, durable, and coherent explanations for major aspects of our life experiences. Numerous examples throughout the book illustrate evolution and complexity formation in action and highlight the core function of computation lying at the work's heart.

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Customer Reviews

The Engine of Complexity is a well-written and erudite book of great importance. It promises to be the best single introduction to the informational concept of evolution, all while being clear and easy to read. (Geoffrey M. Hodgson, University of Hertfordshire)Wide ranging, ambitious, and clearly written, John E. Mayfield's The Engine of Complexity shows how information flowing down the ages in genes, thoughts, and words, guided only by the invisible hand of selection, has built everything from beetles and human brains to steam engines, space shuttles, and iPads. It will open your eyes to a different way of seeing the world. (Mark Pagel, University of Reading, author of Wired for Culture: Origins of the Human Social Mind)John E. Mayfield succeeds beautifully in making

computational and biological concepts understandable to the non-expert reader. He suggests we are about to see a sea-change in our thinking with respect to how we view evolution in our society; he may be right, and his book is good reading to ready yourself for this potential change. (Alan G. Atherly, Iowa State University)An extraordinarily ambitious and broad volume. (Chris Adami Quarterly Review of Biology)

John E. Mayfield is professor emeritus of genetics, development, and cell biology at Iowa State University. He has also taught at the California Institute of Technology, Carnegie-Mellon University, and Harvard University Biological Laboratories. His research focuses on the development of a generalized theory of evolution that relates naturally and easily to fundamental mathematical and physical principles.

I was interested in a description of current artificial evolution computer research and stumble on this book. I bought it knowing it was not quite about it but decided to give it a try. I am grateful for that. Outstanding job. It is not easy, but it is highly recommended for anyone trying to understand this life that we are all going through.

The engine of complexity is one of five great books that have made a revolutionary impact of my thinking on nature. Other 4 books are `Pi in the Sky' by John Barrow, Order out of Chaos by Ilya Prigogine `End of Time' by Julian Barbour, and `The Emperors New Mind' by Roger Penrose.I was initially reluctant to purchase this book because of popular strong AI claims in computer science that algorithms is the be all and end all to intelligence and I was not certain about a relationship between Algorithms and Complexity.However it was clear to me that automobiles have been evolving over the last 120 years in just the same way as life has been evolving over the past 3.5 billion years and for this reason I decided to purchase this book.The foundation of the book is based on the distinction between two different types of physical structures.1) Those that require a code of instructions (a recipe) in order to exist. (coincidence of structure is ruled out as exceedingly highly improbable).2) Those that do not require a code of instructions to exist.Fig 7.1 in the book illustrates this superbly and hopefully will become iconic as E=mc2.Compare life forms/life fossils and man made structures (including economies and institutions etc) on Earth to all other structures on Earth.The Engine that drives complexity in nature is when these instruction codes are processed in space/time while dictated to by the laws of nature and that these outputs are copied back to the inputs with a degree of error (ideally the error is a random element so the search is not constrained

within the search space.)It is the Laws of Nature that dictate this complexity search. It is not that Engine of Complexity searches for Code that create just any physical structure, but all the successful searches code for structure that take most advantage from the Laws of Natures. For example if the instruction code resulted in the construction of a lighter with no flint, then the complexity code for this lighter would be poor and not last long (ie. will not be reproduced unless another use was found for it).However if over 3.5 billion years, results that codes for a body that holds a large brain with the right physical structure to utilise natures laws which allow 'thinking' to take place then this complex code has the potential to be very successful and regarded as complex in our universe.In this book I feel that John Mayfield uses the term `Computation' too loosely.A procedure that inputs several alternatives, processes these inputs and outputs only a selection of the inputs is basically the procedure for the Engine of Complexity.The set of selected outputs are often more complex than the set of inputs. They are often more well-matched to utilising natures laws.However the processing part of the procedure may be a computational process or it may be a non-computational process.In terms of natural selection, the processor is the environment and the inputs are DNA sequences. For the `Engine of Complexity' as a computational process one would have to obtain a code for the complex environment, the part that is relevant to the selection of the DNA inputs (ie possibly a subset of the universe). If this is not possible in principle then the process is a non-computational process.The same engine drives complexity in those computer programs that utilise the same principles, but in this case the search space is more limited, constrained by the physical functioning of a computer and the coded selection factors. By virtue of being processed by a computer the selection factors must have a code and therefore the `Engine of Complexity' within the confines of computer processing is a computational process.When we look about at the Grandeur of life of this refined 3.5 billion year evolutionary search, it is not necessarily so that the complexity generated over this time, that we experience about us, is simply the result of some Galactic Digital Computer churning through some Galactic digital algorithm, as the subtitle of this book may suggest.It may have been more appropriate to subtitle this book as, "Evolution as Informational Processing"."Evolution as Computation" sounds good but unfortunately computation has a specific meaning in mathematics as an algorithmic process (a process that requires finite precision digital code).The Engine of Complexity is encapsulated within The Laws of Nature.The fuel that drives the Engine of Complexity is an Entropy Gradient.The Entropy Gradient of the Universe can be defined as all the different states of the Universe, from the Big Bang through to a state of uniform radiation in the extreme distant future. At this current instant the entropy of the Universe is much closer to the former than the later.Molecular Motion and chaos is also

