

Leeches, Cyborgs, and Nanobots

Written by Victor Rozek

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□ *A computer is like an Old Testament god, with a lot of rules and no mercy.* □ Joseph Campbell

Leeches have few discrete virtues and they are not acutely charismatic. But among their hidden assets are uncommonly large neurons. Unfortunately, for the hapless leech, these generous neurons appeal to a curious class of scientists who envision melding living organisms with computer technology.

In 1995, researchers at the Max Planck Institute of Biochemistry in Germany succeeded in doing just that. Using silicon chips to stimulate nerve cells and electronic devices called neuron transistors to collect ionic nerve impulses and transform them into electric impulses, they established two-way communication between a computer system and the biological neurons of a living leech. In laboratory experiments, they were able to control the movement of the annelid worm from their computer.

At the University of Tokyo in 1997, the even less charismatic cockroach became the first of its kind to be computer-controlled, its motor neurons attached to electrodes regulated by a microprocessor.

While there is undeniable novelty in making a cockroach or a leech do the limbo at the touch of a keyboard, the breakthrough came with rats. A rat trained to press a lever when it wanted food had electrodes implanted in its brain. When it recovered from the travails of nonelective surgery, it had only to □ think □ about pressing the lever and the electrodes would signal the computer of its intent. The computer would then depress the lever and food would automatically appear. It was the first instance of in vivo collaboration between a carbon-based life form and silicon-based intelligence.

The possibilities were not lost on the medical community, and new procedures were developed to combat an array of human infirmities. Scientists seeking to assuage the ravages of Parkinson's disease and multiple sclerosis began to use neural implants to neutralize tremors. Some forms of deafness were reversed with the assistance of a cochlear (acoustic nerve) implant. The blackout drapes of blindness were even slightly parted when scientists interfaced a tiny pinhole camera with the visual cortex in a patient's brain, restoring his ability to discern shapes.

But perhaps the most startling breakthrough occurred when a paralyzed stroke victim had a silicon chip attached to the motor neurons in his brain and was able to move a cursor on a computer screen using only his mind.

The ability to transmit thoughts directly to a computer opened a Pandora's box of possibilities. It is a double-edged irony of technological

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progress that while one group of scientists worked to find curative medical applications for this promising technology, another group saw its military potential and set about designing systems that would allow us to kill our fellow beings by remote contemplation. Paradox notwithstanding, a future looms in which people will soon be able to communicate and affect their environment through the computer-amplified projection of will.

Now comes Kevin Warwick, researcher, professor of cybernetics at the University of Reading near London, and self-proclaimed cyborg. Warwick had himself implanted with a chip that resided in his arm for a period of nine days, transmitting radio waves to a series of antennae strategically located throughout his department. The antennae relayed signals to his computer, which recognized its master and performed a variety of tasks on his behalf. Doors opened, machines greeted him by name, and lights came on when he entered a room.

As reported in the February edition of *Wired*, Warwick believes that being born human was merely "an accident of fate" and that he can improve on the design. His next foray into human renovation will take place just over a year from now, when he volunteers for a more sophisticated implant that will open a channel between his nervous system and a computer. What he describes as a "little vicar's collar" will be surgically wrapped around some nerve fibers in his upper arm. The collar will be linked by a thin wire to a small glass tube containing a power supply ("a copper coil energized by radio waves to produce an electric current") and three tiny printed circuit boards that broadcast and collect data. If there are no complications, he plans to reengineer his wife as well, and the two of them hope to tap into a whole new range of experience and possibility. Apparently, wherever two or more implants gather in the name of research, there is love.

Spousal involvement, however, may be partially the result of an unanticipated turn of events. Warwick reports that, during the period of his first implant, he became "emotionally attached" to his computer. "As a scientist," he said, "the feelings I had were neither expected nor completely explainable." When he shared them with his wife, she understandably got "rather worried" and, evidently, wanted to discover for herself just exactly what Warwick was experiencing.

Whatever it was, the information traveled up and down his nerve fibers, which serve as the brain's information superhighway. Using the neural implant, Warwick intends to trap a wide range of biophysical transmissions, store them, and then play them back. In essence, he hopes to upload his experience and determine whether it can be replicated from storage—the first step in a much more controversial process that I'll discuss further on. His implanted chips will receive data from the collar and transmit it instantly to his computer. When, for example, Warwick moves his hand, the commands his brain issues to facilitate the movement will be recorded. Warwick wonders what will happen when he plays the same commands back. When the computer issues the directive rather than his brain, will his hand still move? If so, it should be possible to control artificial limbs with an implant and an assortment of experiential software.

