Chapter 1
The Technological Future

Introduction

Let me start the book with a controversial and bold statement—our future is to merge with artificially intelligent machines! How I reached that conclusion is the subject of this book. I don't mean to imply that in the coming decades we humans will look and act like robots on an assembly line, rather, that we will be equipped with so much technology, including computing devices implanted within the brain itself, that we will have been transformed from a biological being into a technology-based being, evolving under laws of technology, more so than under the laws of biological evolution. At the same time that we are becoming more "machine like" (or "cyborg like"), advances in robotics, artificial intelligence, neuroscience, and materials engineering are allowing scientists to create intelligent machines that have sophisticated human—like functionality and are rapidly gaining in intelligence—"they" are becoming like us. I see the logical outcome of technological advancements in robotics, artificial intelligence, prosthesis, and brain implants, as a future merger between humans and machines.[1] This will not be a conscious decision made by humanity, but will be a gradual process, and inevitable. But not so gradual as to take centuries, but in all likelihood something that will happen this century or early next.

As a confession, I may have played a small role in this outcome (our future merger with machines), because as a faculty in engineering, I headed a research laboratory whose goal was to design wearable computing and sensor technology that was fully integrated with the human body. In the early 1990s, I began to formalize my thinking about the future direction of technology, and wrote about it in

[1]Of course, while seminal robot experts and artificial intelligence pioneers such as Hans Moravec hold the view that our future is to merge with machines, many experts disagree, and others argue that humanity should stop this outcome from occurring.

W. Barfield, *Cyber-Humans*, DOI 10.1007/978-3-319-25050-2_1

2001, in a chapter 1 co-authored, *Computing Under the Skin*, in which my colleagues and I argued for the use of sensors and cyborg implants to fix, repair, replace, and enhance damaged human anatomical and physiological systems.[2] At the time, my colleagues and I also mused about the future directions of "wearable" devices, making predictions about technology that are being implemented today. But in hindsight, it seems that we didn't go far enough predicting the future that has unfolded and we were too conservative in stating how close we are to the Singularity and afterwards Posthuman age.

Much of my work on the design and use of "wearable" technology was published in two books I co-edited, *Virtual Environments and Advanced Interface Design,* and *Fundamentals of Wearable Computers and Augmented Reality.*[3] Since the publication of the first edition of these books over a decade ago, the landscape in human enhancement technology and artificial intelligence has changed dramatically. To address these changes, I wrote this book to present an up-to-date summary of recent advances in genetics, prosthesis, and brain-computer interfaces; and to discuss current efforts to create artificially intelligent machines that learn and solve problems in ways not predicted by humans. Another goal in writing this book was to generate discussion among the public on the law and policies which should be enacted as humans are enhanced by technology, and as artificially intelligent machines gain human, or beyond human, levels of intelligence. Given the nature of the topics presented in this book, the discussion will be wide ranging cutting across diverse fields such as biology, engineering, ethics, and law.

As often stated by Google's Ray Kurzweil, the rate of technological change in engineering, medicine, and computer science is accelerating.[4] In some areas, what was science fiction just 10–20 years ago is now mainstream science. If advances in several key technologies continue to accelerate, the twenty-first century will indeed be a time of great change, amazing developments, and unique challenges for humanity. As predicted by computer scientists, engineers, and philosophers, by the end of the twenty-first century, advances in science and engineering will have led to such significant changes in the structure of our bodies that the very nature of what it means to be human will be questioned. On this point, the science fiction writer William Gibson, who coined the term "cyberspace" in the short story "*Burning Chrome,*"[5] sees a "cyborg" future for humanity which includes implantations of silicon chips into the human brain modified with DNA. Fast forward to Professor Theodore Berger's

[2]Dwight Holland, Dawn J. Roberson, and Woodrow Barfield, 2001, Computing Under the Skin, in Woodrow Barfield and Thomas Caudell (eds), *Fundamentals of Wearable Computers and Augmented Reality*, CRC Press.

[3]Woodrow Barfield and Thomas Caudell, *id*.; Woodrow Barfield and Thomas Furness (eds.), 1995, *Virtual Environments and Advanced Interface Design*, Oxford University Press.

[4]Perhaps Ray Kurzweil is most recognized for his ideas about the Law of Accelerating Returns discussed in his seminal book, Ray Kurzweil, 2006, The Singularity is Near, When Humans Transcend Biology, Penguin Books.

[5]William Gibson, 2003, Burning Chrome, Harper Voyager Press. Gibson coined the term "cyberspace" in the 1980s.

laboratory at the University of Southern California, where our cyborg future is being designed now in the form of remarkable neuroprosthetic devices.

Enhancing Humans

According to Sidney Perkowitz writing in "*Digital People: From Bionic Humans to Androids,*"[6] there are two main ways to categorize artificial enhancements of humans: firstly, as functional prosthetic devices and implants, such as artificial limbs, replacement knees and hips, and vascular stents (which aid in the flow of blood in blocked arteries); and secondly, as cosmetic or vanity implants, like hair plugs, false teeth, artificial eyes, and breast implants. This book concerns both categories of enhancements, and it is interesting to note that the efforts of some researchers to develop human-like robots, could be thought of as cosmetic or vanity enhancements to the machine, as such enhancements may be nonfunctional. Enhancement technologies may also occur in a multitude of ways, supported by a variety of technologies, in which human beings enhance their looks, abilities, features, or functions. In fact, enhancements to the human body range from performance enhancing drugs, plastic surgery and silicone implants for (perceived) beauty purposes, to bionic limbs and chip-enhanced cognition in humans. While the distinguishing feature of "cyborg" enhancement technology is to improve human functioning above 'normal' or 'average', many technologies for enhancement are being used for medical or regenerative purposes; for example, plastic surgery for burn victims or prostheses for lost limbs; the purpose in these cases being to bring the people 'back to normal'.

In addition to efforts to enhance the human body with a range of technologies, other important progress is being made in robotics and artificial intelligence that is also setting the stage for a human-machine merger. Due to major improvements in algorithms and sensors, machines are becoming more autonomous, software is becoming 'smarter', and robots are being developed that are beginning to look and act more like humans than machines (see Chaps. 3, *The Law of Artificially Intelligent Brains*, and 7, *The Law of Looks and Artificial Bodies*). In fact, one area of research in robotics is towards developing realistic looking robots that mirror human appearance (i.e., androids); another strand is towards developing facial features that cause a robot to appear as if expressing emotions; in particular, facial expressions like smiling or raising eyebrows. Once 'humanoid' robots are equipped with artificial intelligence—and thus acquire more autonomy from their human masters—the vision of an android in the spirit of Star Trek's "Data" might become a reality. At this point one can imagine two interesting scenarios: firstly, that the world may become populated by different types of species than those we see around us today: non-enhanced and enhanced humans, cyborgs, robots, and

[6]Sidney Perkowitz, 2004, Digital People: From Bionic Humans to Androids, Joseph Henry Press.

androids among them, all of which will function, in different but perhaps also in similar ways, in day-to-day social life.[7] And secondly, from advances in technology there could emerge one intelligent species, based on the merger of human and machine. In my view, before humanity could eventually merges with machines, there will be several intermediate forms of human-machine combinations, some of which we will term cyborgs. Again, when I speak of "merging with machines," I mean equipping humans with the technology (typically information technologies) to enhance the human body and mind, to go beyond current capabilities, essentially, to become more "cyborg-like." Throughout this book, I refer to the technology to enhance the human body and mind as "cyborg technologies." And I refer to the "cyborg future," "cyborg age," or coming "age of cyborgs," to refer to the future in which we will become equipped with technology to repair, replace, and extend our senses, and cognitive functions. An "emerging cyborg law," then is the legal issues which will be important to consider for our technological future. Further, whether a complete machine body containing a human consciousness uploaded to a machine architecture is a human or machine, is an interesting philosophical question, and the subject of discussions by various authors (see Chap. 7: *The Law of Looks and Artificial Bodies*).[8]

The vision of a future world populated by humans, cyborgs, intelligent robots, and androids raises many interesting questions. One such question is what this development means for fundamental or constitutional rights for the range of intelligent beings that may exist in the near future. Will cyborgs be considered human enough to still be bearers of 'human' rights? Can androids claim 'human' rights if they look and function in the same way in society as humans or cyborgs? And can human beings keep robots under control as they become increasingly autonomous; in other words, will robots comply with Asimov's three laws of robotics, or will they, like HAL in *2001—A Space Odyssey*, revolt and try and control humans? Society has been warned of this very outcome by physicist Stephen Hawking and entrepreneur and CEO of Telsa Motors Elon Musk.[9] Some argue that since cyborgs will evolve in gradual steps from the human species, they will most likely be considered humans by future generations. The scenario may work out as follows—as soon as different enhancement technologies are adopted by a critical mass, after the initial pioneers, enhanced humans will simply be the new appearance of the human species. As a result, it is argued that cyborgs will be the

[7]See Human enhancement, at: http://www.fidis.net/resources/identity-use-cases-scenarios/human-enhancement-robots-and-the-fight-for-human-rights/.

[8]Patrick Lin and Keith Adney, 2014, Robot Ethics: The Ethical and Social Implications of Robotics, MIT Press.

[9]Rory Cellan, Stephen Hawking Warns Artificial Intelligence Could End Mankind, BBC News, at http://www.bbc.com/news/technology-30290540; Ellie Zolfaghariford and Victoria Woollastan, 2–15, Could robots turn people into PETS? Elon Musk claims artificial intelligence will treat humans like 'labradors', at: http://www.dailymail.co.uk/sciencetech/article-3011302/Could-robots-turn-people-PETS-Elon-Musk-claims-artificial-intelligence-treat-humans-like-Labradors.html.

inheritors of human rights that exist today.[10] Now suppose that robots and artificially-intelligent machines perform similar functions as cyborgs do, and perhaps even become androids who are in looks and functions equivalent to cyborgs, then should they not have the same catalogue of rights? This issue will require substantial debate in society and legal academia.

Another issue that technologically enhanced people may raise is whether a social, or digital divide will develop between enhanced and non-enhanced humans. Human rights can play an important part in this debate: because they lay down the basic rules for treating people. At first sight, the right to non-discrimination will provide substantial guidance: non-enhanced people should not be treated unequally. However, what is 'unequal', if in the future enhanced humans are different in important ways from non-enhanced humans? For example, if an employer can choose between an unenhanced person with an IQ of 120 and a cyborg with an IQ of 260 or beyond, does he discriminate if he chooses the cyborg? This is just one example of questions concerning specific human rights in relation to human enhancement that merit public debate.

Humans, Bionics, and Cyborgs

As we become equipped with prosthesis and brain implants, we are moving beyond the human capabilities provided by our evolutionary history and coded in our genes. Since I believe technological advances are leading humanity towards a "cyborg" future and an eventual merger with machines; I should define some basic terms. Let's start with one of the main characters in this book—a "cyborg". Generally, a cyborg is a human-machine combination that has certain physiological and intellectual processes aided or controlled by mechanical, electronic, or computational devices. "Cyborg," is actually a compound word derived from cybernetics and organism, and was coined by Manfred Clynes[11] in 1960 to describe the need for mankind to artificially enhance biological functions in order to survive in the hostile environment of Space.

To introduce some other basic terms, "transhuman" is a term that refers to an evolutionary transition from the human to the Posthuman. To transhumanist thinkers, a Posthuman is a hypothetical future being "whose basic capacities so radically exceed those of present humans as to be no longer unambiguously human by our current standards."[12] The difference between the Posthuman and other hypothetical sophisticated non-humans is that a Posthuman was once a human, either in

[10]Human enhancement, robots, and the fight for human rights, at: http://www.fidis.net/resources/identity-use-cases-scenarios/human-enhancement-robots-and-the-fight-for-human-rights/.

