THE TECHNO-HUMAN SHELL: A JUMP IN THE EVOLUTIONARY GAP

Joseph Carvalko
Sunbury Press, Inc., 2012
204 pages, $16.95
ISBN-10: 1-62-0061651
ISBN-13: 978-1-62006-165-7
(paperback)

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Joseph Carvalko's *The Techno-Human Shell: A Jump in the Evolutionary Gap*[1] is an indispensable guide to the future of mankind. The author has mastered the developments presently occurring in the worlds of biology, robotics, synthetic biology, nanotechnology and digital technology, and has projected the future course of these research enterprises. It is an amazing tale. The book holds its own in that ever growing field of volumes on technology and the future; its chief virtue is its attention to most areas of scientific progress that will intimately affect mankind.

A central thesis of the book is that "[a]s computers with ever increasing computational power of the famous Watson IBM computer spiral downward in size, the wholesale incorporation of these devices into the anatomy will become as common as a pill ingested, a vaccine injected or a body pierced."[2] The result will be a vastly extended lifespan, an expansion of human capacities and abilities, alleviation, prevention and diagnosis of illnesses and disabilities, and transformation of the human species. Anyone who would like to be kept abreast of the upcoming future, including lawyers and legislators who desire to know which technologies require regulation, and why, would do well to read this book.

The author is a lawyer, and serves as adjunct Professor of Law, Science and Technology at Quinnipiac University School of Law. He is also an electrical engineer, who has worked as a technologist on radar and artificial tech-

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1. JOSEPH CARVALKO, THE TECHNO-HUMAN SHELL: A JUMP IN THE EVOLUTIONARY GAP (2012).

2. *Id.* at 3.

nology. As a research associate in the biomedical engineering field, he designed and programmed cellular automata computers. The owner of ten patents, he has also practiced in the field of patent law. He is a member of the Community Bioethics Forum at Yale School of Medicine, where he is a participant in the Technology and Ethics working group. Hence he brings expertise in the fields of engineering, technology, computers, law and ethics to investigating the future of in-the-body technologies. This background enables him to research, understand and explicate this technical and socially important field. Indeed, it becomes apparent in reading this book that it is imperative to have someone with an amazingly varied background to investigate and report on the future of man's melding with machines. In this future, man will be essentially coupled with bioelectronic devices, and actually become science fictions' "cyborgs."

Indeed, some are already such, among them Carvalko. Having become a cyborg himself, with the lifesaving implantation of a pacemaker, Carvalko was motivated to investigate the state of the art in the cyborgization of humans, and to consider both ethical and regulatory dimensions. What happens when large numbers of people in society become dependent on cyborg technology? What will "post, post-moderns" be like? "Will a wide-spread practice of installing technology into the body fundamentally change human essence?"[3] This volume seeks to raise consciousness about the present ubiquity of in-the-body technology, and the future prospect of humanity altering advances in technology. It not only depicts what this future human will be like, but asks whether this will be good for man, and what regulations should mitigate the probable deleterious effects.

Using the *American Heritage Dictionary's* definition of cyborg as "[a] human who has certain physiological processes aided or controlled by mechanical or electronic devices,"[4] Carvalko posits that humanity has transitioned into a phase where our survival depends on technology. In the fields of health—with drugs, bone marrow transplants, pacemakers and other implants, in the financial world of banking systems, and in the area of security, policing, and the military—our existence is totally enmeshed with technology. The book is about the changes that are and will be produced by:

> RFID chips embedded beneath the skin for personal identification and for integrating ourselves into the consumer supply/demand chain; internal computer processors to countervail against geophysical changes (climate changes, genetically modified foods); prosthetics to replace malfunctioning, missing, or damaged body parts; carbon-based nano-prosthetics to seek and destroy diseases such as cancers; DNA bioengineered sequences to fix genomic defects; computer stimulators and suppressors for alleviating pain, depression or neurological diseases, such as Parkinson's disease; silicon-based artificial organ processors to replace any one of nearly two dozen major body organs; permanent analytical and diagnostic tools drawn from an array of bioinformatics technologies; sensors to keep vigilant over an organic anat-

3. *Id.* at 4.
4. *Id.* at 6.