Pain and pleasure also travel neural pathways. What if the sensations of orgasm could be captured, stored, and made available for replay on demand? Perhaps one's sexual euphoria could even be shared with an implanted partner from a distance. I suspect the good doctor sees a marketing opportunity here.

Beyond, if you'll pardon the expression, the hotly anticipated prospects of a pleasure chip, Warwick foresees an open field of possibilities, perhaps even the development of new senses. Humans, for example, cannot process light from the ultraviolet spectrum or hear sounds at ultrasonic frequencies. But machines can. What would happen if such signals were piped directly to the nervous system, bypassing the eyes and ears? Could we learn to perceive them? Warwick intends to find out. "Anything," he said, "a computer link can help operate or interface with could be controllable via implants." A short list includes automobiles, airplanes, farm machinery, military hardware,

financial transactions, and, given the anticipated developments in nanotechnology, real-time detection and treatment of medical conditions—plus, of course, Internet access.

Imagine acquiring the boundless capabilities of the Internet by being able to access it at will via a chip implanted in your brain. Humans linked to millions of super-intelligent machines; all of humanity interconnected in what Warwick describes as a "cyborg community." Individual intelligence amplified a billion times: the equivalent of putting evolution on Methedrine.

Warwick, by his own admission, wants to create "superhumans": an unoriginal story with an unpredictable ending. History would suggest caution. Warwick, in his enthusiasm, disregards the dark side of superiority. Whether earned or imagined, once superiority is claimed by individuals, nations, or ethnic and racial groups, it tends to breed contempt of lessers, and contempt invites oppression. Human evolution, after all, is not only based in biological imperative but also advanced by the process of people educating one another. That won't happen if, as George Bernard Shaw observed, "half of us consider the other half not good enough to talk to." Warwick himself concedes that "just as humans have always valued themselves above other life forms, it's likely that cyborgs will look down on humans who have yet to evolve." How they would actually respond to their inferiors is unknown but, based on human proclivity, not unknowable.

Accelerated evolution as an end in itself and the "freeing of the human mind from its severe physical limitations" are Dr. Raymond Kurzweil's rationalizations for promoting the next logical step in this process: the attainment of silicon-based immortality. If we can isolate and upload a single human experience, why not all of experience? Kurzweil, an author, inventor, and MIT-trained artificial intelligence guru, believes that, at the current pace of technological evolution and with projected enhancements in miniaturization, "by 2030, we'll have the means to scan the human brain and recreate its design electronically."

There is, he argues, already a precedent, albeit somewhat invasive for my taste. Seven years ago, a condemned murderer volunteered to have his brain sliced and scanned, and, according to Kurzweil, "you can access all 10 billion bytes of him on the Internet." But the scanning technology was not yet "at a high-enough resolution to recreate the interneuronal connections, synapses, and neurotransmitter concentrations that are the key to capturing the individuality within a human brain."

That was then. Within 30 years, Kurzweil predicts, "we will be able to send billions of nanobots: blood-cell-size scanning machines" through every capillary of the brain to create a complete, noninvasive scan of every neural feature. "Our knowledge, skills, and personalities, he anticipates, "will be copied into a file and stored in a computer," where it will survive our passing.

In Kurzweil's brave new world, nanobots could be programmed to override sensory signals, which stimulate nerve fibers, suppressing unwanted inputs from the natural world and replacing them with virtual ones. For example, two people linked via the Internet could stroll down a virtual beach in Bali, assume any physical form that pleased them, feel the sun on their shoulders, feel the breeze in their hair, and even make love in the warm sand, and it would all seem quite real, provided, of course, there were no sudden power outage. The unnerving component is that neither person need even be alive.

The very nature of consciousness, Kurzweil predicts, will be challenged and ultimately redefined. If, for example, all of the nuances and particulars of my personality and intellect, all of my memories and aspirations, can be stored in a neural computer, will not that computer rightfully and with all of the eloquence it (or is it I?) can muster, claim to be me? In many ways, my cyberego will be much superior. It will enjoy a longevity unconstrained by my physical body. Its intelligence will not fail but only amplify with time. Linked to a global network of resources, my electronic consciousness will learn, experience, and achieve things I can only dream of. It will, in effect, evolve independently of me. Will it be recognized as an autonomous entity? If so, what rights will it have?

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Then there are the more prosaic issues such as the inevitability of equipment failure. When hardware is the repository of human consciousness, failure gives new meaning to

the term [head crash](#). For that matter, after my physical passing, who is going to back me up regularly?