[11]M. E. Clynes and N. S. Kline, 1960, Cyborgs and Space, *Astronautics*, 26–27, 74–75.

[12]Posthuman, Wikipedia, https://en.wikipedia.org/wiki/Posthuman.

its lifetime or in the lifetimes of some or all of its direct ancestors.[13] As such, a prerequisite for a Posthuman is a transhuman, the point at which the human being begins surpassing his or her own limitations, but is still recognizable as a human person. In this sense, the transition between human and Posthuman may be viewed as a continuum rather than an all-or-nothing event.

The field of cybernetics is concerned with communication and control systems involving living organisms and machines. The artificial parts used to create cyborgs do more than replace the main functionality of an organ or limb, they add to, enhance, or replace the computational abilities of biological systems. In a typical example of a cyborg, a human fitted with a heart pacemaker might be considered a cyborg, since s/he is incapable of surviving without the mechanical part whose computational capabilities are essential. As a more extreme example of a cyborg, some would view clothing as a cybernetic modification of skin; because it enables us to survive in drastically different environments by the use of materials that aren't naturally existing in those environments. In my conceptualization of a cyborg, if the clothing had computational capabilities that aided the wearer,[14] then I would conclude that the "clothing enhanced human" was a cyborg. However, in almost every case, throughout this book the "cyborgs" I discuss are the result of being enhanced with technology worn on or integrated into the body.

In the popular culture the terms "bionic human" and "cyborg" are often used interchangeably to refer to any human enhanced with technology. However, I draw the distinction that while a bionic human is a person that has been enhanced by mechanical or biological means; going a step further, a cyborg has computational processes enhanced or aided by technology, the goal being to go beyond current human sensory and cognitive abilities. Interestingly, while there are clearly many bionically enhanced people, there are also cyborgs living amongst us now. If we want to determine how many cyborgs or bionic humans there are, the number will depend on the definition used. For example, if by using the term "bionic human," one means to signify a person who is artificially enhanced in some way, then the digestion of medicine would create a bionic human and there would be literally hundreds of millions of such beings alive today. If, however, one meant that to be a "bionic human" a certain number of human parts were replaced by mechanical implants and prosthesis, then the number of such humans would not number in the hundreds of millions, but in the millions. According to one commentator, many current people could be defined as "bionic," in that eight to ten percent of the U.S. population, that is, approximately 25 million people, currently have some sort of artificial part- a number expected to grow as the population ages. In fact, just considering the sense of audition, thousands of cochlear implants are currently in use, including some placed in deaf children.

Finally, if one meant that to be a "cyborg" that a brain function was artificially enhanced or replaced, then the number of such people would likely be in the

[13] *Id.*

[14] Kate Hartman, 2014, Make: Wearable Electronics: Design, Prototype, and Wear Your Own Interactive Garments, Maker Medic Inc. Publisher.

thousands, a number expected to increase dramatically in the next 10 years. As an example of brain implant technology currently being used, starting in the late 1990s physicians have implanted electrodes into the brains of patients in the hope of developing a computer-brain interface which would allow those "locked-in " their bodies to operate a robotic arm or move a cursor on a screen. Further, technology that may allow memories to be digitally stored in the brain is under development. The neuroprosthesis (artificial hippocampus) referred to earlier and that is being designed and tested by Theodore Berger and his team at the University of Southern California[15] and by Dr. Sam A. Deadwyler and Dr. Robert Hampson of Wake Forest Baptist Medical Center could serve this purpose.[16]

In many discussions of enhanced humans, whether a person equipped with technology is termed bionic or cyborg, is not an important distinction—most people use the terms interchangeably to refer to any person equipped with technology. But under the law, the degree to which a person is enhanced by technology could matter. For example, under disability law a person with a given handicap may need to be accommodated by an employer; but the type of disability and what technology is used to address it, would matter in the legal analysis of the disability and the rights afforded the disabled person. And consider athletes who have lost their legs yet still compete against athletes without prosthesis. Competitors often raise concerns about the unfair advantage the "cyborg" would have over them due to the lightness of their carbon-fiber prosthetics. While this example may appear to be something of an outlier, as prosthetic technology improves, the potential for prosthetic limbs to equal or even surpass the capabilities of natural limbs is great.[17] Further, prosthetic limbs may be stronger, and allow the user to carry heavier loads than they may normally be able to carry. Alternatively, they may be more flexible, or allow for greater accuracy in certain tasks—how many people can boast of having a wrist that rotates 360°? While this may seem an inane example, the possibilities nevertheless exist for people once considered 'disabled' to become 'over-abled' in comparison to non-enhanced individuals. Will this give those individuals a competitive advantage over others that are non-enhanced in employment? As with some enhanced people, will a perceived superiority of the artificial over the natural create resentment between 'enhanced' and 'non-enhanced' people? As a result, will new categories of discrimination law be necessary? Under the U.K. *Equality Act*, someone is 'disabled' if they are considered to have an impairment that has a substantial and long-term adverse effect on their ability to carry out normal day-to-day activities; if someone is able to surpass the ability of

[15]Theodore Berger, Artificial Hippocampus, in Memory Implants, MIT Technology Review, at: http://www.technologyreview.com/featuredstory/513681/memory-implants/.

[16]Theodore W. Berger, Dong Song, Rosa H. M. Chan, Vasilas Z. Marmarelis, Jeff LaCoss, Jack Wills, Robert E. Hampson, Sam A. Deadwyler, and John J. Granacki, A Hippocampal Cognitive Prosthesis: Multi-Input, Multi-Output Nonlinear Modeling and VLSI Implementation, IEEE Trans Neural Syst Rehabil Eng. 2012 Mar; 20(2): 198–211, doi: 10.1109/TNSRE.2012.2189133.

[17]Human Enhancement Technologies—Edging towards the Cyborg? at: http://www.scl.org/site.aspx?i=ed31780.

fully-able people to undertake those activities through the use of enhancement technologies, can we truly consider them to be disabled?[18]

Interestingly, one jurisdiction may have already recognized a person as a cyborg. Artist, Neil Harbisson,[19] is completely color blind suffering from a visual impairment called achromatopsia, which means he sees the world in shades of grey. To perceive colors, Neil wears a sensory augmentation device in the form of a head-mounted antenna attached to a chip at the back of his skull. As a form of sensory substitution, the "Eyeborg" turns colors into sounds, allowing Neil to "hear" electromagnetic energy representing color. After a long dispute with the U.K. authorities, Neil's passport photo now includes a picture of him with his cyborg device, a recognition by the authorities that his cyborg enhancement is a permanent part of his appearance. With a passport photo that shows the Eyeborg as part of Harbisson's face, it will be difficult for people to argue that his Eyeborg is an optional accessory, like a camera or a hat, and somebody trying to take his augmentation off could be committing an assault and battery equivalent to injuring his face. Interestingly, under the law, a "battery" may occur even if the aggressor does not touch the plaintiff (i.e., cyborg) directly, but instead touches something closely related to his or her person (like a cybernetic enhancement attached to the body).[20] For example, courts have held that touching the cane a person uses to walk may be battery, even if the defendant never touches the person herself. In this case, the cane is like an extension of the person's body, so touching it is the same thing as touching the person's body. In many situations, clothing, hats, and bags may also count as part of a person enough for the person wearing them to prove battery. However, as we will see in a later chapter, the law in this area is evolving in response to cyborg technologies.

A major point to make early in this book is that while humans are becoming equipped with prosthesis and implants, and thus becoming more cyborg-like, during this century, robots will continue to get smarter and at a speed defying human imagination (actually our bias towards linear thinking see Chap. 3: *The Law of Artificially Intelligent Brains*). In fact, robots equipped with artificial intelligence, and a host of sensors, actuators, and algorithms are leading the way to the creation of machines that may surpass humans in intelligence and motor capabilities by the middle, and almost certainly, the end of the twenty-first century. As technology advances, new forms of humans may evolve from different techniques to enhance human physiology, anatomy, and cognitive structures. All this may create a continuum of intelligent beings from human to machine, progressing from human, bionic human, cyborg, android, robot, software bot, and machine; how artificial intelligence may add to, or "disrupt" this continuum is discussed throughout this book.

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[18]UK Equity Act of 2010.

[19]Neil Harbisson, BBC News, The Man Who Hears Color, at: http://www.bbc.com/news/technology-29992577.

[20]Gowri Ramachandran, Against the Right to Bodily Integrity: Of Cyborgs and Human Rights, 2009, Denver Law Review, Vol. 187, 1–57.

Advances in artificial intelligence may also result in disembodied software beings that roam the internet, possibly downloading their consciousness to remote robots or to androids to gain mobility at particular locations around the world. One commentator has even used the term "digital people" to refer to entities that include artificial and partly artificial beings, from mechatronic robots (mechanical plus electronic) to humans with bionic (biological plus electronic) implants. In addition, Martine Rothblatt in her book, *Virtually Human: The Premise and the Peril of Digital Immortality*, argues that the brain can be simulated using software and computer technology. From this discussion, the impression is conveyed that different types of artificially intelligent beings may coexist in the future.

Brain-Computer Interfaces

Based on medical necessity, enhancement technologies are being used to repair and replace human anatomy and physiology, and to repair and enhance human cognitive and perceptual abilities. For example, brain-computer interfaces are assisting people suffering from debilitating neurological disorders, such that they are "locked-in" their own body. A brain-computer interface which consists of recording electrodes placed on a person's scalp or implanted into their brain, allows those locked-in the capability to communicate and interact with the world, by thought alone.

Additional progress is being made in other areas of brain-computer interface design. For example, scientists have used brain scanners to detect and reconstruct the faces that people are thinking of, according to a study published in the journal *NeuroImage*.[21] In the study, Yale scientists hooked participants up to an fMRI brain scanner—which determines activity in different parts of the brain by measuring blood flow—and showed them images of faces. Then, using only the brain scans, Professor Marvin Chun and his team were able to create images of the faces the people were looking at.[22] One can imagine in the future that a witness to a crime might reconstruct a suspect's face based on "extracting" the image from his mind. Yale researchers pointed out that an important limitation of the technology as it exists now, is that this sort of technology can only read active parts of the brain, it couldn't read passive memories—to do this you would have to get the person to imagine the memory to read it. Interestingly, at the University of California-Berkeley, scientists are moving beyond "reading" thoughts to predicting what

[21]Bill Hathaway, 2014, Yale Researchers Reconstruct Facial Images Locked in a Viewer's Mind, http://news.yale.edu/2014/03/25/yale-researchers-reconstruct-facial-images-locked-viewer-s-mind; also in Neuroimage. 2014 Jul 1;94:12–22. doi: 10.1016/j.neuroimage.2014.03.018.

[22]Bill Hathaway, Yale researchers reconstruct facial images locked in a viewer's mind, at: http://news.yale.edu/2014/03/25/yale-researchers-reconstruct-facial-images-locked-viewer-s-mind.

someone will think next.[23] And at Carnegie Mellon University, in Pittsburgh, cognitive neuroscientist Marcel Just from the *Center for Cognitive Brain Imaging* has a vision that will make Google Glass and other similar technologies seem very last century.[24] Instead of using your eye to direct a cursor, Just envisions a device that will dial a number by interpreting your thoughts.[25] However, what if all of our thoughts were public? Dr. Just envisions a terrifying version of the future, where officials read minds in order to gain control over them. But more optimistically, Marcel also envisions a more positive future, with mind reading devices offering opportunities to people with disabilities—and to those not disabled.