> omy . . . ; specialized artificial intelligence processors to improve our integration into and our resilience in a technological world, by increasing our cognitive processes, such as the intellect; and finally processors to maintain the replicative superiority of the technology itself.[5]

Installing technology into the body will proceed in stages, commencing with medical therapies, then diagnostics, followed by enhancements, both physical and mental. Breakthroughs in physics, information theory, biology and communications have allowed developments such as the bypasses, stentings, implantable cardioverter-defibrillators and left ventricular assist devices, which have kept Dick Cheney alive, and the equally remarkable artificial legs, made of carbon graphite, used in Oscar Pistorius' Olympic competition.[6] Individuals, such as these, are, arguably transhuman. The innovations that spawned such benefits "spark a wide range of social, legal, political, and cultural issues."[7] Indeed, they are the subjects of governmental study. As early as 2001, a report from the National Science and Technology Council (NSTC) considered the implications of nanotechnology and nanoscience.[8] In 2005, a report on Managing Nano-Bio-Info-Cogno Innovations was developed for the National Science Foundation.[9] These reports focused on the convergence of nanotechnology, biotechnology, information technology, and cognitive science (NBIC). Carvalko adds to this investigation knowledge of the development of the prosthetic genome, proceeding from the invention of synthetic DNA, and draws attention to the potential uses of these technologies by the military.

The book is divided into seven sections with subsections in each. It consists of a preface, an introduction, sections entitled, "Snapshot of the Future," "Embedded Technologies," "Tectonic Future," "Form in Cyborgization," and a conclusion. An index would have been a helpful addition. Despite the notable strengths of the book, including its amazing grasp of present and future technologies, its limitations include a less than complete analysis of ethical issues, and some stylistic matters, including sprawling sentences, and nonparallel structures.

In the section entitled "Snapshot of the Future," the book imagines the life of a young girl named Eve, as it will be ten years from now. This device, projecting future technologies and giving them a human face, is repeated at intervals throughout the volume. Eve and her family experience technology's benefits and burdens, first in 2022, skipping next to 2042, then 2050, 2075, and lastly, 2082. Using this narrative scheme enables the reader to clearly envision

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5. *Id.* at 9.

6. *Id.* at 13.

7. *Id.* at 14.

8. *See* NAT'L SCI. FOUND., SOCIETAL IMPLICATIONS OF NANOSCIENCE AND NANOTECHNOLOGY: NSET WORKSHOP REPORT (Mihail C. Roco & William Sims Bainbridge eds., 2001), *available at* http://www.wtec.org/loyola/nano/NSET.Societal.Implications/nanosi.pdf.

9. MANAGING NANO-BIO-INFO-COGNO INNOVATIONS: CONVERGING TECHNOLOGIES IN SOCIETY (Mihail C. Roco & William Sims Bainbridge eds., 2005), *available at* http://www.wtec.org/ConvergingTechnologies/3/NBIC3_report.pdf.

not only a likely future world, but also the ethical issues that will accompany it. In the opening scenario Eve is eighteen, and preparing to use the smart chip her grandfather gave her; it is an "intelligent RFID computer microchip" which is easily inserted under the skin and which can help the bearer "surf the Web, shop in stores or online, download pay-only sites on demand . . . and manage your finances with ease, security, and convenience!"[10] This RFID technology already exists, and awaits widespread adoption; casting a wide net Carvalko includes a stimulating discussion on how technologies become widespread.

Soon, the individual will not only use an in-the-body smart chip, but will also use other in-the-body systems to gather and transmit information from individual cells and organs regarding the health of the organism. Presumably that information may be shared, not just with our physicians, but also with health departments and the Center for Disease Control. The needs of the public may easily outweigh the individual's desire for privacy.

The individual most likely will be a willing participant in using RFID chips and bioprocessors to achieve greater health and longer life. Between 2015 and 2025 Carvalko proposes that in the developed world

> [t]hese devices may be in combination with: (a) pharmacologicals, for managing and controlling some element of health, (b) patient identification, including a summary of a patient's records either also embedded or automatically accessible when in proximity of an interrogating computer, (c) maintaining patient stasis or stability, (d) diagnosing conditions and reporting on adverse conditions via the Internet or private network, (e) alerting medical authorities to dangerous drops in vital signs, heart rate, heart electrical activity, hormones, enzymes, or changes in the immediate environment (potential airborne hazards e.g., chemical pollutants). [11]

Between the years 2025–2040, medicine will become "predictive, preventive, personalized, and participatory."[12]

This progression will result in an elimination of most physical and mental problems between 2040 and 2060, when scientists will also and most surprisingly, if just briefly mentioned by the author, "perfect downloading the brain into a memory substrate."[13] By 2090, supercomputers will be incorporated into the body and the brain and machines will interface seamlessly. Between 2090 and 2130, human life will extend several centuries and the human species will be changed into a cyborg-like entity.