encapsulated in the Laws of NatureAs we scribe through an Entropy Gradient, Motion and Chaos abound among the astronomical but finite number of particles in the Universe. The majority of these particles/molecules interact creating more complex arrangements via Quantum Mechanics and chance. (see `Life's Ratchet', by Peter M Hoffmann.)This is a source for `Novel Creations'.So Nature has two Pathways to Complexity:1) Chaotic chance ratcheted along a molecular entropy gradient - (slow and achieves only a low upper bound to complexity)2) Engine of Complexity - (super fast and no limit to Natures complexity's upper bound)Planet Earth is the only example we have to date of the `Engine of Complexity' in the Universe ( - it may be the only example).When we envisage the tree of the `Engine of Complexity' on Earth we have things like Humans, dolphins, religions and economies and the arts at the top of the canopy while at the very base we have the original Engine from which all other engines were later built - (at least that is what all the data seems to indicate. As to date we have not found two fundamentally different life forms on Earth).However even this original Engine required a considerable amount of complexity in order to operate. It is possible that the complexity of the original Engine on Earth developed via Path One. It could not develop via path two.The Engine of Complexity is optimised when:1) the error size (mutation) is optimised approx (1/n where n is the length of the input code string).2) The error is a random element (that is; not limited in the search space)It is interesting that a genuinely random element is crucial for the Engine of complexity to perform effectively. This directly relates quantum mechanics to complexity as Quantum mechanics is the only generator of purely random elements in nature.The book also points out that our laws of nature conform to the Engine of Complexity (which is obvious else we would not be around to discuss such matters). But anthropically (if there is such a word) it is interesting to note that the Engine of Complexity does not work for all mathematical structures (possible other universes' laws of nature).John Mayfield is a master on this broad subject and has succeeded in explaining the ideas essential for an understanding of this concept to a layperson. A joy to read.

This book looks at the process that makes complex systems possible. This process is the accumulation of useful information (instructions) through small changes and selection - "the engine of complexity". It allows the creation of highly improbable but very useful objects: from products and services, through culture and specialized knowledge to life itself.The author illustrates the concept with 5 examples: life, adaptive immunity, learning and thought, cultural evolution and computer code. A couple of other examples would have rounded up the exposition nicely: the continuous improvement cycle of quality management, and the accumulation of information in wikis. All of these

systems display the improvement of fitness through better instructions.It is nice to finally have a clear exposition of what these systems have in common and how they work.

Quite a book to plow through! Every sentence takes time to digest (a few I had to read a couple of times) but he pulls it all together. The final two chapters are worth the effort.

An awesome read if you are interested in systems behavior, whether it be biological, social, technological, otherwise, or all of the above.

Mayfield’s work is a powerful synthesis of some of the most revolutionary consequences of fields as diverse as computer science, evolution, statistical thermodynamics, and information theory. His key contributions can be appreciated as a natural extension of Dawkins’ presentation of evolution in The Blind Watchmaker. In this respect, Mayfield’s emphasis on instructions and information processing explores the fundamental nature of evolution as a computational process, and provides a breathtaking account for the presence of objects whose existences would seem overwhelmingly improbable without conscious intervention otherwise. Thus, this book carries Dawkins’ torch in its quest to elucidate an evolutionary explanation for "designed" or Type II objects (things whose explanation require instructions, as Mayfield notes). The ramifications of this perspective emanate in areas such as neuroscience, complex systems theory, and cultural evolution.The way I see it, this interpretation is the most profound scientific concept yet developed, for it draws upon and synthesizes many of science’s most significant concepts, and because an understanding of evolution as computation, and its subsequent application in other fields of study is to discover the true nature of "how we got here" and to turn it on its head to help guide our own evolution (to use the term loosely). Hopefully reading this book will convince you of the same. This is absolutely a must read.

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