According to Duke University neuroscientist Miguel Nicolelis, microchips implanted into the brain could also allow brain-to-brain communication, that is, telepathy.[26] Thus far, brain-wave sensing machines have been used to 'telepathically' control everything from real-life helicopters to characters in a computer game. In its most recent incarnation, the science of telepathy has gone a step further by allowing someone in India to send an email to his colleague in France using thought. To perform this feat, researchers used electroencephalography (EEG) headsets which recorded electrical activity from neurons firing in the brain to convert words into binary. Once the initial thoughts were digitized in India, they were sent to a person's mind in France where a computer translated the message, and then used electrical stimulation to transmit the thought to the receiver's mind. Ultimately, telepathy chips and related brain-computer devices could lead to the emergence of new forms of intelligence, for example, "mindplexes."[27] This is a term used by artificial intelligence researcher Ben Goertzel, which represents a collection of independent human minds, yet also possessing a coherent self and consciousness at the higher level of the telepathically-interlinked human group. Mindplexes could lead to the benefits associated with crowd sourcing in which the combined wisdom of a crowd has in some cases been shown to solve problems beyond the reach of experts. In fact, the characteristics of "wise crowds," which are diversity of opinion; independence of members from one another; decentralization; and a good method for aggregating opinions would be a feature of networked brain-to-brain communication.

Surely, the reading of thoughts would raise a host of legal and policy issues. Not the least of which is privacy law. On this point, courts in the future may have to decide whether listening to and recording a person's thoughts is protected

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[23]Yasmin Anwar, 2011, Scientists Use Brain Imaging to Reveal the Movies in Our Mind, at: http://newscenter.berkeley.edu/2011/09/22/brain-movies/.

[24]Karen Weintraub, 2014, Scientists explore possibilities of mind reading, at: http://www.usatoday.com/story/tech/2014/04/22/mind-reading-brain-scans/7747831/.

[25]*Id.*

[26]Miguel Nicolelis, 2012, Beyond Boundaries: The New Neuroscience of Connecting Brains with Machines-and How It Will Change Our Lives, St. Martin's Griffin Press.

[27]Ben Goertzel, 2014, Between Ape and Artilect: Conversations with Pioneers of Artificial General Intelligence and Other Transformative Technologies, CreateSpace Independent Publishing Platform.

speech, or an unlawful search and seizure of the activity (i.e., cognition) generated by the prefrontal cortex (a topic discussed in Chap. 3). As to implanting microchips, a few states in the U.S. have already enacted anti-chipping statutes which prohibit the "chipping" of vulnerable populations and raises the bar of consent for implanting an identification or tracking device in any person. I will return to this important topic again.

With the ability to hack the brain comes compelling problems of law and policy. If it becomes technically possible to communicate brain-to-brain by thought alone, could the wirelessly networked brains be hacked into by a corporation or government agency that could implant an advertisement, subconscious thought, or memory into one's mind? If you are annoyed by pop-up ads which appear now on a website, imagine the nuisance of a pop-up ad appearing in your mind. Further, the ability to implant a "telepathy chip"—a neural implant that would allow the wearer to project their thoughts or feelings to others, and receive thoughts or feelings from others, raises a huge number of questions philosophically, legally, psychologically, and socially. For example, what would happen, if an implanted computer chip should "crash" after it is in place? What kinds of health and behavior problems might arise in such a case?

Biological Enhancements

While much of this book discusses enhancement technology in the form of hardware, software, and algorithms, to present a more comprehensive picture of what the future may hold, I briefly present here material on current efforts to enhance human abilities by modifying their DNA, and by performance enhancing drugs. In addition, DNA nanobots in 15–20 years could allow humans to access the internet with their mind, in fact, the U.S. agency DARPA, is researching this possibility now. Until recently, human genetic engineering was the material of science-fiction novels and blockbuster Hollywood films. However, genetic engineering of DNA is not confined to books and movies, scientists and doctors are already attempting to genetically alter human beings and our cells. To understand the choices that humanity must confront this century as a result of the ability to genetically enhance a human, it is critical to understand an important distinction under the umbrella of genetic engineering: the difference between therapy and enhancement. Gene therapy and genetic enhancement are technically both genetic engineering, but there are important moral differences.

For decades, researchers have worked toward using genetic modification called gene therapy to cure devastating genetic diseases. Gene therapy works by delivering a copy of a normal gene into the cells of a patient in an attempt to correct a defective gene. This genetic alteration would then hopefully cure or slow the progress of that disease. In many cases, the added gene would produce a protein that is missing or not functioning in a patient because of a genetic mutation. However, genetically engineering a normal person who wants, for example, more muscle to

improve his athletic ability is no longer gene therapy; instead, it is genetic enhancement.[28] Genetic enhancement would take an otherwise healthy person and genetically modify him to be more than human, not just in strength, but also in intelligence, beauty or any other desirable trait. So why is the distinction between gene therapy and genetic enhancement important? Gene therapy seeks to return a patient to normal human functioning. Genetic enhancement, on the other hand, intentionally and fundamentally alters a human being in ways not intended by nature (note cyborg technologies may perform the same function).

When considering biological enhancements to humans, there is another important distinction to discuss. Somatic enhancements are those that affect one person, and therefore, the genetic alterations occur in only one individual, they do not enter the human genome generally. While single-person enhancements may have a dramatic impact on a solitary individual's life, since those changes are not passed on to that individual's children; they do not become part of the larger human genome. In contrast, germline changes are genetic modifications that can be passed on to one's descendants and thus can become permanent components of the human genome; affecting the person receiving the intervention and, at least indirectly, affecting every other human being. Such changes would constitute alterations of the entire complement of genetic traits found within the species, and many people believe that such steps should be taken with great caution, even trepidation, if not banned altogether.[29]

One form of enhancement technology that has great promise for engineering a healthier person, but at the same time, has the potential to impact the very nature of humanity is nanotechnology. The long-term goal of nanotechnology is to manipulate molecular and atomic structures to design and create machines at the atomic level; for example, nanobots to repair the body. Since humans are made of the same basic building blocks as the natural world, nanotechnology will enable the ability to change human tissues and cells at the molecular level. This will open doors in medicine previously thought impossible, and it will enable us to extend the length and quality of human life. It will also open the door to "enhancements" of the body; including better IQ, appearance, and capabilities. These enhancements will undoubtedly benefit many, but they also bring up important moral, ethical, and legal questions that human society is just beginning to face.

Biological enhancements to humans already exist in many forms; for example, according to Maxwell Mehlman, director of the *Law-Medicine Center* at Case Western Reserve School of Law,[30] the U.S. Federal Drug Administration (FDA)

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[28]See generally, Gene Therapy, 2008, at: http://www.marymeetsdolly.com/index.pl?%7C%7Cac=marymeetsdolly&%7C%7Ccm=2c&%7C%7Ccv=1&%7C%7Cpp=20&%7C%7Crp=1&%7C%7Crv=titledescription&%7C%7Csi=00ZKNPHS3VX33PA0I3Z5&%7C%7Csrt=t&%7C%7Csrtin=a&%7C%7Ctr=OIP8JNM0ME&%7C%7Cudid=15&go=50.

[29]Francis Fukuyama, 2003. Our Posthuman Future: Consequences of the Biotechnology Revolution, Picador Press.

[30]Maxwell Mehlman, 2012, Transhumanist Dreams and Dystopian Nightmares: The Promise and Peril of Genetic Engineering, John Hopkins University Press.

recently approved a drug which has the cosmetic effects of lengthening and darkening eyelashes. The drug, Latisse, or bimatoprost, was already on the market as a treatment for glaucoma. And to gain a competitive edge, athletes use everything from steroids and blood transfusions to recombinant-DNA—manufactured hormones. Students have been known to supplement caffeine-containing energy drinks with Ritalin and the new alertness drug modafinil. Further, the military also spends millions of dollars every year on biological research to increase the war-fighting abilities of "cyborg" soldiers. All of these are examples of biomedical enhancements: interventions that use medical and biological technology to improve performance, appearance, or capability in addition to what is necessary to achieve, sustain, or restore health.[31]

One of the recent enhancement movements is the phenomena of DIY biology which advocates open source of DNA information (see Chap. 5, discussing the movement to self-modify the body). This movement emphasizes DIY genetic experiments and open access to scientific and specifically, genetic material. The DIY biology movement attempts to make available the tools and resources necessary for anyone, including non-professionals, to conduct biological engineering of their own body. For example, low-cost thermocyclers (instruments to amplify DNA and RNA samples via polymerase chain reaction) have been created to make a crucial technology more widely available to the public. What about biological enhancements and public policy? An interesting relationship between genetic enhancements and public policy was highlighted by Matthew Liao, a professor of philosophy and bioethics at New York University.[32] Liao explored ways humanity can change its nature to combat "climate change." One of the suggestions Liao discussed was to genetically engineer human eyes to function more like cat eyes so we can see better in the dark. Liao remarked that this would reduce the need for lighting and reduce energy usage. Considering the available pool of resources to feed the planet's rising population, Liao also discussed genetically modifying our offspring to be smaller so they eat less and consume fewer resources. In the face of such suggestions, the NBA, and humanity has much to talk about.

Over the next several decades, it is possible that genetic engineering and other cognitive enhancement techniques could significantly increase human abilities such as intelligence. However, as Ronald Bailey author of works on ecology, economics, and biotechnology points out, critics on both the right and the left worry that the ability to enhance a person's cognitive abilities will undermine political equality.[33] Francis Fukuyama, a strong opponent of engineering DNA for purposes

[31]Maxwell J. Mehlman, Tapping Talent in a Global Economy: Biomedical Enhancements: Entering a New Era, Issues in Science and Technology, Volume XXV Issue 3, Spring 2009, at: http://issues.org/25-3/mehlman/.

[32]See generally Matthew Liao, et al. 2015, Designer Biology: The Ethics of Intensively Engineering Biological and Ecological Systems, Lexington Books.

[33]Ronald Bailey, 2005, Liberation Biology: The Scientific and Moral Case for the Biotech Revolution, Prometheus Books.

of human enhancement, in his 2002 book *Our Posthuman Future: Consequences of the Biotechnology Revolution*, asserted, "The political equality enshrined in the Declaration of Independence rests on the empirical fact of natural human equality".[34] The idea he opposes is that biological enhancements could "allow inequality to be inscribed in the human genome." Fukuyama's argument is that biotechnology could allow a class of "super beings" to be engineered such that "normal" humans would be orders of magnitude less on scales of intelligence, aggression, drive, and so on.[35] While this criticism certainly deserves public debate, some have argued that this is a very weak reason to oppose the enhancement of such important attributes as intelligence. Those in favor of cognitive enhancements point out that cognitive inequality is already inscribed in the human genome, as there is already large difference in intellectual ability between people with low versus high IQs.[36] They also argue that cognitive enhancement could help alleviate political ignorance and increase political equality—at least in so far as political equality is enhanced by cognitive equality.[37] As for the equality issue, cognitive enhancement may follow the same trajectory as numerous previous information-spreading technologies, such as books, radio, television, and computers.[38] Some argue that while at first they may be available mostly to the rich (first adopters), over time costs could go down due to marketplace competition, and the rest of society will then be able to take advantage of them as well. Ultimately, according to some commentators, cognitive enhancement might actually reduce the large "natural" gaps in cognitive ability that currently exist. Again, we humans need to talk about this.

New Opportunities in the 21st Century

Future technological developments leading towards a human—machine merger will also lead to new opportunities for entrepreneurs. For example, according to data from *Global Industry Analysts*, worldwide markets for prosthetics, include the design, manufacturing and fitting of artificial limbs. At the time of this writing a "typical" prosthesis may cost $10,000 to $65,000, and the market is projected to grow from $15.3 billion to $23.5 billion by 2017. The wearable technology market may grow to $6 billion by 2016, and the demand for real-time data, including

[34]Francis Fukuyama, *id.,* note 29.