Part of this story involves science's increasing ability to manufacture new life. While once the world only knew naturally occurring DNA, with the advent of the ability to create synthetic DNA, man will engineer lifelike species. As Carvalko writes, "In the future, the society will include a different kind of

10. CARVALKO, *supra* note 1, at 21.
11. *Id.* at 27–28.
12. *Id* at 28.
13. *Id.* at 29.

humanity based on a new form, which will be as novel as the wheel or the bridge was to the ancients . . . ."[14]

When Carvalko moves to consider Eve's grandfather in the year 2042, he discloses a list of installed health-related technologies: a pacemaker, a processor to manufacture and supply insulin, two cochlear implants for hearing, artificial hip joints and knees with microprocessors, a deep brain stimulator for Parkinson's, and another for depression, and a retinal implant to alleviate macular degeneration.[15] Besides the incredible medical advances promoting health and longevity, society will "cultivate social 'memes': ideas, behaviors, and modes of living that spread from person to person within a culture for the purpose of forming a collective IQ."[16] When this occurs, methods of education and interrelationships will change radically.

This process is accelerating because of developments in many areas: both heart and brain pacemakers, (the history of which Carvalko details), and the invention of retinal implants, based on a knowledge of the workings of the nervous system and of how sight is actually produced. Carvalko clearly explains the history and present developments in these and in the area of cochlear implants, evincing an impressive grasp of biology, medicine and bioelectronics. When considering these sensors and controllers, Carvalko includes mention of work from Duke's Center for Neuroengineering that enabled a monkey to control the action of a robot in Japan over the Internet.[17]

This brief glance at brain-machine interfaces seems somewhat inadequate for an understanding of the future possibilities presented by the work being done by a myriad of investigators, including Donoghue, Kennedy, Moore and Dan.[18] Nicolelis, whose research has focused on decoding the brain activity of rats and owl monkeys, reported in October 2011 that monkeys were enabled "to interpret the signals fed to their brains as a kind of artificial tactile sensation that allowed them to identify the 'texture' of virtual objects."[19] Kevin Warwick, through projects entitled Cyborg 1 and Cyborg 2, has conducted experiments involving the insertion of an active microchip into the nerves of his left arm to link his nervous system directly to a computer. Initially in 1998, the device served to simply open doors, turn on lights, and control heaters. In 2002, with the implantation of a more complex neural system into both Kevin and his wife, the first purely electronic communication experiment between the nervous systems of two humans was achieved.[20] Volumes could be in-

14. *Id.* at 36.

15. *Id.* at 42.

16. *Id.* at 43.

17. Larry Greenemeier, *Monkey Think, Robot Do*, SCI. AM. (Jan. 15, 2008), http://www.scientificamerican.com/article.cfm?id=monkey-think-robot-do.

18. *See* Patricia R. Ourand, *Brain Computer Interface Technology*, ALS ASSOCIATION (Oct. 2004), http://www.alsa.org/als-care/resources/publications-videos/factsheets/brain-computer-interface.html.

19. Erico Guizzo, *Monkeys Use Brain Interface to Move and Feel Virtual Objects*, IEEE SPECTRUM (Oct. 5, 2011, 21:06 GMT), http://spectrum.ieee.org/automaton/robotics/medical-robots/monkeys-use-bidirectional-brain-machine-interface-to-feel-virtual-objects.

20. Kevin Warwick, *The Next Step Towards True Cyborgs*, U. READING, http://www.kevinwarwick.com/Cyborg2.htm (last visited Oct. 1, 2013).

cluded on the research, often supported by DARPA, to implant neuroprosthetic devices in humans.[21] But as this is just one of the technologies Carvalko elucidates, it reveals that each of the topics he explicates contains far more information than he can describe, in this introductory, but still, very technical volume. One of the benefits of this book is that it introduces the reader to areas of technology development previously completely opaque. Carvalko's analysis of impending molecular computers is especially interesting, inasmuch as he proposes that this invention will be neither electronic nor mechanical, but will be installed in the human anatomy, and lead to targeted medicine when combined with nanoparticles that will destroy abnormal cells.

