# Book Review: G. Simons' *Are Computers Alive ? Evolution and New Life Forms* and S. Levy's *Artificial Life: A Report From the Frontier Where Computers Meet Biology*

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This paper will briefly review the two books mentioned in the title; the purpose for including both books in the same review is because they both deal with the same, important area of computer research, namely the area which has come to be called "AL" (artificial life). Each book, however, provides a unique perspective on the work accomplished to date. It is these differing perspectives which I will attempt to clarify.

In *Are Computer's Alive ?*, Simons expresses his view that computers and robots are, albeit still evolving, a new, emerging life-form. Cleverly, he coins the scientific pseudonym *"machina sapiens"* (knowing machines) to refer to them. However, the emphasis in Simon's argument is not so much on convincing the reader that such machines are intelligent—this job belongs more to the defenders of AI (artificial intelligence)—as it is to provide a rational framework for regarding computers and robots as living entities in the process of climbing the evolutionary ladder towards an intelligent apex. In 1983, when this book was first published, the state-of-the-art robotic artifacts more likely resembled insects than Nobel Prize-winning physicists (or even taxi drivers). This, in Simons' view, however, is not to be taken as cause for despair, as steady technological progress, he believes, will insure that more intelligent specimens of *machina sapiens* are sure to appear in the future.

I assume that most readers would be, as I was at the start, rather skeptical about the idea that machines such as computers and robots are alive. Simons' is aware that this is likely to be the case:

> We would expect...observers to be hostile to the idea that computers could be regarded as an emergent life-form.... In fact most people show a quick reaction to the idea of computer life: the notion is first rejected and then the reasons are sought: all known life is based on hydrocarbons; machines cannot reproduce; computers and robots can only derive their powers from human beings; 'mere' machines cannot be conscious, creative, intelligent, aware; nor can they make judgments, take decisions or experience emotion; computers and robots may mimic certain human activities, but artifacts will never be truly intelligent and they will certainly never be alive.[1)]

In order to convince us, Simons' approach is simple and logical:

first, he defines the concepts of "living entity", "life form", "being alive", etc., in basic ontological terms that every reader would agree to; these essential characteristics he calls "life criteria", i.e., the types of phenomena or characteristics we commonly use to "recognize" a living entity when we encounter one, e.g., locomotion, reproduction, aging, energy processing (such as the ingestion and metabolism of food and the excretion of waste matter), and, not least important in the case of "intelligent life", information processing (e.g., awareness of the environment that results in adaptive behavior and problem solving). The next step is to show the reader a number of examples of computer and robot "behavior" which can readily be seen to conform to these same "life criteria": robots are, indeed, capable of locomotion; machines do, under sophisticated numerical control, actively participate in the creation of their own kind, hence, they "reproduce"; that they age, thereby losing functionality, is not to be disputed; that they can, if fitted with the appropriate sensors and input ports, actively seek out and utilize energy sources in order to "recharge themselves" is a demonstrated fact; that they produce and discharge heat as a result of the utilization of energy can be construed as the equivalent of energy processing (waste production as the result of metabolism); and, again, robots, equipped with "grippers" (the mechanical analog to the biological hand), camera "eyes" with which to perceive objects, various sensors to register distance, temperature, etc., do respond appropriately and adaptively to their environment in the act of making judgements and decisions, i.e., in solving problems. Simons gives innumerable examples of all of the above, with the intention to stretch the reader's previously-held common-sense notion of what is animate and what is inanimate, so as to include robots and the computer "brains" which control them in the "animate" category.

But are we really convinced ? The feeling persists that something important and essential to our everyday beliefs has been glossed over, as when the magician pulls the rabbit out of the hat. While it is certainly true enough that at this point in history our encounters with robots (leaving the question of computers aside for the moment) are rare, to say the least, surely they do exist, and certain manufacturing environments depend on them to a large degree. But this lack of first-hand experience in our day-to-day lives makes them seem less than substantial, "creatures" belonging more to the realms of sci-fi à la such films as "Robocop" and "Terminator", than to our quotidian lives. Those robots which do exist in offices and factories, performing useful work, are surely just clever machines—to ask us to believe that they are "alive", by any definition of the criteria of life, is asking a great deal.

Apparently not so for Simons though. His acceptance of the notion that computers and robots are alive is so complete that it often appears as a "given" in his writing, as witness the following passages, viz.:

> *The reality of machine life* suggests that it is also feasible to consider such concepts as machine evolution, machine mutations and machine generations not simply as loose metaphors or allegories on acknowledged life-forms but as *literal descriptions,* as binding on machine progress as the similar terms are on the development of the familiar biological life systems.[2] (Italics mine)

Or, again:

> ...Research into artificial intelligence is seen to be relevant both to definitions of the most rudimentary types of *computer life* and to the nature of the different forms of *computer life* that will develop....[3] (Italics mine)

The gratuitous use of the words "machine life" and "computer life" (other examples abound in the book), amounts, in my view, to an *a priori* assumption of the fact by the author, rather than a reasoned argument. This I find to be a major, but perhaps the only, flaw in the book. Otherwise, Simons is to be praised for his keen awareness and thoughtful analyses of the problems raised by the notion of regarding computers and robots as living entities, and for his provision of numerous concrete examples of software and robot capabilities. While the reader may not ultimately agree with Simons' view, her/his knowledge and understanding of the subject are sure to be enhanced by reading the book.