[35]Francis Fukuyama, *id.,* note 29.

[36]Francis Fukuyama, *id.,* note 29.

[37]Illya Somin, 2013, The Case for Designer Babies, The Volokh Conspiracy, at: http://volokh.com/2013/10/21/case-designer-babies/.

[38]*Id*.

personal health information, will grow from 14 million devices which provide health information to 171 million in 2016.[39] Further, an ageing population and the rising prevalence of health issues such as diabetes, as well as degenerative joint diseases such as arthritis and osteoporosis, is building demand for prosthetics. And considering cyberspace, virtual reality already has value. In 2004 David Storey became the Guinness World Record holder at the time for "Most valuable object that is virtual" when he purchased an island in the virtual world *Entropia* for 265,000 Entropian dollars, or $26,500 in 2010 dollars. Storey set up a virtual rare game preserve business on the island, which he claimed drew in around $100,000 in revenue. However, you don't have to be a player paying the entry fee to a club in *Entropia*, or buying virtual swords in *World of Warcraft* to have encountered the virtual economy. If you're on Facebook, and bought a birthday cake icon for a friend, you just paid real money for a virtual good.[40]

What about the law and financial transactions in cyberspace? Consider the development of "Bitcoin," an open source digital currency used in cyberspace to pay for goods and services using peer-to-peer technology with no central authority or banks involved.[41] In some cases, Bitcoin is the *only* accepted form of payment in cyberspace. However, it seems that where financial transactions occur, government regulations and the law are close behind. And on just this point, the New York State Department of Financial Services issued subpoenas for digital-currency companies and investors in an attempt to determine if the state needs to regulate cyberspace transactions. Why would the state want to regulate cyberspace? Because the things a person can buy with the digital currency Bitcoin is continuing to grow, from sandwiches to art and even expensive cars, as a man using Bitcoin bought a Tesla Model S from a Lamborghini dealership in Newport Beach, CA, who was the first dealer to accept Bitcoin as a form of payment.[42] Globally, Bitcoin has had a mixed reception, with China's central bank banning lenders from handling the virtual money. The U.S. Internal Revenue Service hasn't offered guidance on Bitcoin beyond saying it's working on the issue and that it has been monitoring digital currencies and transactions since 2007. Interestingly, there is also a connection between digital currency and cyborg technologies. A Dutch entrepreneur has had two wireless computer chips implanted under the skin in his hands to allow him to store digital currencies like Bitcoin inside his body. Martijn Wismeijer the founder of *Mr. Bitcoin*, operates a company which installs and operates crypto-currency cash machines in and around his native Amsterdam and across Europe.

[39]Lucas Mearian, 2012, Wearable Technology Market to Exceed $6B by 2016, Computerworld, at: http://search.aol.com/aol/search?s_it=topsearchbox.search&s_chn=prt_aol20&v_t=comsearch&q=Lucas+Mearian%2C+Wearable+Technology+Market+to+exceed+%24B+by+2016.

[40]Paray Khanna and Ayesha Khanna, Time to Pay Attention to the Virtual Economy, at: http://bigthink.com/hybrid-reality/time-to-pay-attention-to-the-virtual-economy.

[41]Nathaniel Popper, 2016, Digital Gold: Bitcoin and the Inside Story of the Misfits and Millionaires Trying to Reinvent Money, Harper Press.

[42]Emily Foxhall, 2013, O.C. Lamborghini dealership sells car for 91.4 bitcoins, at: http://articles.latimes.com/2013/dec/12/local/la-me-ln-lamborghini-bitcoin-20131212.

Remarkably, Martijn chose to undergo a painful procedure to embed NFC (near-field communication) chips under his skin. These chips can be read by a range of devices including smartphones, and can be adapted for a range of uses.

In another example of economic opportunities that will develop this century, just as the current markets for plastic surgery, mood-altering drugs, and even beauty and fitness aids total in the billions of dollars, tomorrow this market will be multiplied many times over in a world where longevity and health enhancement become valued assets. In the U.S., medical technology developments including bio-enhancing medicines, fall within the jurisdiction of the FDA and are specifically regulated by the *Federal Food, Drug, and Cosmetics Act* and the *Public Health Service Act*. Under these acts, the U.S. FDA regulates a broad range of products, although different products are treated in different ways. Some products, such as drugs, devices, biologics, food and color additives, are subject to "premarket authorization," while other products are not. Premarket authorization means, among other things, that the FDA can require manufacturers to provide needed scientific information concerning safety and product effectiveness to the agency. Besides premarket analysis, the FDA's responsibilities include the discovery of safety problems with marketed products, to remove specific versions of a product from the market or to ban dangerous products completely, as required by the need to protect consumers and patients.

New drug approval is even more demanding and such guidelines should be considered by those developing cyborg technologies. The clinical trial process is intended to gather sufficient data needed to determine whether new drugs are safe for human use. If artificially intelligent machines gain legal status, would the FDA regulate the hardware and software updates which affect their well-being? Would any government agency be concerned with their needs? Surely the law of contracts would be implicated in the context of financial transactions. To address these and other issues, the current human-centric focus of the law may need to be revised in the future. Currently, provisions of the FDA say nothing specifically about cyborgs or artificially intelligent machines arguing for rights, although the prosthesis and treatments received by those falling under the term "bionic human or cyborg," are covered by FDA regulations. However, rather than waiting for FDA approval for implantable technology, self-directed body hackers are taking matters in their own hand and enhancing their body with off-the-shelf sensors and other implantable devices (see Chap. 5: *Modifying, Enhancing, and Hacking the Body).*

Issie Lapowski comments that "the potential for artificial intelligence has, for decades, been mostly relegated to the larger-than-life imaginations of Hollywood directors."[43] She says that from *Blade Runner* to *Terminator*, it always seems to take place in some distant and dystopian future. And yet, if there's one thing to be learned from Google's recent acquisition of the artificial intelligence startup DeepMind, it's that the heyday for this type of technology is not a century or even decades away. Furthermore, the global market for artificial intelligence was valued

[43]Issie Lapowski, 4 Big Opportunities in Artificial Intelligence, at: http://www.inc.com/issie-lapowsky/4-big-opportunities-artificial-intelligence.html.

at $900 million in 2013, according to the market research firm *Research and Markets*. Meanwhile, a study out of Oxford University found that in the near future artificially intelligent technology could take over nearly half of all U.S. jobs.[44] It's scary news for some, but it's also a huge opportunity for entrepreneurs innovating in this space.

I agree with some commenters that envision several main markets for emerging applications of artificial intelligence.[45] According to Issie Lapowski, staff writer for *Wired*, the first is in understanding "big data." The big data market has been maturing for years now, but while there's plenty of technology that can crunch the numbers and spit them out in a spreadsheet or chart, there's a difference between having the data on hand and truly understanding it. Now, entrepreneurs are beginning to fill that gap with technology that not only synthesizes the data, but interprets it, too.[46] One such company, Chicago-based *Narrative Science*, has developed a program called *Quill* that goes so far as to provide users with a written report of the data in story form. The second main market for artificial intelligence, according to Lapowski, is in making smarter robots.[47] The days of robots performing simple manufacturing tasks manually controlled by humans are far from over, and yet there's a land rush going on among startups vying to build a better robot brain and sensors which would allow machines to operate autonomously. There's Baxter, of course, *Rethink Robotics'* famously friendly-looking research robot, which is already on the market, and can actually be trained. Others, like *Hanson Robotics*, have invented remarkably human-like robots, capable of carrying a conversation and recalling personal history. Thirdly, Lapowski reports that artificial intelligence will lead to smarter assistants.[48] Ubiquitous as Siri is, she's far from perfect; *Incredible Labs*, has already developed Donna, a personal assistant app that not only reminds you when you have an appointment, but tells you when to leave, how to get there, and memorizes your preferences. Taking that a step farther is *Jarvis Corp*., a startup, which so far, is still in the conceptual phases of building a virtual assistant that can access the Internet and answer questions; but can also act as a control for all the connected devices in a house, and act as an Internet server. Artificial intelligence isn't just for processing requests and synthesizing data anymore. Now, some startups are even developing technology that can understand sentiment, a trend known as affective computing. A Tel Aviv-based startup, *Beyond Verbal*, according to Lapowski "uses technology to analyze vocal intonations to determine a person's mood." Affectiva's software accomplishes a similar mission, but by monitoring a person's face. The idea is that by understanding emotions, artificially intelligent technology could predict a person's

[44]Artificial Intelligence is Changing the World and Humankind Must Adopt, Wired, at: http://www.wired.com/2014/07/artificial-intelligence-changing-world-humankindmust-adapt/.

[45]Issie Lapowski, *id*., note 43.

[46]*Id.*

[47]*Id.*

[48]*Id.*

needs in drastically more human ways. Of course, as we teach "them" how to understand us, we may be opening Pandora's Box in terms of giving artificial intelligence the information it may need to manipulate us.

Cyborgs and Virtual Reality

Leading robotic experts and artificial intelligence researchers have predicted that during this century, artificially intelligent machines will take on far more of a human-like appearance, express emotions, and reach, or possibly surpass, human levels of intelligence (see Chap. 7: *The Law of Looks and Artificial Bodies*). Machines with such capabilities, and appearing in human-like form, termed "androids," will enter society, negotiate contracts with humans, and likely argue for legal and other rights; including "human rights" and liberties. Also during this century, humans will be equipped with far more machine parts and computing power than now; the result being bionic humans and cyborgs.

By the middle of the twenty-first century, "virtual reality" will also be far more realistic and immersive than now, and as such, humans, cyborgs, artificially intelligent machines, and intelligent virtual avatars (sometimes referred to as virtual human or digital person) will spend time living in virtual reality where they will form governments; produce, buy, and sell products; and engage in many of the social activities that occur in the real world.[49] If in the future virtual reality will be inhabited by artificially intelligent virtual avatars, some working as our personal digital assistants, some working for intelligent machines, and some representing themselves, how will we humans relate to intelligent virtual avatars that we will encounter in virtual reality? How will intelligent virtual avatars be viewed by the legal system, I topic I wrote about in *The Akron Law Review*? Will intelligent avatars have legal rights? Will they be citizens, have the right to vote or marry, or through genetic algorithms, have progeny that they can claim? Will uploading a computer virus be considered an assault and battery? And where will jurisdiction lie for disputes involving virtual avatars that roam the internet? Furthermore, will intelligent avatars have the right to "treatment" if infected by a computer virus? On this point, at a 2013 conference on law and robotics hosted by Stanford Law School, after I spoke, Joanne Pransky, a person who has lectured on the social aspects of robots, handed me her card which tongue-in-cheek presented her as the world's first robotic psychiatrist.