These reflections lead to projecting that in the year 2050, the possibility of improving the abilities of a concert pianist, this time Eve's son, arises.[22] At that time, scientists should be able, using a combination of stem cells, synthetic genetic biology, and a replicator computer, to regrow and improve a severed muscle, so that the pianist's hand span is greater. Presently new synthesized genetic parts—over 3400—are fabricated and stored at M. I. T.'s Registry of Standard Biological Parts; this collection is designed to make biology easier to engineer. Carvalko moves from describing current work in synthetic biology to proposing that a microprocessor could be constructed to manufacture synthetic DNA and that an Artificial Intelligence machine would then direct progressive modifications of this structure.[23]

After an exhaustive tour through future technologies, Carvalko takes up issues of regulation. He notes that there are safety and privacy issues; he questions whether the Food and Drug Administration will regulate in-the-body devices, and their central computers; he inquires whether property rights and equitable rights may need further development. "To what commercial, medical and legal standard will those who supply enhancements be held? Suppose the guaranteed gain in human intelligence falls short, or the advertised extended human lifetime is off by a decade or two, or the warrantee as to an invulnerability to a virus has been breached?"[24] Carvalko, the lawyer, suggests that property "takes on a new significance because of the intangible features of information. . . ."[25] Patent law will inevitably apply, as will civil law.

With the author's explications, it has become obvious that regulation is imperative to secure safety, equity, privacy, autonomy, and justice. "In-the-body technology is not the same as most commodities, and its equitable distribution must not be lost. Economic models need to consider patenting, licensing, pricing and universal availability."[26] The author points out that the scheme used to divide property interests—tangible personal property, and intangible

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21. Ellen M. McGee, *Bioelectronics and Implanted Devices*, *in* MEDICAL ENHANCEMENT AND POSTHUMANITY 207–224 (Bert Gordijn & Ruth Chadwick eds., 2009); *See* Ellen M. McGee & Gerald Q. Maguire Jr., *Becoming Borg to Become Immortal: Regulating Brain Implant Technologies*, 16 CAMBRIDGE Q. HEALTHCARE ETHICS 291–302 (2007).

22. CARVALKO, *supra* note 1, at 95

23. *Id.* at 108.

24. *Id.* at 119.

25. *Id.*

26. *Id.* at 121.

intellectual property—does not function satisfactorily for in-the-body medical or enhancement devices. At the same time, any radical change in patent or licensing law might have the effect of restricting progress, so a difficult balancing act is crucial. Carvalko calls for society to consider that in regard to intellectual property, "policy ought to consider not only the narrow goal of rewarding inventors and the commercial interests that invest in these technologies, but also the underlying purposeful nature of the products. . . ."[27] In proposing this he looks to *Brenner v. Manson*,[28] and nonpatentable invention, those "injurious to the morals, health, or good order of society."[29]

Carvalko suggests that government should reconsider patent laws, and move towards a new type of paradigm for ownership, marketing, and recompense for basic inventions and research that result in products which keep people alive.[30] In a subsection of the book—"Rationing Therapeutics"—he continues the metaphor of Eve to elucidate the concerns arising from a purely capitalistic model of cyborgization. The year is 2060 and Eve's grandmother needs a "cyber-lift."[31] At this point, the grandmother, Sarah, needs "not only a new processor but a new operating system and new applications that require a new central processor" as well as new RFID technology.

All these enhancements come with hefty price tags because the companies that provide the technologies have exclusive licensing and patenting rights. Further illustration of the economic problems caused by our economic system as applied to health care and medical innovation is provided by the author in considering the South African AIDS and drug debate, the period after Sept 11, 2001 and the unavailability of Cipro, the patent trial over the Pallin method for cataract surgery, and the Myriad patent for BRCA analysis.[32] Lawyers and legislators should be interested that Carvalko intimates that laws and regulations may need to change to protect the interests of all when inventions and developments affect human health and well-being.

By the year 2075, in a subsection entitled "Through the lens of a Cyborg, part of the Tectonic Future," Eve is transhuman, and, although actually 60, she has married a 25 year old and is expecting a baby boy, for whom the couple will purchase language accelerator technology. This would be more easily affordable if the husband, Adam, did not also need a new $50,000 type of installed technology just to keep his job.[33] The brave new world on the horizon is extremely expensive! For the imagined Eve, going back to work in 2084 also involves upgrading, and illustrates the difficulties of melding machine and man, with the cost of these products and the allied questions of reliability, warranty, and future surgeries.

