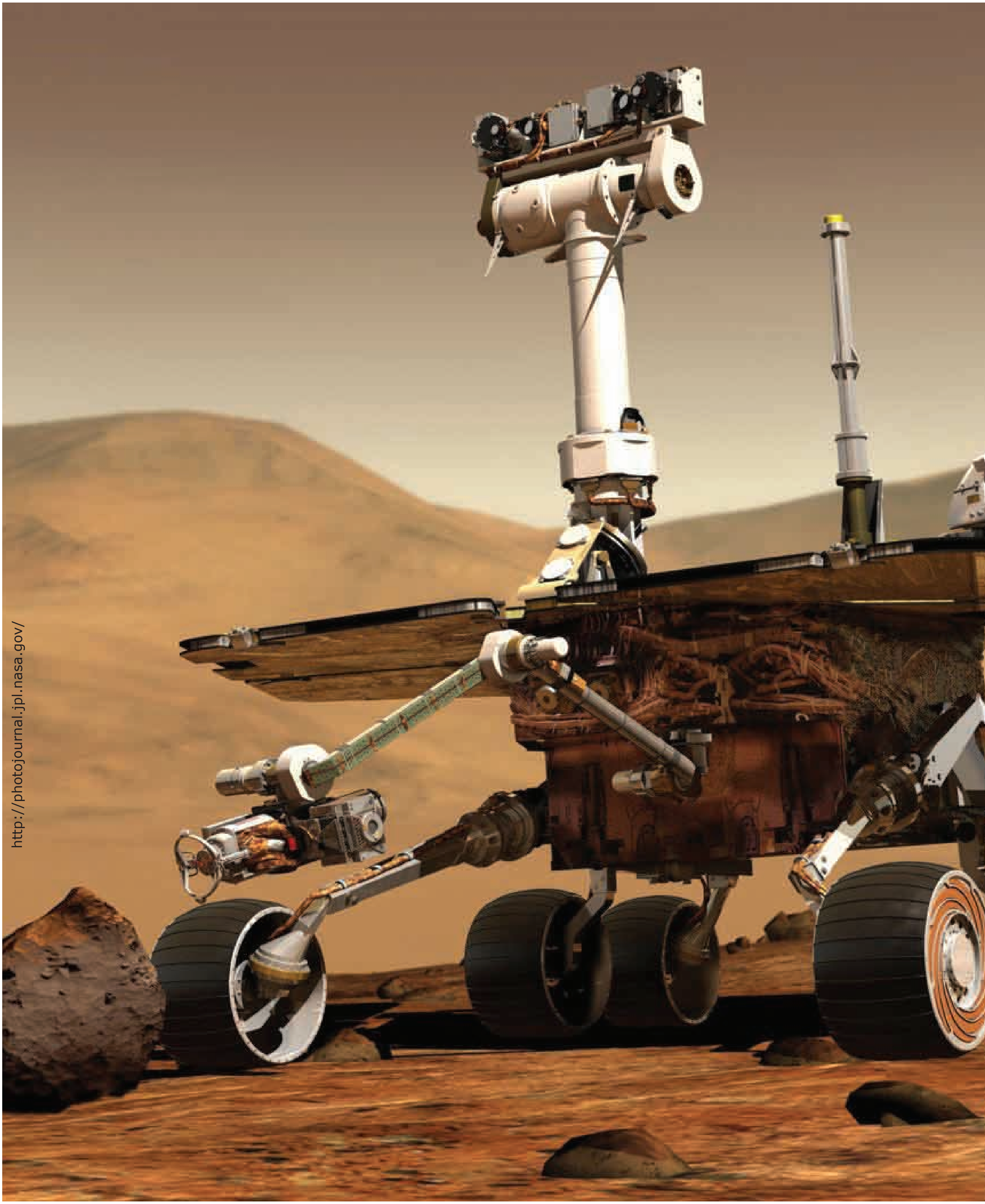


http://photojournal.jpl.nasa.gov/

The Mars Exploration Rover (Spirit).

Robo Sapiens

The Future of Artificial Intelligence?

by Tania Rojas

Robo sapiens: n (English, from robot, a mechanism guided by automatic controls; and Latin, from Homo sapiens, mankind) 1. A hybrid species of human and robot with intelligence vastly superior to that of purely biological mankind; began to emerge in the twenty-first century. 2. The dominant species in the solar system of Earth.