Where will technological developments in virtual reality, intelligent systems, and cyborgs ultimately lead? Some scientists have argued that the convergence of this technology, along with developments in nanotechnology, will result in the emergence of "Posthumans," a term used by some commentators to refer to future beings whose basic capacities will so radically exceed those of present humans as

[49]Woodrow Barfield, Intellectual Property Rights in Virtual Environments: Considering the Rights of Owners, Programmers and Virtual Avatars, 39 Akron L. Rev., 649 (2006).

to be no longer human by our current standards. What could be the form of Posthumans? Posthumans could be artificial intelligences in a variety of forms (such as human-like robots), they could be uploaded human consciousness to computing machines or to the internet, or they could be the result of making many smaller but cumulatively profound augmentations to a biological human. Conceptually, the latter alternative would probably require either the redesign of the human organism using nanotechnology or its radical enhancement using some combination of technologies such as genetic engineering and advanced prosthesis.[50]

The above predictions on humans merging with machines and artificial intelligence equaling and then surpassing human intelligence are bold and to some controversial, and not easy for many people to accept; however, to use a cliché, the future is moving towards us at an amazing speed. In fact, the distinction between human and machine is already blurring. In our present era, a human may be equipped with a retinal prosthesis, cochlear implant, artificial hip, heart, kidney, and limbs, as well as implanted sensors and a heart pacer. Further, people like Professor Steve Mann of the University of Toronto have been wearing computers for 30 years; or as Steve told me years ago, "packing heat." In addition, Professor Kevin Warrick from the University of Reading has also pioneered the movement toward a cyborg future by participating in a set of studies known as Project Cyborg.[51] The first stage of this research, which began in 1998, involved a simple sensor being implanted beneath Warwick's skin, which was used to control doors, lights, heaters, and other computer-controlled devices based on his proximity to them. The second stage involved a more complex neural interface which consisted of an internal electrode array (consisting of 100 electrodes), connected to an external "gauntlet" that housed supporting electronics. The electrode array was implanted in Warwick's arm in 2002, and interfaced directly into Warwick's median nerve. The demonstration proved successful, and the signal produced was detailed enough that a robot arm was able to mimic the actions of Warwick's own arm.[52]

As we develop technology to enhance the human body, be it out of necessity or to create humans with abilities beyond those of current people, we are changing the ratio of human to machine parts; an idea espoused by Ray Kurzweil and Terry Grossman in their 2005 book "*Fantastic Voyage: Live Long Enough to Live Forever*."[53] In fact, the ratio of human to machine parts may be a useful, albeit simplistic, measure of "cyborgness." We can postulate that C = m/h, where "C" equals cyborg, "h" represents the number of human parts, and "m" represents the

[50]Transhumansm; Post-Human and Trans-Human, at: http://www.miqel.com/transhumanism_nano/transhuman-posthuman-uberman.html.

[51]Kevin Warwick, The Next Step Towards True Cyborgs? at: http://www.kevinwarwick.com/cyborg2.htm.

[52]Kevin Warwick, Wikipedia, at: https://en.wikipedia.org/?title=Kevin_Warwick.

[53]Ray Kurzweil, 2005, Fantastic Voyage: Live Long Enough to Live Forever, Plume Publisher.

number of machine parts. However, the deciding factor determining the degree of "cyborgness" may not be a simple ratio of human to machine parts, but more on the issue of how much information processing is performed by the human or machine components of the cyborg/human. Thus, we can posit the following relationship: $C = \Sigma\ (m_i/h_i)$, where the subscript "i" represents the information measured in bits transmitted by a particular body or mechanical part (the human brain is a petaflop biological computer). We presently don't know the information processing capabilities of different body parts or physiological systems, but the idea that the degree of cyborgness should be related to information theory, seems to me to have merit (and heavily weights the information processing capabilities of the human brain). Barring a breakthrough in brain prosthesis, each technological advancement alone will not significantly alter the ratio of human biological to mechanical parts if information processing is the deciding factor, but if one considers the amount of human limbs, sensors, and internal systems (such as the heart or liver) that can be replaced or enhanced with technology, clearly the "cyborg" ratio is beginning to change and in favor of the machine.

Developments in cyborg technologies beg the question, "where does the human end, and the machine begin?" This is a question humanity will likely have to address sooner rather than later. In some situations laws that affect people lacking technological enhancements (the current majority) may not be relevant for an enhanced person with a prosthetic arm or leg equipped with more power and information processing capabilities than a non-enhanced person; and what about someone equipped with a brain prosthesis? As an example, in the arena of sports there is already a raging debate as to whether we should allow people enhanced by steroids, drugs, or technology to compete against those lacking such enhancements. From a policy perspective, should people that are enhanced with technology be recognized by society as a separate class? And if so, would they be considered a "protected" class (which would mean in the U.S. that they would receive protection under the 14th Amendment); or in comparison, would nonenhanced people be considered the protected class? The constitutional law issues raised by technologically enhanced beings will result in fascinating cases heard by the Supreme Court and International tribunals.

Cyborg Disputes

Another issue to consider for cyborgs is what liabilities, if any, would be incurred by those who disrupt the functioning of their "computing prosthesis"? For example, would an individual be liable if they interfered with a signal sent to an individual's wearable computer, if that signal was used to assist the individual in seeing and perceiving the world? On just this point, former U.S. Vice President, Dick Cheney, equipped with a pacemaker had its wireless feature disabled in 2007.[54]

[54]Dick Cheney had the wireless function disabled on his pacemaker to avoid the risk of terrorist tampering, at: http://www.theverge.com/2013/10/21/4863872/dick- cheney- pacemaker-wireless-disabled-2007.

On the point of human interaction with cyborgs, there have already been two legal disputes involving the rights of Steve Mann, a Professor of Engineering at the University of Toronto. Steve has lived as a cyborg for decades, wearing computers and electronic sensors that are designed to augment his memory, enhance his vision and keep tabs on his vital signs.[55] In 2002, before boarding a Toronto-bound plane at St. John's International Airport in Newfoundland, due to his "cyborg appearance" Steve went through an ordeal in which he was searched and allegedly injured by security personnel.[56] During the incident, thousands of dollars of his body-worn equipment was reportedly lost or damaged, including the eyeglasses that serve as his display screen. Before traveling, Steve followed the routine he has used on previous flights. He told the airport security guards in Toronto that he had already notified the airline about his equipment, and he showed them documentation, some of it signed by his doctor, that described the wires and glasses, which he wears as part of his research on wearable computers. Without a fully functional system, Steve found it difficult to navigate normally; and reportedly fell at least twice in the airport. In fact, as the number of people with heart devices and artificial joints and bones grows, so will the number of airline passengers who receive lengthier security exams. There are no estimates on the number of people with implants and cybernetic enhancements passing through checkpoints, but the U.S. Transportation Security Administration (TSA) expects more as the huge baby boomer population ages. The orthopedic implant market, for instance, is already growing at twice the annual rate of 5 years ago. The TSA is trying to improve its screening of passengers with implants such as those with pacemakers and defibrillators—life-saving devices that regulate heartbeats—and orthopedic implants, such as hips and knees. Steve believes that based on his status as a cyborg he should receive the same treatment as any person needing special equipment such as wheelchairs; certainly this view should be the subject of a public policy debate and possibly legislative action. But why debate an issue that currently impacts only a few self-professed cyborgs—because more cyborgs are coming, and soon (and more than you think are already here!). For example, there are several million people equipped with arm or leg prosthesis, important progress is being made on improving brain-computer interfaces, and the military is spending millions on efforts to create cyborg warriors.

Restaurants have also entered into the debate about the direction of our cyborg future. Taking a strong stance against a type of wearable computing, Google Glass, a Seattle-based restaurant, *Lost Lake Cafe*, actually kicked out a patron for wearing Glass. The restaurant is standing by its no-glass policy, despite mixed responses from the local community. In another incident, a theatre owner in Columbus, Ohio, saw enough of a threat from Google Glass to call the Department of Homeland Security. The Homeland Security agents removed the programmer

[55]Steve Mann, Cyborg, 2007, at: http://blog.codinghorror.com/steve-mann-cyborg/.

[56]Airport Security vs. Steve Mann, 2002, at: http://it.slashdot.org/story/02/03/14/2051228/airport-security-vs-cyborg-steve-mann.

who was wearing Google Glass connected to his prescription lenses. Further, a San Francisco bar frequented by a high-tech crowd has banned patrons from wearing Google Glass while inside the establishment. In fact, San Francisco seems to be ground zero for cyborg disputes as a social media consultant who wore Glass inside a San Francisco bar claimed that she was attacked by other customers objecting to her wearing the device inside the bar. In addition, a reporter for *Business Insider*, Kyle Russell, said he had his Google Glass snatched off his face and smashed to the ground in San Francisco's Mission District.[57]

Ray Kurzweil, a well-known futurist, calls the attack on Steve (in Paris) the first recorded attack on a cyborg in history; we should also include attacks on people wearing Google Glass and equipped with prosthetic devices in the same category. Should the attacks be considered a precursor for a cyborg hate crime? From a legal analysis hate crimes comprise two elements: a *criminal offence* committed with a *bias motive*. At first glance, incidents involving Steve seems to satisfy both prongs. The first element of a hate crime is that an act is committed that constitutes an offence under ordinary criminal law. This criminal act is often referred to as the "base offence;" in Steve's case the base offense would likely be an assault and battery. Because there are small variations in legal provisions from country to country, there are some divergences in the kind of conduct that amounts to a crime; but in general, most countries criminalize the same type of violent acts. Hate crimes always require a base offence to have occurred. The second element of a hate crime is that the criminal act was committed with a particular motive, referred to as "bias". It is the element of "bias motive" that differentiates hate crimes from ordinary crimes. This means that the perpetrator intentionally chose the *target* of the crime because of some *protected characteristic* (typical of a protected class). This is where Steve would have difficulty proving a hate crime—cyborgs are not considered a protected class.

What does constitute a protected class, that is, a group that cannot specifically be targeted for discrimination? A protected class normally consists of individuals with characteristics that are commonly shared by the group, such as "race", language, religion, ethnicity, nationality, or any other similar common factor. Interestingly, artificially intelligent machines speak a particular binary language and often have common physical characteristics; at first glance, they would seem to have some of the characteristic of a "class," but would they deserve special protection? That is a question for public policy and legislation. But indirectly, in a Supreme Court case, a justice may have given us a peek into the future. Justice Ginsburg focusing on the legislative findings of the American with Disability Act (ADA), commented that "individuals with disabilities are a discrete and insular minority," and "subjected to a history of purposeful unequal treatment, and relegated to a position of political powerlessness in our society."[58] Given that people

[57]Kyle Russell, 2014, I Was Assaulted For Wearing Google Glass In The Wrong Part Of San Francisco, Business Insider, at: http://www.businessinsider.com/i-was-assaulted-for-wearing-google-glass-2014-4.

[58]*Olmstead v. L.C.*, 527 U.S. 581, 587 (1999).

with disabilities are often equipped with prosthesis and other "cyborg technology," can we consider emerging cyborgs to be of a member of a "discrete and insular minority"? Clearly, whether or not cyborgs such as Professor Mann should be considered to be a member of a class deserving special protection under the law is a complex issue and one for the public and legislators to debate.

In addition to FDA regulations on wearable technology in the form of medical devices monitoring health, some jurisdictions are just beginning to regulate cyborg technology. For example, sparsely populated Wyoming is among a small number of U.S. states eyeing a ban on the use of wearable computers while driving, over concerns that drivers wearing Google Glass may pay more attention to their email or other online content than the road.[59] And in a high-profile California case that raised new questions about distracted driving, a driver wearing Google Glass was ticketed for wearing the display while driving after being stopped for speeding. The ticket was for violating a California statute which prohibited a "visual" monitor in her car while driving. Later, the ticket was dismissed due to lack of proof the device was actually operating while she was driving. Further, to show the power and influence of corporations in the debate about our cyborg future, Davin Levine comments that Google has lobbied officials in at least three U.S. states to stop proposed restrictions on driving with headsets such as Google Glass, marking some of the first clashes over the nascent wearable technology.[60]

Two Technologically Driven Revolutions

In discussing what might be in the twenty-first century, Rodney Brooks, former Director of the Computer Science and Artificial Intelligence Laboratory at MIT and now chairman of *Rethink Robotics*, postulated that two technology-driven revolutions would occur.[61] He termed the first, the "robotics revolution," and the second, the "biotechnology revolution."[62] Interestingly, Brooks, when discussing his artificially intelligent robots, sometimes uses the phrase "artificial creatures" to describe them. Normally when one uses the term "creature," they mean to refer to a living entity; but Brook's robots are designed using software, sensors, and mechanical parts such as effectors, actuators, and servomotors—no one would seriously claim that they are alive in any sense that humans or other living creatures are alive. But what if robots continue to gain in intelligence and one day claim to be conscious and alive? How would society and the legal system view this

[59]Laura Zuckerman, 2014, Wyoming among states eyeing laws to ban Google Glass while driving, at: http://www. reuters.com/article/2014/01/29/us-usa-wyoming-google- idUSBREA0S25A20140129.

