

F.4. HUMAN AUGMENTATION AND RELATED TOPICS

This section is in preparation. Here are preliminary notes and an inventory.

F.4.a. OVERVIEW NOTES ON HUMAN AUGMENTATION

1. Human augmentation is the practice or condition of using technology to improve, extend or otherwise modify some aspect of human performance or appearance. This excludes modification for medical reasons, which is intended to ensure or restore normal health or well-being. Augmentation can be temporary, semi-permanent or permanent. Here we consider all human augmentation *other than* that involving genetic modification or artificial intelligence, which are treated in Attachments F.2 and F.3. In this section we also consider major technologies that may not be strictly human augmenting in themselves but are associated with augmentation strategies.

2. As just defined human augmentation could be taken to include *all* technology, and include e.g. hammers, jet aircraft and houses. For now we'll limit our discussion to augmentations that involve some deeper manipulation or modification of the physical human body itself. But the lines are not sharp and the ambiguity points to important questions about the meaning of technology and our understanding of what it means to be human. Example: the development of external [artificial wombs](#) capable of fully gestating an embryo/fetus to term could be considered a form of human augmentation and could have major social and cultural impact. Could a wealthy couple, or any couple, decide to conceive and bring to term 40 children of their own? Should they be permitted to do so?

3. Attachment F.4.b. shows a partial **inventory of types of human augmentation** currently in use, in development or under discussion, with selected examples. Human augmentations may be categorized by the nature of the technology itself (prostheses, ocular surgery) the nature of the final result (ability to run faster or see better), or the social sphere of salience (e.g. cosmetic, recreational, occupational, military). Many augmentations involve multiple technologies, final results and social salience, so taxonomies are fluid. The taxonomy used in Attachment F.4.b. is based loosely on topics of research and application that have generated sustained recent interest.

4. Non-genetic, non-AI human augmentation poses many of the same sorts of social, political, ethical, moral and other challenges as are presented by the other technologies we've reviewed, but nuanced differences pose special challenges. Most human augmentations work on a single individual at a time and are not passed on to offspring. Most don't have the global reach and potential for near instantaneous dramatic impact that AI does. These augmentations thus seem more easily kept under control by the user and by society than do, say, genetic modifications that are passed on to offspring or AI technologies that could disrupt global cyberspace in a nanosecond. The great majority of proposed augmentations are developed for what their developers believe, and believe most people would believe, are benign and beneficial reasons. Further, whereas both HNGM and AI modifications are defined by their particular technologies, human augmentation draws from every and all technologies. For these and related reasons it's difficult to formulate simple arguments against human augmentation as a category of technological application. Further, many appear to fall along a continuum with technologies already well-accepted, such as eyeglasses, hearing aids and medical prostheses. Thus the question of whether human augmentation should be regulated or prohibited (other than for the routine safety and efficacy reasons that apply generally) must necessarily be taken case-by-case. This in turn means that many, perhaps very many, human augmentations are likely to be adopted and perforce normalized. And this, once more in turn, could encourage greater acceptance of more extreme forms of human augmentation, including currently unacceptable applications of HNGM and AI.

5. Some scientists propose that we refrain from augmenting human beings in ways that require permanent or even most short-term physical or physiological alternations and keep humans as we are, and focus instead on developing powerful technologies with which we *collaborate*, e.g., as we do with computers and much other technology today. They note that in chess tournaments such human/computer collaboration has been able to beat *both* the best humans *and* the best computer programs. They note too that such collaborative functionality avoids most of the ethical or "yuck factor" considerations that direct bodily modification generates.

6. These dynamics highlight the important need to develop a deeper understanding of why human augmentation should be limited to certain sorts while other sorts are prohibited, and the need to ground such an understanding in strongly shared social, philosophical and/or religious values. More on this in the final working paper.

7. An example of the mentality of many human augmentation proponents is this quote from Will Rosellini, Chairman and CEO of the neurotech firm Nexxon MedSystems. He predicts that in the future "our bodies are going to look more like cars... where we are making parts that will fit into anybody's system, where we are upgrading parts the way we upgrade a cell phone." See Tracinski (2017).

