

All About Transhumanism

(Concepts and Applications)



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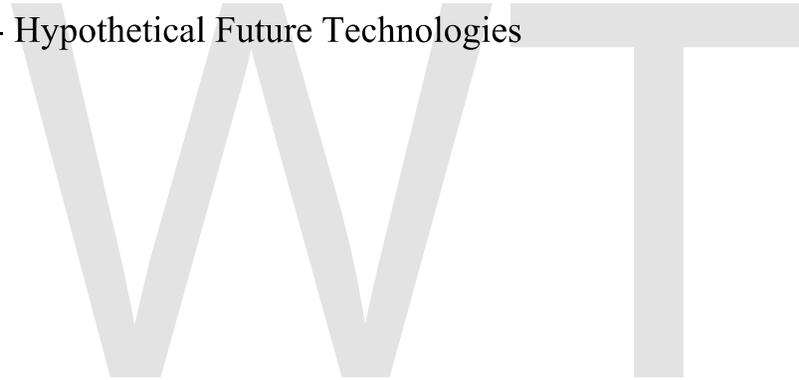
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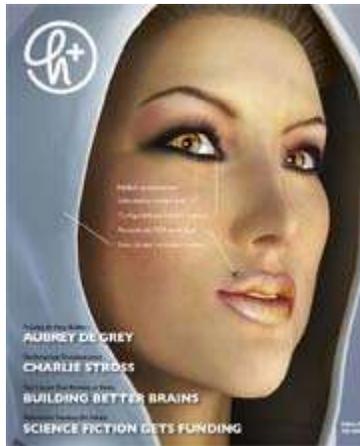
Introduction to Transhumanism

Transhumanism is an international intellectual and cultural movement supporting the use of science and technology to improve human mental and physical characteristics and capacities. The movement regards aspects of the human condition, such as disability, suffering, disease, aging, and involuntary death as unnecessary and undesirable. Transhumanists look to biotechnologies and other emerging technologies for these purposes. Dangers, as well as benefits, are also of concern to the transhumanist movement.

The term "transhumanism" is symbolized by **H+** (previously **>H**) and is often used as a synonym for "human enhancement". Although the first known use of the term dates from 1957, the contemporary meaning is a product of the 1980s when futurists in the United States, such as Max More, began to organize what has since grown into the transhumanist movement. Transhumanist thinkers predict that human beings may eventually be able to transform themselves into beings with such greatly expanded abilities as to merit the label "posthuman". Transhumanism is therefore sometimes referred to as "posthumanism" or a form of transformational activism influenced by posthumanist ideals.

The transhumanist vision of a transformed future humanity has attracted many supporters and detractors from a wide range of perspectives. Transhumanism has been described by one critic, Francis Fukuyama, as the world's most dangerous idea, while one proponent, Ronald Bailey, counters that it is the "movement that epitomizes the most daring, courageous, imaginative, and idealistic aspirations of humanity".

History



Cover of the first issue of *H+ Magazine*, a web-based quarterly publication that focuses on transhumanism, covering the scientific, technological, and cultural developments that are challenging and overcoming human limitations.

According to philosophers who have studied and written about the history of transhumanist thought, transcendentalist impulses have been expressed at least as far back as in the quest for immortality in the Epic of Gilgamesh, as well as historical quests for the Fountain of Youth, Elixir of Life, and other efforts to stave off aging and death. Transhumanist philosophy, however, is rooted in Renaissance humanism and the Enlightenment. For example, Giovanni Pico della Mirandola called on people to "sculpt their own statue", and the Marquis de Condorcet speculated about the use of medical science to indefinitely extend the human life span, while Benjamin Franklin dreamed of suspended animation, and after Charles Darwin "it became increasingly plausible to view the current version of humanity not as the endpoint of evolution but rather as a possibly quite early phase." However, there is ongoing debate within the transhumanist community about whether the philosophy of Friedrich Nietzsche can be considered an influence, despite its exaltation of the "overman", due to its emphasis on self-actualization rather than technological transformation.