After all is said, however, Simons treatment of the subject of AL is rather conventional. Both computers and robots have, indeed, undergone remarkable development since their rather recent inception, so much so that, if one chooses to make the "anthropomorphic leap" which Simons would have us do, then it is certainly possible to give *tentative* credence to the notion that such machines are on a "fast track" to becoming intelligent, living entities. But this requires no great act of imagination—it is simply, in my personal view, a kind of uncritical fantasizing, a granting of the possible, however improbable and counterintuitive, not unlike the "suspension of disbelief" which is brought about by a well-made piece of science fiction, be it a book or a movie.

But Steven Levy's book, *Artificial Life: A report from the frontier where computers meet biology,* while ostensibly a discussion of the same subject as Simons', namely "artificial life", truly challenges the reader to grasp a number of difficult ideas which are startlingly different from ones s/he may have previously encountered in connection with the subject. So different are these ideas and the descriptions of the phenomena from which they spring, that the reader of both books is inclined to wonder if the authors are, in fact, discussing the same subject! These rather exotic ideas were generated in the hidden-away research laboratories of high-tech companies and in departments of computer science and mathematics, rather than on the assembly line. Specifically, the "a-life" (the "a" in this term stands for "artificial") entities which are the subject of Levy's book are "virtual creatures" generated by particular types of software code running on computers.

> They see...They reproduce...They die, and sometimes before their bodies decay, others of their ilk devour the corpses. In certain areas, at certain times, cannibal cults arise in which this behavior is the norm. The carcasses are nourishing, but not as much as the food that can be serendipitously discovered on the terrain.
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> The name of this ecosystem is PolyWorld, and it is located in the chips and disk drives of a Silicon graphics Iris Workstation...It is a world inside a computer, whose inhabitants are, in effect made of mathematics.[4]

The mathematics referred to in the passage above is of a type concerning what are formally referred to as "cellular automata", which were first conceived under a different name of "finite state machines" by the British mathematician, Alan Turing, and later developed into a full-fledged field of considerable significance by other mathematicians of note, such as Stanley Ulam and John von Neumann.

> Ulam...drew from the phenomenon of crystal growth...: an infinite grid, laid out like a checkerboard. Each square of the grid could be seen as a "cell." Each cell on the grid would essentially be a separate finite state machine, acting on a shared set of rules. The configuration of the grid would change as discrete time steps ticked off. Every cell would hold information that would be known as a state, and at each time step it would look to the cells around it and consult the rule table to determine its state in the next tick. A collection of cells on such a grid could be viewed as an organism.[5)]

Long fascinated by the idea of a "self-reproducing machine", von Neumann devoted much of his mathematical genius to trying to prove that such was, indeed, logically possible. Cellular automata provided him with just the right model whereby to focus his former ideas on the subject (the so-called "kinematic model") and base them on a firm mathematical foundation.

> Von Neumann's cellular model for a self-reproducing automaton began with a horizonless checkerboard, with each square, or cell, in a quiescent, or inactive, state—essentially

a blank canvas. Then von Neumann figuratively painted a monster on the canvas, covering two hundred thousand cells on the lattice.... It was the precise combination of those cells in their given states that told the creature how to behave, and indeed that defined the creature itself...the metaphor for this machine's process of reproduction was claiming and transforming territory. It was reminiscent of certain geopolitical board games, where players invade and conquer neighboring countries. More to the point, this was a physical interpretation of what happened in natural reproduction. The atoms and molecules that made up the new entity, the offspring, necessarily came from the environment. The idea—the idea of life really—was to gather those materials in their disorganized forms and integrate them in the highly complex organization of a living being.[6)]

Unfortunately, von Neumann never lived to complete his proof that self-reproducing machines were logically possible. But his work was carried on by others, and has developed into one of the most fruitful areas of theoretical mathematics.