8. In response, Bess (2017) captures why it is that the prospect of such augmentation is importantly disquieting:

“One of the more insidious effects of such self-editing is that it will blur the boundary between persons and things. The reason is simple: bio-enhancements are products. They require machines, chemicals, tools and techniques that develop over time. They become obsolete after a number of years. They are likely to be available for purchase on the open market. Some will be better than others, and more expensive than others. Some – like cars or jewelry or your house – will confer a greater or lesser degree of prestige.”

9. The technologies of neuro-augmentation and in particular the practicability of brain-computer interfaces (BCI) play a key role in the wider debate over AI. Musk, Bostrom, Hawking and others argue that the development and application of human genetic neuro-enhancement will be *too slow* to enable humans to keep up with the self-reinforcing explosion of computer AI and Superintelligence, leaving us vulnerable to extinction or enslavement. Our only practical hope, they say, is to develop **Brain-Computer Interfaces** that allow humans to directly access and collaborate with “friendly” Superintelligent AIs. Such HI+AI systems, they say, will be far superior to either HI or AI alone. Kernal CEO Bryan Johnson goes further and says that HI+AI will *be* the AI of the future and, by implication, the HI of the future as well. See Stall (2017). See also note 14 below.

10. Much of this particular narrative of Superintelligence, friendly and hostile AI, etc. is transparently self-serving poppycock, largely intended to generate paid jobs for the many otherwise unemployable Transhumanist PhD philosophers being produced at Oxford, Cambridge and MIT. But the serious narrative needs to be taken seriously. Neuro-augmentation technologies, for example, do in fact pose hugely consequential societal challenges. An instance: if BCI becomes feasible and is adopted, it immediately faces the risk of third party hacking. See e.g. Glannon (2014).

11. Over the past decade an active cyborg subculture and community has developed, comprised of people who have augmented or otherwise modified their bodies, or desire to, and who identify as cyborgs. The [Cyborg Foundation](#) was established in 2010 to support, promote and work to establish the rights of cyborgs. The initiating leadership of the Foundation were artists who identified as cyborgs and used the flamboyance of body modification as a strategy for gaining attention and promoting their cause. In 2016 the [Cyborg Bill of Rights](#) was presented at South by Southwest [See Attachment F.6.b.]. The [Cybathlon](#) is an international competition “for disabled competitors allowed to use bionic assistive technology, such as robotic prostheses, brain-computer interfaces and powered exoskeletons.” The first Cybathlon was held in 2016 in Zurich; the second is planned for 2020, also in Zurich. The Cybathlon differs from the better-known Paralympics, which prohibits the use of powered performance-enhancing technology. The Cybathlon is sponsored by ETH Zurich, a major Swiss science, technical, engineering and math university.

12. While most **religious traditions** have a large body of teachings concerning human genetic and reproductive technologies they, like most of civil society, have been slow to address the challenges raised by human modification or augmentation by other means. One of the few religious documents addressing these topics is the Vatican’s 2004 International Theological Commission report, [Human Persons created in the Image of God](#). It’s an example of the kind of reasoning that is possible given a religious context but much less so in a secular context. The document says, “Given that man was also created in God’s image in his bodiliness, he has no right of full disposal of his own biological nature. God himself and the being created in his image cannot be the object of arbitrary human

action.” The report goes on to say that bodily intervention that seriously modifies the functioning of the human body should be done in life threatening situations only, and lists further conditions that must be met for any bodily intervention, including a) there can be no other alternatives for preserving life; b) there is a proportionate chance of success in comparison with drawbacks; and c) the patient must give assent to the intervention. See also [Collins \(2017\)](#).