Nikolai Fyodorov, a 19th-century Russian philosopher, advocated radical life extension, physical immortality and even resurrection of the dead using scientific methods. In the 20th century, a direct and influential precursor to transhumanist concepts was geneticist J.B.S. Haldane's 1923 essay *Daedalus: Science and the Future*, which predicted that great benefits would come from applications of advanced sciences to human biology—and that every such advance would first appear to someone as blasphemy or perversion, "indecent and unnatural". J. D. Bernal speculated about space colonization, bionic implants, and cognitive enhancement, which have been common transhumanist themes since then. Biologist Julian Huxley, brother of author Aldous Huxley (a childhood friend of Haldane's), appears to have been the first to use the actual word "transhumanism". Writing in 1957, he defined transhumanism as "man remaining man, but transcending himself, by realizing new possibilities of and for his human nature". This definition differs, albeit not substantially, from the one commonly in use since the 1980s.

Computer scientist Marvin Minsky wrote on relationships between human and artificial intelligence beginning in the 1960s. Over the succeeding decades, this field continued to generate influential thinkers, such as Hans Moravec and Raymond Kurzweil, who oscillated between the technical arena and futuristic speculations in the transhumanist vein. The coalescence of an identifiable transhumanist movement began in the last decades of the 20th century. In 1966, FM-2030 (formerly F.M. Esfandiary), a futurist who taught "new concepts of the Human" at The New School in New York City, began to identify people who adopt technologies, lifestyles and world views transitional to "posthumanity" as "transhuman" (short for "transitory human"). In 1972, Robert Ettinger contributed to the conceptualization of "transhumanity" in his book *Man into Superman*. FM-2030 published the *Upwingers Manifesto* in 1973 to stimulate transhumanly conscious activism.

The first self-described transhumanists met formally in the early 1980s at the University of California, Los Angeles, which became the main center of transhumanist thought. Here, FM-2030 lectured on his "Third Way" futurist ideology. At the EZTV Media venue frequented by transhumanists and other futurists, Natasha Vita-More presented *Breaking Away*, her 1980 experimental film with the theme of humans breaking away from their biological limitations and the Earth's gravity as they head into space. FM-2030 and Vita-More soon began holding gatherings for transhumanists in Los Angeles, which included students from FM-2030's courses and audiences from Vita-More's artistic productions. In 1982, Vita-More authored the *Transhumanist Arts Statement*, and, six years later, produced the cable TV show *TransCentury Update* on transhumanity, a program which reached over 100,000 viewers.

In 1986, Eric Drexler published *Engines of Creation: The Coming Era of Nanotechnology*, which discussed the prospects for nanotechnology and molecular assemblers, and founded the Foresight Institute. As the first non-profit organization to research, advocate for, and perform cryonics, the Southern California offices of the Alcor Life Extension Foundation became a center for futurists. In 1988, the first issue of *Extropy Magazine* was published by Max More and Tom Morrow. In 1990, More, a strategic philosopher, created his own particular transhumanist doctrine, which took the form of the *Principles of Extropy*, and laid the foundation of modern transhumanism by giving it a new definition:

Transhumanism is a class of philosophies that seek to guide us towards a posthuman condition. Transhumanism shares many elements of humanism, including a respect for reason and science, a commitment to progress, and a valuing of human (or transhuman) existence in this life. [...] Transhumanism differs from humanism in recognizing and anticipating the radical alterations in the nature and possibilities of our lives resulting from various sciences and technologies [...].

In 1992, More and Morrow founded the Extropy Institute, a catalyst for networking futurists and brainstorming new memplexes by organizing a series of conferences and, more importantly, providing a mailing list, which exposed many to transhumanist views for the first time during the rise of cyberculture and the cyberdelic counterculture. In

1998, philosophers Nick Bostrom and David Pearce founded the World Transhumanist Association (WTA), an international non-governmental organization working toward the recognition of transhumanism as a legitimate subject of scientific inquiry and public policy. In 2002, the WTA modified and adopted *The Transhumanist Declaration*. *The Transhumanist FAQ*, prepared by the WTA, gave two formal definitions for transhumanism:

1. The intellectual and cultural movement that affirms the possibility and desirability of fundamentally improving the human condition through applied reason, especially by developing and making widely available technologies to eliminate aging and to greatly enhance human intellectual, physical, and psychological capacities.
2. The study of the ramifications, promises, and potential dangers of technologies that will enable us to overcome fundamental human limitations, and the related study of the ethical matters involved in developing and using such technologies.

A number of similar definitions have been collected by Anders Sandberg, an academic and prominent transhumanist.