[Universal Dictionary, 2099]

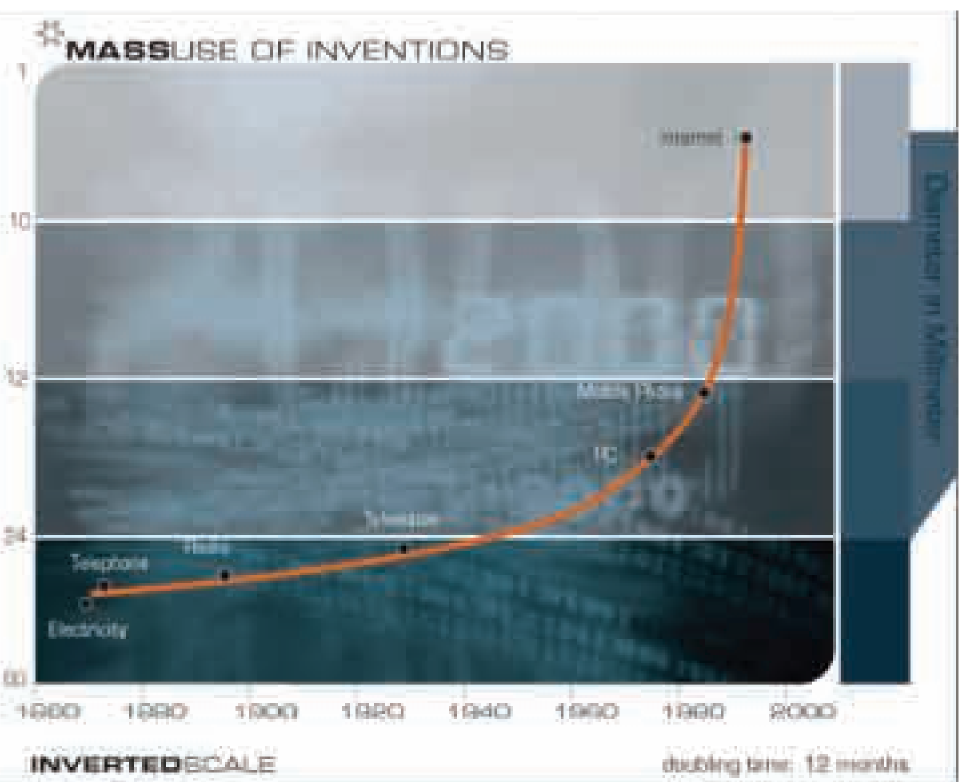
From Stanley Kubrick's widely acclaimed "2001: Space Odyssey" to the highly popular Matrix saga, humans have questioned the existence of artificial intelligence. Sci-fi moguls have envisioned a world of synthetic creatures, wired to exist, panning the globe, behaving very similar to humans, yet with a far superior intellect. These stories make for an excellent evening rendezvous, but they are still fiction, offering only pearls of inspiration to the technological futurist. One such arguably plausible account, however, can be found in the 1980's sci-flick, "*The Terminator*". With the intelligence and appearance of a human, veiling its inner frame of computer chips, steel, and wires, the ruthless Terminator machine may reveal the secrets to achieving A.I. (Artificial Intelligence). By combining emerging nanotechnology with biological material in today's era, it is possible to create a superior being, a “man”chine with artificial intelligence: a *Robo sapien*.

DNA & Nanotechnology

Over a quarter of a century ago, Intel co-founder Gordon Moore observed that the number of transistors in a computer chip would double every two years. His prediction, known as Moore’s Law, has proven correct. Since the 1960’s, the computer chip transistor count and processing speed has grown exponentially, from the 4004 processor (1971) with 2, 500 silicon transistors, to the Pentium IV processor (2002) with 42,000,000 transistors (Intel). Although he predicted the exponential growth of the computer chip, Moore also acknowledged that no exponential is forever. As a result, as the number of transistors on a computer chip increase per square inch, it will take another decade for the silicon transistors to reach their fundamental limit.