Additional background on particular categories of human augmentation

13. PROSTHESES. Protheses are mechanical systems that function like parts of living organisms. Throughout history replacements for noses, arms and legs have been made out of bone, wood and metal. Recent years have seen new technologies applied to the design and manufacture of prostheses. These include advances in materials technology, electronics, control technology, information technology and AI that not only enable prostheses to more closely carry out all the functions that the natural organ did, but can perform these functions with greater speed, strength, versatility and the like than the natural limb or other organ ever could. Two major questions raised by advanced prosthetic technologies are 1) does a person who has lost, say, an arm or a leg have the right to replace that arm or leg with one possessing *greater* or *novel* functionalities than the original organ did?; and 2) does a person have the right to amputate their healthy organ and acquire a new prosthetic one, presumably engineered to some higher level of performance than their natural organ had?

14. BRAIN-COMPUTER INTERFACE (BCI). A BCI is any system, usually electronic, that allows people to control a computer, and thus everything else that a computer might control, by *thinking about it* rather than by operating a keyboard or mouse. Some limited brain-computer interfaces have been developed but systems able to completely substitute for current input devices may be far off. Major firms, investors and researchers have made the development of more capable BCIs a priority, as noted in note 9 above. They believe computer technology has a far better chance of attaining post-human Superintelligent capabilities than does even radical heritable genetic modification. But in the absence of high-speed, reliable and flexible BCIs, they say, the Superintelligent computers would 1) be far less useful and 2) be far more likely to innovate their way out of human control. At the same time, the potential dangers and risks raised by the advent of effective BCIs should be obvious. Just as a mind could directly control a computer via BCI, a computer could control a mind. Rats have already been augmented with brain-computer interfaces such that they walk forward, stop or turn at the behest of a lab worker holding a signal box. Kurt Vonnegut’s *The Sirens of Titan* (1959) grimly envisions such brain-computer interface capabilities applied to military and penal operations.

15. NEUROTECHNOLOGICAL AUGMENTATION [notes in preparation].

16. PHARMACOLOGICAL AUGMENTATION [notes in preparation].

17. OTHER DIRECT HUMAN BODY AUGMENTATION [notes in preparation].

18. LIFESPAN EXTENSION, DELAYED SENESCENCE, IMMORTALITY, CRYONICS [notes in preparation].

F.4.b. INVENTORY OF TYPES AND EXAMPLES OF HUMAN AUGMENTATION

This partial inventory of augmentation technologies is based on topics of research and application that have generated sustained and focused recent interest and that loosely cohere around certain types of technologies and outcomes. Many applications of human genetic engineering and artificial intelligence are human augmentation, and we show those categories for completeness, but as noted they are discussed in Attachments F.2 and F.3. The list of augmentation technologies shown here is partial and preliminary; a full and detailed list, including the many speculative augmentations, could run into the hundreds.

A. AUGMENTED PROSTHESES AND PROSTHETIC SYSTEMS

- * Artificial limbs, limb systems and other external body parts, designed to provide degrees and/or types of functionality and performance not normally present in humans. Examples: a) prosthetic arms that can bear and lift greater loads; b) prosthetic leg segments that allow faster and/or extended running and jumping.
- * Supernumerary limbs. Examples: humans with 4 or 6 functional arms; humans with ten digits per hand.
- * Exoskeletons: Rigid structures that fit around and outside a body and that complement rather than replace limb or sensory functions. Potential early use is anticipated by the military, law enforcement, fire-fighting, disaster response and other high-risk jobs that depend importantly on strength and endurance.
- * Chipping: Radio-frequency identification chips (RFID chips) inserted under the skin (fingers, hand, arm, forehead, elsewhere) used to a) transmit or receive information concerning your physiological or geographic status; b) interface with external medical, financial, legal and other official records and agents; c) function as a key or code for opening/activating doors, appliances, devices, on-line accounts and more.