[60]Dan Levine, 2014, Exclusive: Google sets roadblocks to stop distracted driver legislation, at: http://www.reuters.com/article/2014/02/25/us-google-glass- lobbying-idUSBREA1O0P920140225.

[61]Rodney Brooks, 2003, Flesh and Machines: How Robots will Change Us, Vintage Publisher.

[62]*Id.*

development? Would such "creatures" be granted rights independent from their creator? Could they be citizens, vote, or own property? Could they be liable in tort in a civil action or guilty under criminal law for any harm that resulted from their actions? Brooks thinking on these questions is presented in more detail in Chap. 8, which summarizes the law of cyborgs and the emergence of artificial intelligence in the twenty-first century.

It is likely that humanity will be required to face these very questions this century as advances in technology are quickly leading to more intelligent machines that act independently from human programmers, that is, are autonomous, and that more-and-more resemble humans in form and behavior. If artificially intelligent machines are aware of their actions, and if they can think and plan-out their conduct, would they be liable for harms resulting from their conduct? Brooks made some interesting observations of relevance for law and policy when he postulated that humans would relate to intelligent robots in ways different from previous machines, and that the upcoming robotic revolution would change the fundamental nature of society itself.[63] Just how might humans relate to an intelligent robot? Would they be our equal under the law, our property, indentured servants, or some other yet to be defined relationship? And would they be considered a legal person under the law and receive the rights that citizens receive?

At this point, some distinctions are in order. In jurisprudence, a natural person is a real human being, as opposed to a legal person, which may be a private (i.e., business entity) or public (i.e., government) organization. In fact, in the U.S. the law does grant personhood status to nonliving entities. Corporate personhood is the legal concept that a corporation may be recognized as an individual in the eyes of the law. For example, corporations may contract with other parties and sue or be sued in court in the same way as natural persons or unincorporated associations of persons. The corporate personhood doctrine does not hold that corporations are flesh and blood "people" apart from their shareholders, officers, and directors, nor does it grant to corporations all of the rights of natural citizens. In many cases, fundamental human rights are implicitly granted only to natural persons. For example, the Nineteenth Amendment to the United States Constitution, which states a person cannot be denied the right to vote based on gender, or Section Fifteen of the Canadian Charter of Rights and Freedoms, which guarantees equality rights, apply to natural persons only. Another example of the distinction between natural and legal persons is that a natural person can hold public office, but a corporation cannot. Of course artificially intelligent machines are not considered to be a legal person (bionically equipped people and current versions of cyborgs are); but surely the corporate personhood doctrine provides precedence that a non-human entity can be recognized as a person under the law.

In terms of laws that may relate to artificially intelligent robots, most people are familiar with Isaac Asimov's three laws of robotics. The first says that a robot may not injure a human being, or allow a human being to come to harm. The second

[63] *Id.*

law is that a robot must obey the orders given to it by human beings, except where such orders would conflict with the first law. And the third law states that the robot must protect its own existence, as long as it doesn't conflict with the first or second laws. While these laws have resulted in much discussion since they were first written in the short story "*Runaround*" published in 1942,[64] they say nothing about many areas of law that would have to be considered should robots gain in intelligence. For example, how much responsibility should artificially intelligent robots have for making enforceable contracts? Could they serve as agents for humans, or could humans serve as agents for artificially intelligent robots? Could artificially intelligent robots own real property or receive rights for their intellectual property? And could artificially intelligent robots bequeath property (in the form of software?) to future generations of intelligent machines? These are just a few of the legal and policy questions humanity may have to consider this century.

The notion of personhood has expanded significantly, albeit slowly, over the course of history. Throughout history, women, children and slaves have at times been considered property rather than persons. The category of persons recognized in the courts has expanded to include entities such as women, slaves, human aliens, illegitimate children and minors as well as unnatural or juridical persons, such as corporations, labor unions, nursing homes, municipalities and government units.[65] Clearly legal personhood makes no claim about morality, sentience or vitality. But to be a legal person is to have the capability of possessing legal rights and duties within a certain legal system, such as the right to enter into contracts, own property, sue and be sued. Not all legal persons have the same rights and obligations, and some entities are only considered "persons'" for some matters and not others. New categories of personhood are matters of decision, not discovery. The establishment of personhood is an assessment made to grant an entity rights and obligations, regardless of how it looks and whether it could pass for human. As stated by Mark Goldfelder: to make the case for granting personhood to artificially intelligent robots, it's not necessary to show that they can function as persons in all the ways that a "person" may, it's enough to show that they may be considered persons for a particular set of actions in a way that makes the most sense legally and logically.[66]

A question at the heart of the issue of personhood for artificially intelligent machines is at what point will such an entity move from the status of property to personhood (this likely will not be a step function)? To some, legal personhood for artificially intelligent robots in the near future makes sense. They argue that artificial intelligence is already part of our daily lives. For example, bots are selling

[64]Isaac Asimov, Runaround, written in October 1941 and first published in the March 1942 issue of Astounding Science Fiction. *Runaround* is notable for featuring the first explicit appearance of the Three Laws of Robotics, which had previously only been implied in Asimov's robot stories.

[65]Mark Goldfeder, 2014, The Age of Robots is Here, http://www.cnn.com/2014/06/10/opinion/goldfeder-age-of-robots-turing-test/.

[66]*Id*.

merchandise on eBay and Amazon, and semiautonomous agents are determining our eligibility for Medicare and other government programs. Predator drones require less and less supervision, and robotic workers in factories have become more commonplace. Google is testing self-driving cars, and General Motors has announced that it expects semiautonomous vehicles to be on the road in a few years. But when the robot acting autonomously makes a mistake, as it inevitably will, who exactly is to blame? The retailor who sold the machine? The current owner who had nothing to do with the mechanical failure? Or the party who assumed the risk of interacting with the robot? What happens when a robotic car slams into another vehicle, or even just runs a red light? To be able to assign liability is why some legal commentators argue that robots should be granted legal personhood. As a legal person, the robot could carry insurance purchased by its employer. As an autonomous actor, it could indemnify others from paying for its mistakes giving the system a sense of fairness and ensuring commerce could proceed unchecked by the twin fears of financial ruin and of not being able to collect.[67]

As to the second upcoming revolution, Brooks spoke about biotechnology, discussing how it would transform the technology of our bodies and also that of our machines.[68] On this point, Brooks envisioned a future in which machines would become more like humans and humans would become more like machines. Along these lines, one of Brook's students, and now a Professor of Media Arts and Science at MIT, Cynthia Breazeal, has created a particularly interesting robot "Leonardo" as well as a host of other personal robots.[69] Leonardo has the capability to react to people by changing its facial expressions and by moving its head towards people when they speak. Interestingly, people who have interacted with Leonardo seem to get the feeling that Leonardo is conscious at some level. Even though Leonardo is clearly not aware of its own existence, by reacting to people in a more human-like and social manner, people come to think of the robot as if it were a person. If such a reaction occurs to robots with such a rudimentary level of intelligence and social skills such as Leonardo, imagine what will be the reaction of people just 10–20 years from now when robots are far more intelligent, and more closely resemble humans in form and behavior? A later chapter discusses some interesting ideas about how humans emotionally react to artificially intelligent machines approaching human likeness.

Merging with Machines

Another leading scientist in the design of artificially intelligent robots is Hans Moravec, formerly head of the Robotics Institute at Carnegie Mellon University. Moravec, who studied robotics at Stanford University, takes a much stronger

[67] *Id.*

[68] Rodney Brooks, *id.,* note 61.

[69] Cynthia Braezeal, 2004, Designing Sociable Robots, A Bradford Book.

position than Brooks when discussing the future of humans and artificially intelligent machines in that he proposes that the future destiny of humans is to actually merge with machines. As expressed by Moravec in his 1998 book, *Robot: Mere Machine to Transcendent Mind,* the robots of the 1980s and 1990s could think only at an insect level, essentially equipped with the sensory and motor capabilities to crudely navigate environments.[70] But due to the exponential growth in computing power that has occurred in the last 25 years, and based on advances in algorithms he predicts that by midcentury robots will become as smart as humans and will eventually begin their own process of evolution which, according to Moravec, will render humans extinct in our present form. Yet Moravec claims that this is not something humanity should fear as he concludes that merging with intelligent machines is the best future humans could hope for, as he puts it- the ultimate form of human transcendence.[71]

Moravec is not the only prominent scientist to predict that humans may someday merge with machines. Google's Ray Kurzweil, an inventor, futurist, and author of several books on artificial intelligence and human destiny has made the same argument. Interestingly, Kurzweil views technological advances, especially in computing power, as a continuation of the process of evolution. According to Kurzweil, far from being some distant science-fiction dream, human-machine combinations will evolve sooner rather than later. This prediction is based on one of Kurzweil's key ideas, the law of accelerating returns, which was presented in his seminal book, *The Singularity Is Near: When Humans Transcend Biology*. In essence, Kurzweil says progress occurs at an exponential rate- at the low end of the exponential curve, progress is extremely slow; for example, eons elapsed between the emergence of one-celled microorganisms and the arrival of Homo sapiens. But once Homo sapiens started to develop technology, it took only about ten to twelve thousand more years for hunter-gatherers to develop a technology that eventually lead to computers. And once computers were invented, Moore's Law, which says microprocessor power doubles every 18 months or so became a factor in the evolution of computing technology. Kurzweil's law of accelerating returns posits that this same exponential pace governs efforts to splice DNA, unravel genomes, reverse-engineer the brain and develop nanotech machines.[72] Given all these developments, expanding at exponential rates, Kurzweil considers it inevitable that our own technological creations will infuse new capabilities into human biological systems. Kurzweil, well-known for his predictions about human and machine evolution, for example, that humans may merge with machines, has also written that someday software-based humans will inhabit the Web, projecting

[70]Hans Moravec, 2000, Robot: Mere Machine to Transcendent Mind, Oxford University Press.

[71]*Id.*

[72]Tom Abate, 2005, 2 Way-out views of technology's role in shaping the future / Inventor predicts the fusion of human and machines; author says let go of technological fixes for humans' sake, at: http://www.sfgate.com/business/article/2-way-out-views-of-technology-s-role-in-shaping-2604873.php.

bodies whenever they need or want them, including virtual bodies in diverse realms of virtual reality.[73]

Considering the above prediction for the future of humanity, specifically, the continuing evolution of intelligent machines such that they eventually gain human-like or beyond intelligence, that humans may merge with our intelligent machine inventions, and that software versions of humans could inhabit the internet, should these predictions come true, they will surely raise the most significant philosophical, legal and policy issues that humanity has ever confronted, and would shake the very foundation of what it means to be human. Since the predictions made by Kurzweil, Moravec, and Brooks, could profoundly transform humanity, humanity would be prudent to have a comprehensive debate about the desirability of these potential outcomes.