One possibility for delaying this predicament is by making faster computers through molecular transistors composed of carbon nanotubes, about one ten-millionth of an inch in diameter. Molecular transistors, according to local reports, outperform their silicon counterparts, but scientists have problems manufacturing large quantities—a problem that could be solved by a recent scientific experiment. On November 13, 2003, Scientists in Israel used strands of DNA along with tiny nanotubes to create a molecular-sized transistor. According to Dr. Erez Braun, a professor at the Technion-Israel Institute of Technology where the experiment took place, scientists utilized biological components, DNA, to self-assemble an electronic device in a test tube.

The Israeli scientist saw DNA as “smart glue” that would allow each nanotube to attach to only one other strand. DNA, along with other proteins, can align itself and link together in the correct order within a cell. The scientists took advantage of this unique property through a process known as *DNA recombination*, where they identified a piece of DNA, cut it out, and replaced it with an identical DNA fragment with the help of a special protein. The Israeli scientists attached the nanotubes to these special proteins, which then moved to the exact location on the new DNA strand as it replaced the excised DNA fragment. Once the nanotubes were in place, the scientists coated the DNA strand with gold, producing an electronic device consisting of a nanotube connected to gold wires at the end. When they placed the device in an electric field, the scientists successfully managed to turn it on and off—the definition of a transistor. By using DNA as a template, scientists hope to wire together billions of the molecular transistors needed to make a computer chip.



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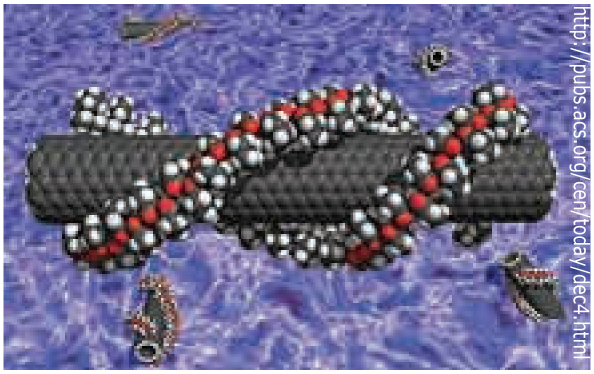
This graph demonstrates the exponential growth of technology by the power of 10.

The Beginnings of A.I.

Interestingly, scientist and futurist Eric Drexler surmised nearly 20 years ago in his book Engines of Creation that the rise of stand-alone computers (our



A carbon nanotube entwined in polyvinyl pyrrolidone.

*Robo Sapien*s), would involve the unity of DNA, particularly the portion coding for brain cells, with molecular computers. Artificial intelligence could be created, he wrote, through "molecular switching to emulate the parallel processing of the brain". Once DNA technologies are merged with nanotechnology, the resulting transistors could form what computer software developer and futurist Charles Dunlop calls "the ultimate chip to which we all aspire in synthetic manufacturing."

According to U.S. Naval Research Lab scientist Forrest Carter, we have hit the jackpot. In an ominous prediction made nearly two decades ago, he wrote that to make a molecular computer, one had to "learn from the principles of self-organization and self-synthesis from the biological world and then try to apply it to the inorganic and organic world." Within the human brain, neural synapses respond to signals in thousandths of a second, while nanoelectronic signals, according to Drexler, travel billions of times faster. The difference between these two signals lies in the fact that neural synapses are more complex than electronic switches because they can respond to stimuli by *changing their structure*. When a long-term mental change occurs, a process we call *learning*, the brain's inner networks transform; synapses form between other neurons or disappear.

As a result, we can look at technology and DNA as a viable source for intelligent matter, based on the mutual cooperation between genetic and computer codes. Hugo de Garis, computer scientist for ATR laboratories in Japan, coined the term "Darwin Machine," to describe a computer with self-directed, internally constructed neural networks that utilizes evolutionary engineering to design itself. This suggests that both the genetic code and the computer's binary code can be considered equal forces in the formation of A.I.

Robot Nation

The difference between artificial intelligence and artificial entities is clear when taking robots into consideration. Coined by Czech writer Karel Capek in his play R.U.R. (1920), robots are machines capable of performing tireless tasks with a high degree of accuracy, in many cases, much better than their human creators. Robotics writer Faith D'Alusio envisions robots assisting the elderly, cleaning bedrooms, watching babies, and providing company to the lonely. These robots, however, do not *think or learn;* they simply follow a set of programmed commands that can be so complex that they can even fool humans in making them seem real.