B. BRAIN-COMPUTER INTERFACES (BCI)

- * *Generic BCI*: Full and complete interactive communication between brains and computers. This is considered to be the critically important technology necessary to realize the full potential of AI. It would allow massive augmentation of memory, cognition and modes of sensation, and confer direct control over an enormous array of intelligent gadgets: computers, the internet, medical aids, mobile devices, vehicles, weaponry, etc.
- * *Neural implants*: permanent or removable (e.g., via permanent sockets) devices, commonly electrodes, connecting a brain with machinery, usually electronic.
- * *Neural lace*: a proposed ultra-thin mesh that fits over an entire scalp and contains many very small electrodes.
- * *BodyNET*: sensors implanted in the body, woven into the skin or worn as clothes.
- * *DYI-BCI, Do-it-yourself BCI*; see e.g. [Maldarelli \(2016\)](#).
- * Key efforts to develop neural links include:
 - Elon Musk established [Neuralink](#) in 2017 to develop neural lace. See Regalado (2017a), Winkler (2017).
 - Entrepreneur Bryan Johnson founded [Kernal](#) with \$100M to develop BCI. See Regalado (2017b).
 - [Thomas Reardon](#). Created Microsoft Explorer, left to found CTRL-Labs to build BCI. See O'Reilly (2017).
 - UK engineering professor [Kevin Warwick](#), founder of *Project Cyborg*, has had BCIs surgically implanted.
- * Examples of the risks of developing BCI are inventoried in [Burwell et al \(2017\)](#) and Glannon (2014).

C. NEUROTECHNOLOGICAL AUGMENTATION

- * Ubiquitous integration of systems to monitor physiological states throughout the body:
 - involving direct implantation of electrodes and other mechanical devices
 - involving mostly external devices, e.g. "smart clothes," "smart shoes."
- * Modification of sensory organs and related structures to enhance sight, hearing, smell, taste, touch, etc.:
 - Cochlear implants that increase the range of audible sound.
 - Retinal implants; bionic eyes with active lenses that gives 60-60 vision; telescopic contact lenses; contact lenses that can record video; combined modifications that give night, ultraviolet & infrared vision.
- * Introduction of novel sensory modalities:
 - *Cyborg skull antennae* - In 2004 UK artist [Neil Harbisson](#) had an antenna surgically inserted in his skull and wired to his occipital lobe. He is reportedly able to experience colors, including non-visible colors with wavelengths in the ultra-violet and infrared portions of the light spectrum, as *vibrations*.

* “Machines that can mind-read.” Scientists were able to correlate EEG patterns with photos of particular faces that subjects were viewing. Scientists were subsequently able to successfully determine what images a subject was viewing by analysis of her EEG patterns. Note that the procedure was able to succeed only by brute force of AI pattern recognition; there was no new understanding of the deep workings of the human brain involved. Even so, the refinement of such techniques could pose great practical challenges. See Nemrodoy (2018).

D. PHARMACOLOGICAL AUGMENTATION

* *Steroids and other drugs* that enhance body functions such as respiration, muscle action and endurance that allow improved athletic performance.

* *Drugs that confer long-term advantages*, e.g. steroids that over time build up muscle mass.

* *“Better Than Well” pharmaceuticals*: drugs that enhance mental states of mood, emotion, alertness, etc. above normal positive levels. See Peter Kramer’s *Listening to Prozac* (1993) and Carl Elliott’s *Better Than Well* (2004).

* *Nootropics*: “smart drugs,” supplements and other substances that improve cognitive function, particularly executive functions, memory, creativity or motivation, in healthy individuals. An example of such “steroids for the brain” is the FDA-approved **alertness drug modafinil**. See Plotz (2003).

E. OTHER DIRECT HUMAN BODY AUGMENTATION

I’m provisionally using this category for human augmentation that don’t fall into the three other categories:

* Replacement of normal organs and organ systems with augmented ones, including transplants, laboratory-grown, mechanical and/or pharmaceutical components. Examples:

- stomachs that can digest cellulose
- enhanced artificial nutrition: e.g. skin that can photosynthesize CO₂ and H₂O into carbohydrates
- artificial vocal chords with expanded range and tonal properties
- heart and lung systems with greatly expanded capacities
- organs generated via 3D printing, with augmented functionality

* Transplantation that creates an augmentation: [Womb transplants](#) for men and other cross-sex transplantation.