In possible contrast with other transhumanist organizations, WTA officials considered that social forces could undermine their futurist visions and needed to be addressed. A particular concern is the equal access to human enhancement technologies across classes and borders. In 2006, a political struggle within the transhumanist movement between the libertarian right and the liberal left resulted in a more centre-leftward positioning of the WTA under its former executive director James Hughes. In 2006, the board of directors of the Extropy Institute ceased operations of the organization, stating that its mission was "essentially completed". This left the World Transhumanist Association as the leading international transhumanist organization. In 2008, as part of a rebranding effort, the WTA changed its name to "Humanity+" in order to project a more humane image. Humanity Plus and Betterhumans publish *h+ Magazine*, a periodical edited by R. U. Sirius which disseminates transhumanist news and ideas.

Theory

It is a matter of debate whether transhumanism is a branch of "posthumanism" and how posthumanism should be conceptualised with regard to transhumanism. The latter is often referred to as a variant or activist form of posthumanism by its conservative, Christian and progressive critics, but also by pro-transhumanist scholars who, for example, characterise it as a subset of "philosophical posthumanism". A common feature of transhumanism and philosophical posthumanism is the future vision of a new intelligent species, into which humanity will evolve, which will supplement humanity or supersede it. Transhumanism stresses the evolutionary perspective, including sometimes the creation of a highly intelligent animal species by way of cognitive enhancement (i.e. biological uplift), but clings to a "posthuman future" as the final goal of participant evolution.

Nevertheless, the idea to create intelligent artificial beings, proposed, for example, by roboticist Hans Moravec, has influenced transhumanism. Moravec's ideas and transhumanism have also been characterised as a "complacent" or "apocalyptic" variant of posthumanism and contrasted with "cultural posthumanism" in humanities and the arts. While such a "cultural posthumanism" would offer resources for rethinking the relations of humans and increasingly sophisticated machines, transhumanism and similar posthumanisms are, in this view, not abandoning obsolete concepts of the "autonomous liberal subject" but are expanding its "prerogatives" into the realm of the posthuman. Transhumanist self-characterisations as a continuation of humanism and Enlightenment thinking correspond with this view.

Some secular humanists conceive transhumanism as an offspring of the humanist freethought movement and argue that transhumanists differ from the humanist mainstream by having a specific focus on technological approaches to resolving human concerns and on the issue of mortality. However, other progressives have argued that posthumanism, whether it be its philosophical or activist forms, amount to a shift away from concerns about social justice, from the reform of human institutions and from other Enlightenment preoccupations, toward narcissistic longings for a transcendence of the human body in quest of more exquisite ways of being. In this view, transhumanism is abandoning the goals of humanism, the Enlightenment, and progressive politics.

Aims

While many transhumanist theorists and advocates seek to apply reason, science and technology for the purposes of reducing poverty, disease, disability, and malnutrition around the globe, transhumanism is distinctive in its particular focus on the applications of technologies to the improvement of human bodies at the individual level. Many transhumanists actively assess the potential for future technologies and innovative social systems to improve the quality of all life, while seeking to make the material reality of the human condition fulfill the promise of legal and political equality by eliminating congenital mental and physical barriers.

Transhumanist philosophers argue that there not only exists a perfectionist ethical imperative for humans to strive for progress and improvement of the human condition but that it is possible and desirable for humanity to enter a transhuman phase of existence, in which humans are in control of their own evolution. In such a phase, natural evolution would be replaced with deliberate change.

Some theorists, such as Raymond Kurzweil, think that the pace of technological innovation is accelerating and that the next 50 years may yield not only radical technological advances but possibly a technological singularity, which may fundamentally change the nature of human beings. Transhumanists who foresee this massive technological change generally maintain that it is desirable. However, some are also concerned with the possible dangers of extremely rapid technological change and propose options for ensuring that advanced technology is used responsibly. For example,

Bostrom has written extensively on existential risks to humanity's future welfare, including risks that could be created by emerging technologies.

Ethics

Transhumanists engage in interdisciplinary approaches to understanding and evaluating possibilities for overcoming biological limitations. They draw on futurology and various fields of ethics such as bioethics, infoethics, nanoethics, neuroethics, roboethics, and technoethics mainly but not exclusively from a philosophically utilitarian, socially progressive, politically and economically liberal perspective. Unlike many philosophers, social critics, and activists who place a moral value on preservation of natural systems, transhumanists see the very concept of the specifically "natural" as problematically nebulous at best, and an obstacle to progress at worst. In keeping with this, many prominent transhumanist advocates refer to transhumanism's critics on the political right and left jointly as "bioconservatives" or "bioluddites", the latter term alluding to the 19th century anti-industrialisation social movement that opposed the replacement of human manual labourers by machines.