But before discussing in greater detail the legal, policy, and technical issues that may occur should the above predictions come true, let us consider for a moment that the predictions are inaccurate, that human destiny is not to merge with machines or that robots will not eventually develop consciousness and human-like, or beyond, intelligence. Even so, due to efforts to fight disease, repair diseased systems, and fix damaged anatomy, future humans will be equipped with more-and-more non-biological components—whether to control diabetes or the functioning of the kidneys; or to equip the human with better cochlear, retinal, or body limb prosthesis. And the more biological parts which are replaced by mechanical parts, the more the question will be raised by policy makers and the public as to whether the resulting human-machine combination is in fact human. Furthermore, with regard to artificially intelligent machines, even if machines never gain consciousness and human levels of intelligence as some have predicted will happen this century, advances in artificial intelligence will still continue to be made that will result in machines that by any measure of intelligence, will be considered "smart" even if only in a limited domain. These developments alone will raise significant legal issues in many areas of law just as they already have in the field of electronic commerce where intelligent software agents form contracts under the direction of their human principals.

That we may merge with machines is of course a very controversial prediction, but one point is clear, many humans from medical necessity alone are in fact becoming more cyborg-like given the integration of technology within their body to replace or enhance failed biological systems or repair anatomical structures. On this point, according to physicist Sidney Perkowitz of Emory University, in the U.S. alone, eight to ten percent of the population, that is, around 25 million people are already artificially enhanced, or bionic.[74] A case on point is the work of Dr. Ross Davis and his team at the Neural Engineering Clinic in Maine. This group has been using the technology of implanting chips in the brain to treat patients whose central nervous systems have been damaged or affected by diseases such as

[73]See also, Martine, Rothblatt, 2014, Virtually Human: The Promise—and the Peril—of Digital Immortality, St. Martin's Press.

[74]Perkowitz, *id*., note 6.

multiple sclerosis. Further, a team at Emory University in Atlanta has implanted a transmitting device into the brain of a stroke patient. After linking the motor neurons to silicon, a test patient was able to move a cursor on a computer monitor using thought alone. This finding means that a human was able to transmit thought signals directly to a computer in order to operate it, albeit in a rudimentary way. The Emory team is looking to gradually extend the range of controls carried out by the patient. Some scientists argue that thought-to-thought communication is just one feature of cybernetics that will become vitally important to humanity should we face the possibility of being superseded by highly intelligent machines. A later chapter summarizes recent developments in the use of thought for telepathic communication and to control machines. However, before such events happen at all, humanity should engage in a debate focusing on three vital questions: (1) whether there should be a limit placed on enhancing, augmenting, or replacing human biological parts? (2) whether or not we should create machines that are superior in intelligence to unenhanced people? and (3) whether or not we should continue to evolve on a separate path from artificially intelligent machines?

Questions for Our Cyborg Future

The first critically important question for humanity to consider in the face of rapid technological advances in the ability to enhance the human body and brain is whether there should be a limit placed on enhancing, augmenting, or replacing human biological parts? Referring to human enhancements, this question raises a number of important issues under ethics, law, and public policy. For example, would only the wealthy be able to afford enhancements, and if so, would we be creating a society of superior cyborg-enhanced individuals, and a group of individuals that were too poor to afford enhancements? If cyborgs are equipped with cognitive, auditory, visual, or motor prosthesis that "separate" them from non-enhanced people, would they be afforded special protection under the law (recall Steve Mann's altercations presented above)? The law of body modifications and body hacking is the topic of a chapter in this book, but it is worth briefly noting here: part of the answer would depend on whether the human was enhanced out of medical necessity or not.

If the human was enhanced due to a disability, many jurisdictions around the world afford protection for such people in the workplace. For example, in the U.S., the Americans with Disabilities Act (ADA), provides protection for employees with certain disabilities and requires employers to accommodate the disabilities, when possible. Currently though, to be covered under the ADA, an individual must be a qualified worker and must have a legally recognized disability to be protected. An example of the types of disabilities covered include a physical or mental impairment that substantially limits a major life activity (such as the ability to walk, talk, see, hear, breathe, reason, work, or take care of oneself). Since bionic humans are enhanced to repair or replace human anatomy or physiology,

their disabilities would likely be covered by the ADA, but cyborgs may not receive protection under the ADA if their enhancements are done for reasons other than medical necessity such as to increase a human ability beyond normal.

The second vital issue for humanity to consider with regard to artificially intelligent machines is whether or not we should create machines that are superior in intelligence to unenhanced people? Of course computers are already "smarter" than people in many domains, but by this question I refer to computers with "strong artificial intelligence," that is, consciousness, sentience, and the ability to successfully perform any intellectual task a human can. On this note, Professor Stephen Hawking, former Lucasian Professor of Mathematics at Cambridge University expressed grave concern that a future danger to humanity was the possibility that intelligent machines would someday "take over the world."[75] Hawking commented that computers were evolving so rapidly that they would eventually outstrip the intelligence of humans and that computers with artificial intelligence could therefore come to dominate the world. Hawking argued in favor of changes in human DNA through genetic modification to keep ahead of advances in computer technology. He also advocated direct links between brains and computers stating that we must develop as quickly as possible technologies that make possible a direct connection between computers, so that artificial brains contribute to human intelligence rather than opposing it.[76] Research that provides support for the proposition that it is possible for a human mind to directly communicate with a computer and other networked minds is beginning to emerge (note that this is a different issue than downloading data from a computer to a mind).

With regard to Hawking's recommendation to genetically engineer humans in order to keep pace with artificial intelligence, Ray Kurzweil has pointed out that genetic engineering through the birth cycle would be extremely slow in comparison to the exponential rate at which computers are gaining in intelligence. According to Kurzweil, by the time the first genetically engineered generation grew up, the era of beyond-human-level machines would already be upon us. For example, even though we are years away from genetically engineering a human, if we start the clock at 2014, recalling Moore's law, computer power doubles about every 18 months, if humans become legally recognized adults at eighteen, by 2032, there would be several doublings of computer power. This would indeed result in a machine with tremendous computational power to view, understand, and think about the world, especially if we consider that the fastest supercomputer available now operates at several petaflops[77] (a petaflop is one thousand million floating point operations per second).

On the issue of genetic modifications, Kurzweil further argues that even if we were to apply genetic alterations to adult humans by introducing new genetic

[75]Rory Cellan, Stephen Hawking Warns Artificial Intelligence Could End Mankind, *id*., note 9.

[76]*Id.*

[77]China surpassing U.S. with 54.9 petaflop supercomputer, at: http://www.computerworld.com/s/article/9239710/China_surpassing_U.S._with_54.9_petaflop_supercomputer.

information via gene therapy techniques, it still wouldn't keep biological intelligence in the lead. Genetic engineering (through either birth or adult gene therapy) is inherently DNA-based and a DNA-based brain is always going to be extremely slow in terms of the speed in which a signal is propagated down an axon and limited in capacity compared to the potential of an artificially intelligent machine. For example, the speed of electronics is already 100 million times faster than our electrochemical circuits (i.e., neuronal); and we have no quick downloading ports on our biological neurotransmitter levels, to move large amounts of data quickly between the human mind and a computer.[78] We could bioengineer smarter humans, but this approach will not begin to keep pace with the exponential pace of artificially intelligent machines.

The third vital question for humanity to consider concerning our technological future is whether or not we should continue to evolve on a separate path from artificially intelligent machines? The issue seems to be whether humanity should continue to evolve under the slow process of biological evolution (the current case), evolve under the relatively faster process of DNA modifications, or consider merging with artificially intelligent machines and evolve at the speed of technology. Evolution does not work quickly. It takes many generations for our genetic code to adapt to changing environments and circumstances. Ted Driscoll of Clarement Creek Ventures comments that what this means is that our twenty-first century human genome is still basically the genome of a caveman.[79] Our genome was well-adapted to the environment of our hunter-gatherer ancestors, because that environment lasted for hundreds of thousands of years. Unfortunately, the twenty-first century world we live in bears little resemblance to the prehistoric world. In contrast, most of the change in technology has occurred in the past few centuries, and ongoing change is only accelerating.

The Reemergence of Luddites

Some people have asked whether humans will embrace changes to their basic being and physical structure, or will they seek to remain the same (that is, technologically unenhanced)? For reasons discussed throughout this book, a strong argument can be made that people *will* embrace technological and biological enhancements to their body and even to their brain. But from a historical perspective, those that resist technology have come to be been termed "Luddites."[80] Where does this term come from? From legend comes the story of a

[78]Ray Kurzweil, 2003, The Human Machine Merger: Are we Headed for the Matrix? at: http://www.kurzweilai.net/the-human-machine-merger-are-we-headed-for-the-matrix.

[79]Ted Driscoll, 2014, Are Humans Equipped for a Big Data World? at: http://recode.net/2014/01/31/are-humans-equipped-for-a-big-data-world/.

[80]Steven Jones, Against Technology: From the Luddites to Neo-Luddism, Routledge Press.

"feebleminded lad" by the name of Ned Ludd who broke two stocking frames at a factory in Nottingham. Henceforth, when an offending factory owner found one of his expensive pieces of machinery mysteriously broken, the damage was conveniently attributed to Ned Ludd.[81] However, the term also has a firm footing in history as well. In the early days of the industrial revolution, workers (or Luddites), upset by wage reductions and the use of unapprenticed workmen, began to break into factories at night to destroy the new machines that the employers were using. In response to the Luddite movement, the British Parliament passed the *Frame Breaking Act* in 1812 that led to people convicted of machine-breaking to be sentenced to death. As a further precaution, the British government ordered 12,000 troops into the areas where the Luddites were active.

Viewing the acts of the Luddites in the early 1800's through the eyes of history, they have come to be viewed as counter-revolutionaries of the "Industrial Revolution."[82] If we consider that in 1890 ninety percent of Americans worked in agriculture, but by 1900 the figure was only 41 %, and by 2000, it was just two percent; and if we consider advances in artificial intelligence, we need to wonder if the same trend of job displacement will occur for professions requiring complex cognitive skills. As a case in point, IBM's supercomputer Watson, the language-fluent computer, recently beat the best human champions at the TV game show of *Jeopardy*. After matching wits with human game show whizzes, Watson has now moved on to becoming an expert diagnostician. Watson's ability to absorb and analyze vast quantities of data is, IBM claims, better than that of many human doctors. After mastering the same amount of knowledge as the average second-year medical student, Watson was tasked to "read" peer-reviewed medical journals relating to oncology; focusing on lung, prostate and breast cancers. According to Ian Stedman, "Watson's ingestion of more than 600,000 pieces of medical evidence, more than two million pages from medical journals and the further ability to search through up to 1.5 million patient records for further information gives it a breadth of knowledge no human doctor can match."[83] If industrial machines perform many of the manual labor tasks that were once done by expert humans, and if artificially intelligent machines perform cognitive tasks once performed by humans, it is no wonder that people like Ray Kurzweil and Hans Moravec argue for a merger of human with artificially intelligent machines; seemingly embracing the idea, "If you can't beat them, join them" (or merge with them!).

Currently, artificial intelligence and robotics are beginning to impact both blue- and white-collar workers, with experts predicting that robots will displace more human jobs than they create by 2025.[84] By 2025, if robots and artificial intelli-

[81] See generally, Luddites, at: http://www.ascrs.org/sites/default/files/resources/Global%20view%20of% 20EMRs.pdf.

[82] *Id*.

[83] Ian Steadman, IBM's Watson is better at diagnosing cancer than human doctors, at: http://www.wired.co.uk/news/archive/2013-02/11/ibm-watson-medical-doctor.