* Cosmetic augmentation, e.g. face transplants for cosmetic reasons; designer ears, hands, and other conventional cosmetic augmentation: cosmetic alteration of facial and other body features; hyper-cosmetic augmentation: extreme modification of facial and other body features, e.g. [“Lizardman.”](#)

* Genomic vaccines conferring lifetime active immunity from a very wide range of diseases.

* Cyborg tissues engineered using carbon nanotubes and plant or fungal cells to secrete substances with various enhancement qualities.

* [“Smart Clothes”](#): self-warming gloves, swim suits with UV monitors, clothes that change color as desired, RFID chips embedded in your shirt cuffs (rather than your skin), super thin motion detectors to assist with athletics, dance, etc. by giving detailed feedback on performance, organic LEDs that allow clothes to glow, batteries charged by the mechanical energy of your body activity. See Temming and Quintilla (2018).

F. LIFESPAN EXTENSION, DELAYED SENESCENCE, IMMORTALITY, CRYONICS [notes in preparation]

The prospect of indefinitely extending the human lifespan was the major motivating focus of the founders of the Transhumanist movement in the early 1990s. Mainstream scientists regarded this as largely a crackpot obsession. For many it still is, but a great many others, including most of the Silicon Valley billionaire cadre, have come to embrace “anti-aging” as a legitimate scientific and medical goal. The line between serious research on age-related impairment and crackpot immortalism has largely vanished.

Various life extension researchers state their objective to be:

1. Increasing the human *lifespan*, i.e. the length of human life.
2. Improving the human *healthspan*, i.e. the length of healthy human life.
3. Achieving human *immortality* (so that all death is accidental or intentional)

Strategies for attaining human immortality under active investigation include:

1. Trace the causes of senescence to their foundational cellular/biochemical/genetic level, and modify the

- appropriate genes, in embryos, neonates, children or adults to delay or suspend the process.
2. Once the root causes of senescence are found, develop hormonal or other chemical treatments that can delay or suspend them.
 3. Mechanical life extension: develop machine or organic replacements for all human organs and systems and perform transplants and replacements as needed.
 4. Caloric restriction: research has shown that strong and continued caloric restriction slows the aging process.
 5. Cryonics: Focus on cryonically suspending human bodies and/or brains until sometime in the future when these can be successfully reanimated and engineered for subsequent immortality.

There are now hundreds of commercial firms, non-profit research organizations and university-based institutes working explicitly to extend the human lifespan or health span in one manner or another. Many prioritize basic research on the aging process, while others pursue approaches that they hope will bear fruit, and profits, in the relatively short term. We'll have more on the anti-aging biomedical industrial complex in the final working paper.

Scores of books and journal articles addressing one aspect or another of human life extension research and speculation appear on a daily basis. Most are strongly boosterish, although there is a steady background of cautionary or skeptical reportage as well. Here are a boosterish piece and a cautionary/skeptical piece:

* Elmo Keep. 2017. "[Can Human Mortality Really Be Hacked?](#)" *Smithsonian Magazine*. 17 June.

* Shelly Fan. 2018. "[We Read This 800-Page Report on the State of Longevity Research So You Don't Have To.](#)" *SingulariltyHub.com*. 14 February.

G. HUMAN AUGMENTATION ACCOMPLISHED PRIMARILY THROUGH GENETIC MODIFICATION

[This topic is discussed in Attachment F.2 and noted here for completeness.]

H. HUMAN AUGMENTATION ACCOMPLISHED PRIMARILY THROUGH USE OF ARTIFICIAL INTELLIGENCE

[This topic is discussed in Attachment F.3. and noted here for completeness.]

I. OTHER TECHNOLOGIES CLOSELY ASSOCIATED WITH HUMAN AUGMENTATION

This is grab-bag category for the many technologies that aren't human augmentation as defined above, nor neatly fit as one of the other categories of technology we've marked off, but are closely associated with many human augmentation technologies and speculations. The list shows several highlight technologies and is not exhaustive.

I.1. Nanotechnology. [notes in preparation.]

I.2. Synthetic Biology. [notes in preparation.]