Currents

There is a variety of opinion within transhumanist thought. Many of the leading transhumanist thinkers hold views that are under constant revision and development. Some distinctive currents of transhumanism are identified and listed here in alphabetical order:

- Abolitionism, an ethical ideology based upon a perceived obligation to use technology to eliminate involuntary suffering in all sentient life.
- Democratic transhumanism, a political ideology synthesizing liberal democracy, social democracy, radical democracy and transhumanism.
- Extropianism, an early school of transhumanist thought characterized by a set of principles advocating a proactive approach to human evolution.
- Immortalism, a moral ideology based upon the belief that technological immortality is possible and desirable, and advocating research and development to ensure its realization.
- Libertarian transhumanism, a political ideology synthesizing libertarianism and transhumanism.
- Postgenderism, a social philosophy which seeks the voluntary elimination of gender in the human species through the application of advanced biotechnology and assisted reproductive technologies.
- Singularitarianism, a moral ideology based upon the belief that a technological singularity is possible, and advocating deliberate action to effect it and ensure its safety.
- Technogaianism, an ecological ideology based upon the belief that emerging technologies can help restore Earth's environment, and that developing safe, clean, alternative technology should therefore be an important goal of environmentalists.

Spirituality

Although some transhumanists report having religious or spiritual views, they are for the most part atheists, agnostics and secular humanists. A vocal minority of transhumanists, however, follow liberal forms of Eastern philosophies such as Buddhism and Yoga or have merged their transhumanist ideas with established Western religions such as liberal Christianity or Mormonism. Despite the prevailing secular attitude, some transhumanists pursue hopes traditionally espoused by religions, such as "immortality", while several controversial new religious movements, originating in the late 20th century, have explicitly embraced transhumanist goals of transforming the human condition by applying technology to the alteration of the mind and body, such as Raëlism. However, most thinkers associated with the transhumanist movement focus on the practical goals of using technology to help achieve longer and healthier lives; while speculating that future understanding of neurotheology and the application of neurotechnology will enable humans to gain greater control of altered states of consciousness, which were commonly interpreted as "spiritual experiences", and thus achieve more profound self-knowledge.

Secular transhumanists are strong materialists and naturalists who do not believe in a transcendent human soul. Transhumanist personhood theory also argues against the unique identification of moral actors and subjects with biological humans, judging as speciesist the exclusion of non-human and part-human animals, and sophisticated machines, from ethical consideration. Many believe in the compatibility of human minds with computer hardware, with the theoretical implication that human consciousness may someday be transferred to alternative media, a speculative technique commonly known as "mind uploading". One extreme formulation of this idea may be found in Frank Tipler's proposal of the Omega Point. Drawing upon ideas in digitalism, Tipler has advanced the notion that the collapse of the Universe billions of years hence could create the conditions for the perpetuation of humanity in a simulated reality within a megacomputer, and thus achieve a form of "posthuman godhood". Tipler's thought was inspired by the writings of Pierre Teilhard de Chardin, a paleontologist and Jesuit theologian who saw an evolutionary telos in the development of an encompassing noosphere, a global consciousness.

The idea of uploading personality to a non-biological substrate and the underlying assumptions are criticised by a wide range of scholars, scientists and activists, sometimes with regard to transhumanism itself, sometimes with regard to thinkers such as Marvin Minsky or Hans Moravec, who are often seen as its originators. Relating the underlying assumptions, for example, to the legacy of cybernetics, some have argued that this materialist hope engenders a spiritual monism, a variant of philosophical idealism. Viewed from a conservative Christian perspective, the idea of mind uploading is asserted to represent a denigration of the human body characteristic of gnostic belief. Transhumanism and its presumed intellectual progenitors have also been described as neo-gnostic by non-Christian and secular commentators.

The first dialogue between transhumanism and faith was the focus of an academic seminar held at the University of Toronto in 2004. Because it might serve a few of the

same functions that people have traditionally sought in religion, religious and secular critics maintained that transhumanism is itself a religion or, at the very least, a pseudoreligion. Religious critics alone faulted the philosophy of transhumanism as offering no eternal truths nor a relationship with the divine. They commented that a philosophy bereft of these beliefs leaves humanity adrift in a foggy sea of postmodern cynicism and anomie. Transhumanists responded that such criticisms reflect a failure to look at the actual content of the transhumanist philosophy, which far from being cynical, is rooted in optimistic, idealistic attitudes that trace back to the Enlightenment. Following this dialogue, William Sims Bainbridge conducted a pilot study, published in the *Journal of Evolution and Technology*, suggesting that religious attitudes were negatively correlated with acceptance of transhumanist ideas, and indicating that individuals with highly religious worldviews tended to perceive transhumanism as being a direct, competitive (though ultimately futile) affront to their spiritual beliefs.

