A review of *From Complexity to Life: On the Emergence of Life and Meaning*

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From Complexity to Life is a collection of eleven essays written by leading complexity thinkers. Each author attempts to address some of the big perennial philosophical questions regarding the existence and meaning of life from a complex systems perspective. Such issues have been debated for thousands of years and it is the position of the authors that complexity theory has something new to say about them. Readers should note that the essays came out of a research symposium. "Complexity, Information, and Design: A Critical Appraisal," held in Santa Fe, New Mexico, on October 14-16, 1999, and that the attendees were primarily natural 'hard' scientists. It should be no surprise then that primarily, despite the broad nature of issues being discussed, a scientific stance is taken. This is perhaps a little disappointing given that science often provides rather bland and spiritually unsatisfying answers to such questions as "what is the meaning of it all?" However, the 'emergence' of the complexity perspective does seem powerful enough to offer some original insights into such profound questions, questions that until recently have only been usefully accessible through philosophy and theology.

In the introductory chapter by physicist Paul Davies, a short summary to the topics to be discussed throughout the text is provided. Particular attention is given to introducing what Davies calls the "emergentist worldview". According to Davies "[t]he emergentist worldview seems to present us with a two fold task requiring the collaboration between the natural sciences, philosophy, and theology. The first is about the causal structure of our world… The second question relates to meaning: How does a sense of meaning emerge from a universe of inanimate matter subject to blind and purposeless forces." Such a pluralist approach will not be new to social scientists, and it is interesting to note that Davies does not list the social 'soft' sciences in his list of required approaches. A Freudian slip from a 'hard' scientist perhaps :-)

After the introduction, the essays are divided into three parts: I. Defining Complexity, II. The Concept of Information in Physics and Biology, and III. Philosophical and Religious Perspectives.

Part I comprises contributions from the mathematician Gregory Chaitin and the physicist Charles Bennett. Chaitin's essay is concerned with randomness and mathematical proof, the contents of which have already been published many times in slightly different forms. Of most interest is the incompressibility of randomness: "A random series of digits is one whose complexity is approximately equal to its size in bits." This is similar to the statement in complex systems analysis that the simplest representation of a complex system is the systems itself. Chaitin then goes on to discuss the limits of mathematical proof, including Gödel's incompleteness theorem. Though making for an interesting read, I have often wondered of the practical implications of Chaitin and Gödel's work for applied scientists. The limits they discuss are concerned with formal systems, i.e. a set of operations that manipulate a defined alphabet such as the natural numbers. There are an infinite number of natural numbers, so in some sense it is little surprise that by taking such an enormous set to operate on some strange results follow. But do we really need an infinitude of numbers to do science? I suspect not , and I am unaware of any 'incompleteness'-laws that apply to formal systems that operate on finite number systems[1].

Bennett's essay "How to define complexity in physics, and why," argues that the measure of 'logical depth' is the best candidate for a measure of complexity. "Logical depth is the execution time required to generate the object in question by a nearly incompressible universal computer program, that is, one not itself computable as output of a significantly more concise program". Bennett critically discusses a variety of different complexity measures in support of using logical depth. The 'why' is simply that without an agreed upon measure, we can't do science, though surely given the ambiguity associated with complexity there is value in having a number of different complexity measures for considering different aspects of complex systems.

Part II is a collection of five essays by the biologist Stuart Kauffman, physicist Paul Davies, evolutionary biologist William Dembski, mathematician Ian Stewart, and biophysicist Werner Loewenstein, all prominent names in their field of expertise. The highlights of Part II, and indeed the book as a whole, are Kauffman's "The Emergence of Autonomous Agents", and Stewart's "The Second Law of Gravitics and the Fourth Law of Thermodynamics". Both essays are excellently written and contain much to stimulate the mind. Kauffman's chapter is essentially an executive summary of his recent book *Investigations*, in which he speculates on the nature of a fourth law of thermodynamics that would complement the well-proven and well-established second law of thermodynamics. Whereas the second law is concerned with increasing disorder (entropy) in the universe, the fourth law would be concerned with the increasing order (or 'clumpiness') observed in the universe. Previous writers have suggested that the fourth law contradicts the second law (which would be a very big deal indeed!), but Stewart argues that these different laws have different 'jurisdictions' and so cannot be in contradiction with each other. Stewart proposes that a second law of gravitics "is currently the best candidate for a 'law of increasing complexity'" and maybe even as a fourth law of thermodynamics. The main reason for this is that a thermodynamic equilibrium is *stable* and so small perturbations will dissipate, whereas gravitational equilibrium is *unstable* and so small perturbations can grow and eventually dominate the system's behaviour. Both Kauffman and Stewart agree that any such law of increasing complexity will be unlike most other laws, in that it's application will be very much context-independent – an observation that may well attract social scientists to perhaps explore an analogy of 'gravitics' in the social realm.