An example of this is SONY's AIBO dog, a robot that behaves and looks like a small dog. The AIBO dog is so real, that a similar version is being used to help relieve hospital patients in Japan from worrying about their illnesses. Yet despite its canine conduct, including lifting up its leg to simulate a peeing dog, this robot cannot learn any tricks and is restricted to its limited programmed actions.

This is to be expected, according to Professor John Searle of the University of California Berkley, because strong A.I. in robots cannot occur. Searle argues that a computer cannot have cognitive mental states, for this would reduce the human mind to a simple computer program. He also argues, "consciousness is a first person, subjective phenomenon that no mechanical computation, no matter how sophisticated, can produce." In short, no matter how fast super-human processing speeds and unlimited information storage we achieve in robots and computers, they must also contain the human facility for insight in order to to *understand* and *learn* from their environment.

Acquiring Intelligence

To create such intelligence, we can once again turn to the principles of biology, specifically our own human biology. About 50,000 years ago, one lonely human managed to evolve a unique genetic mutation in the brain, one that encompassed behavioral adaptations to the environment. Known as the "dawn of human culture," according to anthropologist Richard Klein, it marked the beginning of the human ability to innovate, to transmit information not through genetic means, but through external behavioral adaptations. It was this genetic mutation that allowed for the human development of agriculture, urbanization, industry, computers, and genomics. The "dawn," wrote Klein, is "the seminal revolution without which no other could have occurred."

Assuming that our cognitive abilities are outlined in our genetic code, the obstacles to achieving computer cognition can be overturned with the utilization of human DNA. If the merging of DNA and technology advances, our own biology will be integral in creating intelligence that can *learn* from its environment. We cannot assume A.I. will be evolutionarily superior because of its vast storage of information and lightning speed processes; though it will also be able to combine its machinations with the capacity to learn and adapt to its environment, an ability integrated within our DNA.

The arrival of A.I.: Singularity

In modern times, information technology has become more complex, growing exponentially in terms of storage and processing speeds. We are at an age, according to Nicholas Negroponte, author of Being Digital, where the small differences in yesterday can have suddenly shocking consequences tomorrow. Just as silicon transistors will most likely be replaced with nanotechnology, the exponential growth of a technology will continue until it exhausts itself, resulting in a new paradigm shift which allows another technology to continue where the other left off.

This fundamental change from silicon to nanotube technology to further technological progress is a key point in Ray Kurzweil's essay, The Law of Accelerating Returns. If we look at the bigger picture, Kurzweil argues, we can see that evolution acts as a positive feedback loop that advances from the progress of an earlier stage. Therefore, the "returns" of an evolutionary process, such as speed, capacity for information, and cost-effectiveness, increase over time. Kurzweil states this new paradigm shift involves an unprecedented stage where machine

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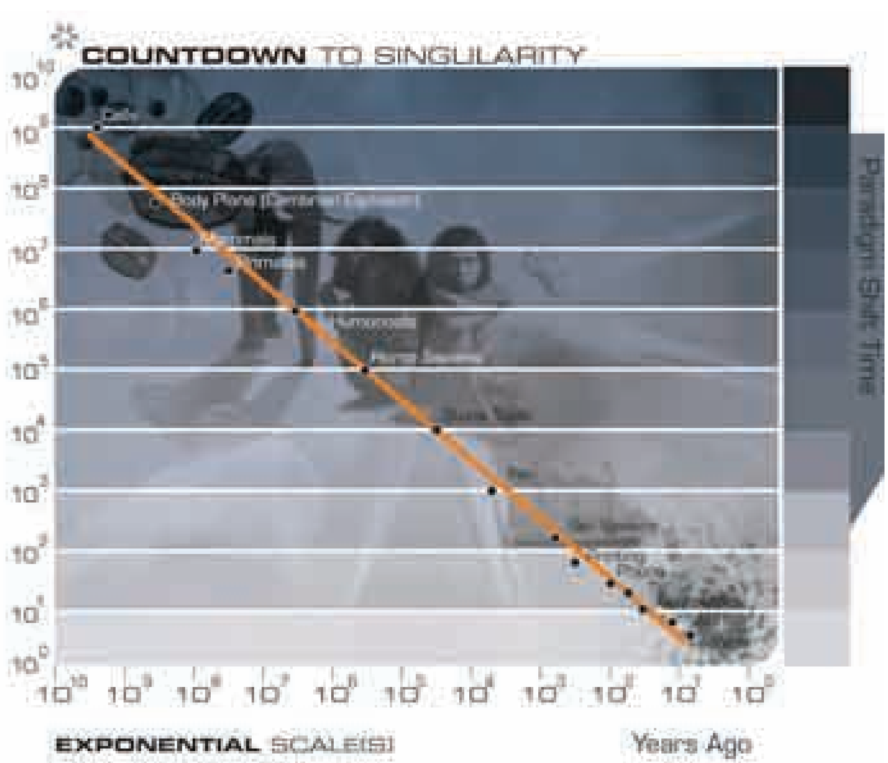