[84] Aaron Smith and Janna Anderson, 2014, AI, Robotics, and the Future of Jobs, at http://www.pewinternet.org/2014/08/06/future-of-jobs/.

gence continue to advance at the same pace of the last few years, robots and artificial intelligence will no longer be constrained to repetitive tasks on a production line. Will advanced artificial intelligence and robots make the world a better place or not? Basically everyone agrees that robotics and artificial intelligence are going to displace a lot of jobs over the next few years as the general-purpose robot comes of age.[85] Even though these early general-purpose bots won't initially be as fast or flexible as humans, they will be flexible enough that they can perform various menial tasks 24/7—and cost just a few cents of electricity, rather than minimum wage. On the other hand, robots may dominate the workplace so quickly that our economic, education, and political systems may struggle to keep up. Previously robots mostly replaced blue-collar workers, but this next wave will increasingly replace skilled/professional white-collar workers.[86] A lot of these specialized workers may find themselves without a job, and without the means to find a new one.

Returning to the Luddites, as artificially intelligent machines become more proficient at cognitive tasks, will the predicted loss of jobs in many service sectors lead to a new generation of humans expressing hostility toward smart machines? In fact, a neo-Luddite movement has sprung up. The most extreme expression of this philosophy was the bombing campaign of Ted Kaczynski, also known as the Unabomber, who was sentenced to life imprisonment. His manifesto, which was eventually published by the New York Times, said that the "Industrial Revolution and its consequences have been a disaster for the human race". One of the leading developers of cyborg technology, Steve Mann is also tentative in his support of the cyborg movement, expressing the view in *Singularity 1 on 1* that "I am not saying more or less technology—I am saying appropriate technology. Instead of technological excess—we should have technology that is balanced with nature. Instead of replacing nature with technology—we should balance it. Instead of replacing intelligence with artificial intelligence—we should use humanistic intelligence…".[87]

The Luddites of the 1800s were opposed to new technology based primarily on economic grounds—the technology was seen as being able to replace human skills in the textile industry, skills that were necessary for people to secure a living and support their families.[88] In current times, people may be opposed to technology for reasons other than basic economics; for example, they argue that to remain human we must oppose the merging of humans with machines. But, proponents of enhancement technology counter that there are many reasons why it may be desirable to augment or enhance humans—for example, they note that one out of every

[85]Martin Ford, 2015, Rise of the Robots: Technology and the Threat of a Jobless Future, Basic Books.

[86]*Id*.

[87]Cyborg Luddite Steve Mann on Singularity 1 on 1: Technology That Masters Nature is Not Sustainable, interviewed by "Socrates," at: https://www.singularityweblog.com/cyborg-steve-mann/.

[88]The Industrial Revolution, at: http://www.historydoctor.net/Advanced%20Placement%20World%20History/40.%20The_Industrial_revolution.htm.

person sixty-five or older has Alzheimer's disease, as do half of those over eighty-five. In the U.S. alone, consumers and insurance companies spend over one hundred billion dollars on the disease each year. How would human enhancement technology help those with Alzheimer's? For the millions of families with relatives living with Alzheimer's, keeping them safe is a major concern. In response to such concerns, doctors can implant an FDA-approved microchip in an Alzheimer's patient's arm, allowing critical medical details to be accessed instantly. The chip, which is about the size of a grain of rice, contains a 16-digit identification number which is scanned at a hospital. Once the number is placed in a database, it can provide crucial medical information. Another form of enhancement that may assist those with Alzheimer's comes in the form of a brain-computer interface. Brain-computer interfaces (BCIs) provide alternative methods for communicating and acting on the world, since messages or commands are conveyed from the brain to an external device without using the normal output pathways of peripheral nerves and muscles.[89] Alzheimer's disease patients in the most advanced stages, who have lost the ability to communicate verbally, could benefit from a BCI that may allow them to convey basic thoughts (e.g., "yes" and "no") and emotions.

According to Ramez Naam, in *More than Human: Embracing the Promise of Biological Enhancement,* in the U.S. more than eight million people had some sort of cosmetic surgery in 2001; and in the U.S. alone there are 20,000 plastic surgeons working to change the shape and appearance of a person's body.[90] The Olympics and other sporting events is replete with stories of doping, where athletes take performance enhancing drugs to compete and there are at least a quarter million quadriplegics in the U.S. that could benefit from brain-computer interfaces. In the U.S. there are also more than 34 million deaf or hearing impaired people that could benefit from enhancements to their auditory system. On this point, more than seventy thousand people worldwide have entered the world of human enhancements with cochlear implants—a microphone with multiple electrodes that electrically stimulate the auditory nerve. So while some percentage of the population will always be opposed to new technology just as the Luddites were in the 1800s, in the twenty-first century many people have already enthusiastically embraced the need for human enhancements and artificially intelligent machines.

[89]Liberati G, Dalboni da Rocha JL, van der Heiden L, Raffone A, Birbaumer N, Olivetti Belardinelli M, and Sitaram R. Toward a brain-computer interface for Alzheimer's disease patients by combining classical conditioning and brain state classification, J. Alzheimers Dis. 2012;31 Suppl 3:S211–20.

[90]Ramez Naam, 2010, More than Human: Embracing the Promise of Biological Enhancement, http://Lulu.com.

Enter the Horse

When discussing the law as it applies to cyborgs, and artificially intelligent machines, there is a basic question to raise—are there any legal issues that are unique to technologically enhanced humans, cyborgs, and artificially intelligent machines? When talking about the law and cyberspace, Judge Easterbrook, of the U.S. Court of Appeals for the Seventh Circuit, claimed that there was no specific more a law of cyberspace than there was a law of the horse.[91] In making this statement, Judge Easterbrook recounted an anecdote involving a former Dean of the University of Chicago law school who had expressed pride in the fact that the University of Chicago did not offer a course in "The Law of the Horse"; while there were, of course cases dealing with topics such as the sale of horses (contract law) or with people kicked by horses (torts), there was no separate course on "The Law of the Horse."[92] According to Judge Easterbrook the best way to learn the law applicable to specialized endeavors, was to study general rules; only by putting the law of the horse in the context of broader rules about commercial endeavors could one really understand the law about horses.[93] His point, of course, was that the "law of cyberspace, cyborgs, and artificially intelligent machines," is much like the "law of the horse," a specialized endeavor best understood with reference to familiar general principles of contract, intellectual property, privacy, free speech and the like, but which does not need, and does not deserve, its own separate category.[94] In response to Judge Easterbrook's assertions, Larry Lessig, a Professor of Law at Harvard, contemplated what a law of cyberspace might actually look like and what lessons it might provide. The "Lessig view" was that cyberspace law might actually exist and say something important about time, place, and national boundaries affected by cyberspace transactions.[95] This book borrows from each approach-while the law of virtual reality, cyborgs, and artificially intelligent systems, will surely benefit from an analysis based on general established rules, each area will move beyond current law quickly, thus, new law and policy will be needed to account for the amazing future that awaits us; a future in which we merge with artificially intelligent machines.

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[91]Frank H. Easterbrook, 1996, Cyberspace and the Law of the Horse, *University of Chicago Legal Forum*, 207.

[92]David G. Post, 1998, Cyberspace and the Law of the (Electronic) Horse, or Has Cyberspace Law Come of Age? at: http://www.temple.edu/lawschool/dpost/horse.html.

[93]Frank H. Easterbrook, *id*., note 91.

[94]*Id*.

[95]Lawrence Lessig, 1999, The Law of the Horse What Cyberlaw Might Teach, 113 Harv. L. Rev. 501.

Concluding Thoughts

There is a strong possibility that advances in human enhancement technologies could offer humanity options that have been the subject of dreams for centuries. Potentially, humans could be modified to live longer and healthier, be smarter and stronger, and by some societal standard, more attractive. According to Jacob Heller and Christine Peterson: "Enhancements could come in the form of extreme intelligence and memory capacity, significantly heightened sense of awareness, and astonishing athletic capability."[96] However, experts have warned that while human enhancements could give rise to numerous benefits, these advances may come at a significant cost to humanity- not the least of which is that technical enhancements to humans could change the essence of what it means to be human. Perhaps humanity would be prudent to heed the warning of prominent computer scientist and cofounder of Sun Microsystems, Bill Joy, who in an essay written in 2000, "*Why the future doesn't need us*," argued that human beings would likely guarantee their own extinction by developing the technologies favored by advocates of enhancement technology.[97] This comment related to the use of nanotechnology to redesign the environment; but if there is the slightest chance that any enhancement technology could lead to such a bleak outcome, the public should demand strong safeguards, even a moratorium on the use of potentially dangerous enhancement technologies.

A point I want to emphasize is that one way or the other, more people in the future will be enhanced with technology, whether due to medical necessity or by choice. Already, biological and technical enhancements exist today in many forms such as steroids, Ritalin, Prozac, plastic surgery, mechanical replacements for body parts, not to mention the "game changing" ability to implant chips into the brain. While to date, the practice of human enhancement has focused mainly on restoration, it is not improbable that this technology will soon extend to the healthy individual. However, if only those who can afford it opt for human enhancement, the appalling inequalities in our society that exist today will become even greater and social mobility will decrease farther.[98] If the wealthy can increase their intelligence and become more physically able, they will likely increase their political and earning power; in this case, the rich will become richer and more powerful. In light of this possibility, should the government guarantee a baseline set of characteristics for all people?

Will legislators act before decisions by scientists and corporations have been made that will be difficult to roll back or that could have deleterious effects on

[96]Jacob Heller and Christine Peterson, Human Enhancement and Nanotechnology, Foresight Institute, at: https://www.foresight.org/policy/brief2.html.

[97]Bill Joy, 2000, Why the Future Doesn't Need Us, Wired Magazine, 8.04.

[98]Francis Fukuyama, *id*., note 29.

humanity? I can only offer a weak response, "possibly." But how should we approach the problem of safeguarding humanity, or at least making sure the future is one of our choosing? Enter the courts, the media, and the arena of public opinion. In a recent Supreme Court case, all nine justices agreed that placing a GPS tracking device on a car without a warrant was an unlawful search and seizure and violated the Fourth Amendment to the U.S. Constitution. Justice Alito observed that "in circumstances involving dramatic technological change, the best solution to privacy concerns may be legislative."[99] But since there was no specific GPS tracking device law for guidance (i.e., no Law of the Horse), Justice Alito and his colleagues looked to Fourth Amendment precedent to analyse warrantless use of GPS technology and to create a privacy solution.[100] Justice Alito is not alone in thinking that new legislation is needed to deal with rapid technological change. In the U.S. Congress, bills have been introduced to regulate online tracking, to create rules for the collection of geolocation data, to protect children's privacy and to regulate the collection and use of personal data generally. Further, in the U.S., some states have enacted statutes which regulate the degree to which people can be implanted with microchips. In my view, far-reaching legislation by mid-to-late century will be necessary to establish and protect the rights of human's vis-à-vis cyborgs and artificially intelligent machines. And to determining the right of cyborgs with beyond-human abilities, and finally to determine the rights of artificially intelligent machines, with respect to unenhanced humans and to each other.

As we progress into the twenty-first century, I believe that from a human rights perspective humanity will need to develop a *Robot and Cyborg Ethics Charter*; essentially a set of rules intended to govern the interaction between humans, cyborgs, and artificially intelligent machines. A working version of such a code for robotics is being developed by a group of robotics engineers in South Korea,[101] which I might add represents an expansion of Asimov's Three Laws of Robotics. The Korean charter recognizes that robots of the future may require legal protection from abusive humans, just as animals sometimes need legal protection from their owners. While some experts welcome the introduction of the *Robot Ethics Charter* and similar proposals, noting that wanton human abuse of intelligent machines could be cause for moral outrage we also need to be concerned that humans could be abused by our intelligent creations (and thus the Terminator movie series). This and other important issues of law, technology, and policy for the future of humans and our intelligent creations, is the subject of this book.

[99] *U.S. v. Jones*, 132 S.Ct 945, 565 U.S.__2012.

[100] *Id.*

[101] South Korean Robot Ethics Charter, at: https://akikok012um1.wordpress.com/south-korean-robot-ethics-charter-2012/.