After detailing the early background of a-life and the people responsible for its development, Levy then goes on to present a brief history of the first scientific conference devoted specifically to artificial life. This conference was held in Los Alamos, New Mexico in September, 1987. As defined in the official conference announcement:

Artificial life is the study of artificial systems that exhibit behavior characteristic of natural living systems. It is

> the quest to explain life in any of its possible manifestations, without restriction to the particular examples that have evolved on earth. This includes biological and chemical experiments, computer simulations, and purely theoretical endeavors. Processes occurring on molecular, social and evolutionary scales are subject to investigation. *The ultimate goal is to extract the logical form of living systems.* (Italics mine)
>
> Microelectronic technology and genetic engineering will soon give us the capability to create new life forms *in silico* as well as *in vitro*. This capacity will present humanity with the most far-reaching technical, theoretical, and ethical challenges it has ever confronted. The time seems appropriate for a gathering of those involved in attempts to simulate or synthesize aspects of living systems.[7)]

Attended by 160 computer scientists, anthropologists, theoretical biologists, population geneticists, biochemists, ethologists, physicists and others, the Los Alamos conference was a success in helping to establish AL as a legitimate field of scientific endeavor in that the participants had "reached an implicit consensus of the key points of what would be called artificial life."[8)] Among these was the idea that life was defined as "a property of the organization of matter, rather than a property of the matter which is so organized".[9)] If such organization could be manifested by a computer program, then it would deserve to be called "alive" as much as any natural manifestation of the same organization. Physical "matter", as such, simply did *not* matter.

In order to grasp this idea, Levy gives a description of a program developed by Craig Reynolds modeled on the flocking behavior of birds. Reynolds derived three rules to account for such behavior after many hours of watching blackbirds during his lunch hours:

> 1) A clumping force that kept the flock together.
>
> 2) An ability to match velocity so that the birds in the flock would move at the same speed.
>
> 3) A separation force that prevented birds from getting too close to each other.
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> He then implemented these rules for birds inside his computer. He called these "boids".... As they flew, the boids would notice what their neighbors were doing—as though they were cells in a cellular automaton—and apply that information to their own actions in the next time step.... As he fine-tuned the program over the next few months...he began to get precisely the kind of flocking you [would] see on nature shows. Uncannily so. The boids, each one using nothing but Reynold's simple rules, were able to flock in large configurations so convincingly that ornithologists, intuiting that real birds might be performing the same algorithms as Reynold's creations, began calling...to find out his rules.[10)]

In addition to giving other fascinating examples of the simulation (duplication?) of natural behaviors on computers (e.g., ant movements, also plant growth), Levy treats at length the development and application of "genetic algorithms", computer "viruses", fractal flora and fauna, and many other topics as they apply to AL. In contrast to Simons, Levy remains throughout the objective observer and reporter of the work and ideas of others, allowing the reader to draw his own conclusions as to the feasibility and reality of artificial life.

Both books stretch the reader's imagination: Simons would have us believe that robots with computer "brains" are an evolving life form; Levy would have us consider, in the manner that many AL researchers do, that the disembodied and evanescent phenomena viewable on a computer screen (along with the internal programs which generate them) are, likewise, examples of a new form of life in the making. In both cases, our former notions of what things are alive and what things are not alive are strongly challenged.

**Notes:**

1) Simons, Geoff, *Are Computers Alive ? Evolution and New Life Forms.* Birkhaüser, Boston, 1983, p. 3.
2) Simons, p. 22.
3) Simons, p. 32.
4) Levy, Steven, *Artificial Life: A Report From the Frontier Where Computers Meet Biology,* Vintage Books, New York, 1993, p. 3.
5) Levy, pp. 42-43.
6) Levy, pp. 43-44.
7) Chris Langton, as quoted in Levy, pp. 113-114.
8) Levy, p. 118.
9) Chris Langton, as quoted by Levy, p. 118.
10) Levy, p. 77.

## 〔抄　訳〕

Geoff Simons 著 *Are Computers Alive? Evolution and New Life Forms* と Steven Levy 著 *Artificial Life: A Report From the Frontier Where Computers Meet Biology* は最近脚光を浴びている人工生命学の分野における最新の発展やその諸問題を紹介した注目すべき文献である。1987年，New Mexico 州 Los Alamos 市で人工生命学の第一回会議を開催するにあたって，主催者側は人工生命学の目的を次のように説明した。「人工生命学とは自然界に実在する生命体系の行動特性を示す人工体系に関する研究である。……その最終的な目標は合理的な人工生命形態の開発である。」分野として，人工生命学と人工知能学とは酷似しているが，人工知能学は人間の知的な行動を再現することに焦点をあてているのに対し，人工生命学は自然界の行動，即ち，成長，繁殖，代謝そして進化などを再現することを課題としている。

Simons は興味深い発想を力説しているが，むしろ伝統派に属する。技術革新によって改善されつつあるコンピューターやロボットは進化しつつある生命体の性格を備えていると彼は主張する。他方 Levy はより過激な発想を展開している。コンピューターのソフトウエアや画面上にしか存在しない「仮想生命体」は実に自然界の実在生物に匹敵するほどの「生命体系」として考えられると彼は言う。

無限の可能性を秘めている科学のこの新しい分野に関する刺激的な発想や豊富な情報にこれら両研究の真の価値があると思う。