Information technology is changing progressively faster every day as this countdown to singularity illustrates.

intelligence will surpass human intelligence, leading to the *Singularity*, "technological change so rapid and profound it represents a rupture in the fabric of human history." As a result of this shift, Kurzweil predicts the merging of biological and non-biological intelligence, the aforementioned *Robo sapiens*.

What makes Kurzweil's claim on technology so interesting is that it is possible; we can create artificial intelligence in this manner. Christopher Dewdney, author of The Last Flesh: Life in the Transhuman Era, sums this up in a poignant statement: "Never before has human life been able to change itself, to reach into its own genetic structure and rearrange its molecular basis; now it can." The human genome project, genetic engineering, DNA recombination, and gene therapy are all examples of our technology's ability to meddle with our genetic base. The construction of the first functional replicator, according to Drexler, a self-producing nano-machine that creates unlimited copies of itself, similar to our DNA, is the point where A.I. is first created, when humans have reached singularity.

The Dawn of Robo Sapiens

What then of the human race when A.I. is achieved at Singularity? Scientist John von Neumann, who coined the term "singularity," believed that in addition to describing the end-result of our exponential technological growth, singularity is the point at which human affairs as we know them could not continue. Singularity could not be understood by us, the ancestral *Homo sapiens* with brains not fast enough to comprehend the light-speed processing speed of our descendants, the *Robo sapiens*. With *Robo sapiens'* unfathomable capacity of knowledge, it is possible to surmise that it may not just conquer the world as its previous ancestors did, but conquer the galaxy. Yes, this may seem a little too sci-fi, but with such immense A.I., *Robo sapiens* could have the capacity to understand universal laws, theories, and dimensions, just as man has been able to speculate on the laws of gravity, quantum mechanics, and black holes. In the words of Dewdney, consciousness and knowledge will not cease to exist, but continue in a more advanced form. Humans, however, may disappear.

Robert Jastrow, founder of NASA's Goddard Institute, sees humans as another stepping-stone for the next evolutionary species, an idea that came to him as he watched an IBM 360 and its fourth-generation replacement: "Suddenly I became aware that powerful forces were at work…man would be able to create a thinking organism of quasi-human power- a new form of intelligent life…a non-biological intelligence, springing from the human stock, and destined to surpass its creator". We've experienced the "dawn" of human culture, but the "dusk" is hard to imagine. Could we, space-travelers, poets, cathedral-builders, and gene-meddlers, be another speck in the cycle of life?

Dream or destiny?

Of course, A.I. has often been criticized as the past-time of the sci-fi dreamer, a fictitious possibility that could never occur. We are still in the age of Pentium IVs and wireless PDAs, an age where we are just beginning to experiment with DNA and nanotechnology. Critics, such as John Searle, argue that the computer is simply a giant processing unit driven by a set of programs and commands, an idea summed up by a statement in IBM's 650 manual : "A computer is not a giant brain…it is a remarkably fast and phenomenally accurate moron. It will do what you tell it to do, no more, no less."

However, as mentioned before, these criticisms are rebutted when we consider the application of biology to create A.I. It is still too early to say if our future technology will be able to self-replicate and combine thoroughly with biology or if the other technology we have created will destroy us first. But, take heed, the very technology scientists speculated about 20 years ago is currently taking place. Nanotechnology along with DNA has been able to self-assemble, and gathering from our innovative abilities, progress is sure to follow. For humans, as the Terminator put it best, this might just mean "hasta la vista, baby." S