Such concerns notwithstanding, Kurzweil, like Warwick, is enthusiastic about the prospect of combining human intelligence with [a computer](#)'s inherent superiority in speed, accuracy, and the sharing ability of its memory. If Warwick fancies himself the builder of [superhumans](#), Kurzweil has loftier ambitions. [Technological evolution](#), he boasts, moves us inexorably closer to becoming like God.

Of course, becoming Godlike is not without its pitfalls. Consider unrestrained nanobot replication. Kurzweil warns. A technology dependent on billions or trillions of nanobots could afford a defect in the mechanism curtailing self-replication. Like a cancer, these biomechanical bacteria would endanger all physical entities, biological or otherwise.

Kurzweil also admits that such undetectable technology if covertly introduced through the food supply or a water source would make a formidable weapon in the hands of governments or extremist groups. Even unethical corporations, eager to control the thoughts and behaviors of the buying public, could find innovative marketing uses for nanobots and surreptitiously introduce them through candy bars, soft drinks, or cigarettes.

But perhaps the greatest risk of creating a race of cyborgs or a host of potentially self-replicating imperceptible devices is that it would, in effect, introduce a new and superior species into a closed system. In nature, such acts of hubris typically result in the displacement and eventual extinction of native species. To a cyborg, able to amplify his intelligence by a factor of a billion or more, the average, lowly, unevolved citizen will seem no more consequential than an amusing source of nostalgia. More likely, once the nostalgia wears off, those left behind will become an annoyance and an embarrassment, shunned as the mentally deficient were in the 19th century or used to perform tasks that are beneath the dignity of Godlike beings.

If my acceptance of a cyborg citizenry is tentative and skeptical, it is because the technological dream of a self-correcting world is a delusion. Technology both solves and creates problems, and, all around us, we see the unintended consequences of our scientific, chemical, and biological ingenuity. Atomic power promised bountiful energy at such low cost that it would not even have to be metered. The energy, it turns out, was limited, the cost was high, and the technology produces tons of nondisposable deadly byproducts with a half-life of 24,000 years. Likewise, chemicals allow us to produce a stunning array of products, but the earth is poisoned with them, and we carry them in our bodies and pass them on to our children.

This is not meant to imply that progress should be curtailed. It is futile to even suggest it. Discovery is our birthright. But it is equally futile to believe that only more technology will solve technological problems. Each fix will create a new fracture that will, in turn, require fixing. There is no final fix. That is the nature of things. The question is, are we willing to pay the price for changing our fundamental nature? And who among us will decide that we must pay it?

Squint a little, and you can almost see the future as described by H.G. Wells in *The Time Machine*: Again, the exclusive tendency of richer people due, no doubt, to the increasing refinement of their education and the widening gulf between them and the rude violence of the poor is already leading to the closing, in their interest, of considerable portions of the surface of the land. As Wells predicted, one potential outcome of melding man and machine is that, along with a race of superhumans, we will have evolved a formidable caste system in which dull, domesticated Elois are made to serve a race of cyber-Morlocks. After centuries of unraveling class-imposed privilege, we will resoundingly reinstitute it: all men created equal but some upgraded.

Clearly, the costs and benefits of these emerging technologies will be balanced on the backs of future generations. Their potential in health care and in facilitating quantum leaps in human intelligence are undeniable. Perhaps space exploration and colonization may one day be accomplished by the construction of component people whose stored brains

reside in synthetic bodies. Such entities would be capable of enduring travel times measured in generations and withstanding the inhospitable conditions of space by substituting silicon for sustenance and a power source for people.

Yet no less an intellect than Albert Einstein warned, "We should take care not to make the intellect our god; it has, of course, powerful muscles but no personality." Indeed, a world of eternal mind seems to devalue and ignore so much of what makes us human. What will become of our physical, emotional, and spiritual components? By focusing entirely on amplifying intellect, we risk a grotesque imbalance in human development.

Already, we see that many of the problems that beset the earth are the result of technology outracing common sense and emotional maturity. Well, technology is about to receive a quantum boost, and one need not be a Luddite to voice concerns about the ethical and moral implications of granting some among us unlimited power and, perhaps, unlimited life.

If Warwick and Kurzweil are even mildly prescient, life as we know it will be changing dramatically in the very near future. There is a part of me excited by the possibilities and, frankly, a part of me grateful I won't live to see it. Near it will be a world full of wondrous distractions and void of spirit; a world of accelerated intelligence but stagnant wisdom; a world populated by emotional cripples who, in the rush to expand their minds, leave their other parts behind with no hope of ever catching up. The power of genius, driven by the emotional maturity of infancy, with all the spiritual values of silicon. Digital compassion. Virtual integrity. The miracle of the contingent on the kindness of computers.

It may prove to be a Faustian bargain. Because, in the final analysis, intelligence without spirit is only software.