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27. *Id.* at 130.
28. 383 U.S. 519 (1966).
29. CARVALKO, *supra* note 1, at 130 (quoting Brenner v. Manson, 383 U.S. 519, 533 (1966)).
30. *Id.*
31. *Id.* at 131.
32. *Id.* at 134–37.
33. *Id.* at 144.

Of the ethical issues arising from these technologies, Carvalko gives most attention to questions of distributive justice, and the peril of creating a world of greater haves and have-nots. But, he is also aware of the trenchant autonomy and privacy issues that in-the-body technologies create.

> Will we remain autonomous after being injected by RFIDs, infused with semiconductor sensors, modified by synthetic-DNA, and adapted with molecular and nano computers affecting our metabolic process, our mind, its perception, intuition, evaluation, and feelings? Will we retain autonomy in the sense of free will?[34]

Carvalko succeeds well in his goal of examining present and soon to be in-the-body technologies; he, perhaps necessarily, devotes far less space to his goal of discussing the reasons for controlling these technologies. For the most part the ethical and regulatory issues remain implicit. As befits a patent attorney, Carvalko is most knowledgeable and vocal about the sphere of cyborgization property.

However, serious questions are raised by in-the-body technologies, particularly brain implants, especially when the technologies move from therapy to enhancement. Even when exploited only to remediate, to allow those who are paralyzed or deaf or blind to overcome, issues arise concerning access, equity and the costs of acquiring the technologies. When used in the future for enhancement, as Carvalko imagines, these technologies will put new forms of stress on privacy, autonomy, and justice, and will even raise questions about what it means to be human.[35]

Significant additional ethical issues that need to be addressed are (1) the possibility of achieving a type of immortality through cloning of an individual and implanting the clone with a chip that contains the uploaded memories, emotions, and knowledge of the clone's source; and (2) the chance that humankind, as we know it, may eventually be phased out or become just a step in guided evolution.[36] Once it is possible to scan a brain, with all of its memories, emotions and intentions, it could be uploaded to a computer, or a robot. An individual could exist without a body; minds would survive in virtual environments and have experiences in virtual reality.[37]

Unquestionably the most troubling aspect of this new technology is the potential for control of persons. Microchips could enable not only global tracking of individuals but also be used to "see" and "hear" what an individual is experiencing.[38] Brain-monitoring devices could be used to influence and foresee buyer inclinations, to validate memory in court cases, to detect falsehoods,

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34. *Id.* at 146.

35. McGee & Maguire, *supra* note 21, at 291–302.

36. Ellen M. McGee, *Should There Be a Law? Brain Chips: Ethical and Policy Issues*, T.M. COOLEY L. REV. 81–97 (2007).

37. Ray Kurzweil, *The Coming Merging of Mind and Machine*, *in* UNDERSTANDING ARTIFICIAL INTELLIGENCE 90–99 (2002).

38. *See* G.Q. Maguire, Jr. & Ellen M. McGee, *Implantable Brain Chips? Time for Debate,* THE HASTINGS CENTER REP., Jan.–Feb. 1999, at 7–8,

and to provide lie detection.[39] Brain implants could be used to change behavior and attitudes. Individuals' thoughts, emotions, moods, and motivations, could be monitored, controlled, or directed; it would be easy to ascertain where anyone is and with whom they are in touch.

Before these and the other scenarios that Carvalko envisions are widespread, there is time to develop ethical guidelines and worldwide regulation. New systems need to be created to consider the extraordinary social and policy questions raised by these in-the-body technologies.[40] As Carvalko's book demonstrates, the future will bring a transhuman; present man should guide his development.

39. Henry T. Greely, C. Wendell & Edith M. Carlsmith Professor of Law, Professor (by courtesy) of Genetics, Stanford University, Remarks at the Regan Lecture: Prediction, Litigation, Privacy, and Property: Some Possible Legal and Social Implications of Advances in Neuroscience (Apr. 20, 2004), http://www.scu.edu/ethics/publications/submitted/greely/neuroscience_ethics_law.html.

40. McGee & Maguire, *supra* note 21.