Davies's "Complexity and the Arrow of Time" is a rather conventional discussion of the history and future of the universe. Though interesting if you aren't aware of currently established cosmological theories, there is little reference to complexity theory per se. I was rather surprised to find no reference to the work of Toffoli and Fredkin concerning their theories on a digital universe inspired by the writings of Zuse in 1967 who first suggested that the universe might be a complex system (a cellular automaton to be exact). Dembski's "Can Evolutionary Algorithms Generate Specified Complexity?" is a rather technical exploration of the limits of genetic/evolutionary algorithms. His answer to the question posed in his title is "no". One of the most surprising results regarding evolutionary algorithms reported in Dembski's essay is the no-free-lunch theorem: "the average performance of any evolutionary algorithm is no better than blind search" - a brilliant insight indeed.

Part III opens with the biologist and philosopher Harold Morowitz's "Emergence of Transcendence" in which he briefly discusses the different roles of reductionist and emergentist approaches, and explores the possibility of the existence of nondynamical principles, such as Pauli's exclusion principle, at different levels of existence. By 'nondynamical' it is meant that "it doesn't follow from force laws but rather has a kind of noetic feature" – although this could simply be because the force laws used are incomplete, and that in a more comprehensive dynamical representation such seemingly nondynamical rules may well emerge naturally. Supposedly, all of chemistry follows from Pauli's exclusion principle, which operates at the level of quantum reality. The existence of other nondynamical principles would provide insights regarding the nature of the products that emerge from a particular hierarchical level – we might even discover principles that determine how the mental mind emerges from the physical brain. The final two essays, biologist-theologian Arthur Peacocke's "Complexity, Emergence, and Divine Creativity", and philosopher-theologian Niels Gregersen's "From Anthropic Design to Self-Organized Complexity", attempt to reconcile the view from complexity thinking with Christian theology. Why the authors feel need to find justification for Christianity within a complex systems perspective is unclear to me. Personally, I have always regarded religion and science as having two quite different domains of interest with two incommensurable standards of determining what truth is. Though religion and science certainly have a complex relationship, I think it is unwise to use one to justify the other. The fact that some complexologists have sufficient confidence to embark on such an undertaking perhaps demonstrates the explanatory power that complexity thinking is perceived to have. It is a little disappointing that the authors only deal with the biggest of questions, such as 'what is the meaning of life, the universe and everything?', rather than contemplating how we each create personal meaning based on personal circumstances and context. For example, how does the meaning associated with different words/labels emerge in a dynamic society? Complexity thinking has a lot to say about these more down to Earth questions, none of which are addressed in this text.

Overall, *From Complexity to Life*, contains some very insightful essays on how complexity theories can be applied to explain the occurrence of life in the universe and how meaning (in its largest sense) might emerge. For me, the book didn't quite live up to its title, but that shouldn't detract from the excellent contributions from authors such as Kauffman and Stewart for example. I found the theological discussions rather too general and frankly a little superficial, but the seeds have been sown for a renewed review of the relationship between science and theology – whether the two can be reconciled, or indeed need to be, remains to be seen. The theories and ideas of complexity thinking contain a multiplicity of profound philosophical implications that have by no means been fully explored; *From Complexity to Life* makes a useful contribution to that exploration.

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NOTES

[1] This does not deny the possibilty of continuum-based theories, for example, being useful in explaining certain aspects of reality. It simply means, given that the vast majority of scientific evidence currently suggests that reality is fundamentally quantized, incompleteness issues with such theories are not necessarily of interest to physicists.