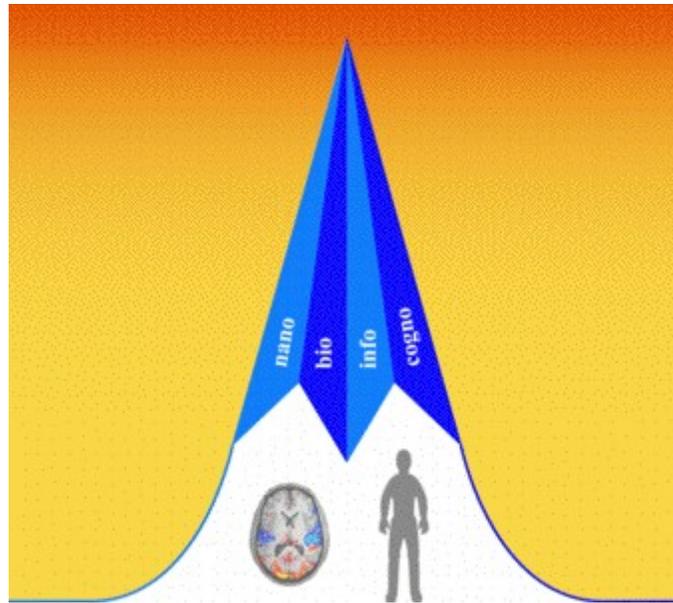
Since 2009, the American Academy of Religion holds a “Transhumanism and Religion” consultation during its annual meeting where scholars in the field of religious studies seek to identify and critically evaluate any implicit religious beliefs that might underlie key transhumanist claims and assumptions; consider how transhumanism challenges religious traditions to develop their own ideas of the human future, in particular the prospect of human transformation, whether by technological or other means; and provide critical and constructive assessments of an envisioned future that place greater confidence in nanotechnology, robotics, and information technology to achieve virtual immortality and create a superior posthuman species.

Practice

While some transhumanists take an abstract and theoretical approach to the perceived benefits of emerging technologies, others have offered specific proposals for modifications to the human body, including heritable ones. Transhumanists are often concerned with methods of enhancing the human nervous system. Though some propose modification of the peripheral nervous system, the brain is considered the common denominator of personhood and is thus a primary focus of transhumanist ambitions.

As proponents of self-improvement and body modification, transhumanists tend to use existing technologies and techniques that supposedly improve cognitive and physical performance, while engaging in routines and lifestyles designed to improve health and longevity. Depending on their age, some transhumanists express concern that they will not live to reap the benefits of future technologies. However, many have a great interest in life extension strategies, and in funding research in cryonics in order to make the latter a viable option of last resort rather than remaining an unproven method. Regional and global transhumanist networks and communities with a range of objectives exist to provide support and forums for discussion and collaborative projects.

Technologies of interest



Converging Technologies, a 2002 report exploring the potential for synergy among nano-, bio-, info- and cogno-technologies, has become a landmark in near-future technological speculation.

Transhumanists support the emergence and convergence of technologies such as nanotechnology, biotechnology, information technology and cognitive science (NBIC), and hypothetical future technologies such as simulated reality, artificial intelligence, superintelligence, mind uploading, chemical brain preservation, and cryonics. They believe that humans can and should use these technologies to become more than human. They therefore support the recognition and/or protection of cognitive liberty, morphological freedom, and procreative liberty as civil liberties, so as to guarantee individuals the choice of using human enhancement technologies on themselves and their children. Some speculate that human enhancement techniques and other emerging technologies may facilitate more radical human enhancement no later than the midpoint of the 21st century.

A 2002 report, *Converging Technologies for Improving Human Performance*, commissioned by the National Science Foundation and US Department of Commerce, contains descriptions and commentaries on the state of NBIC science and technology by major contributors to these fields. The report discusses potential uses of these technologies in implementing transhumanist goals of enhanced performance and health, and ongoing work on planned applications of human enhancement technologies in the military and in the rationalization of the human-machine interface in industry.

While international discussion of the converging technologies and NBIC concepts includes strong criticism of their transhumanist orientation and alleged science fictional character, research on brain and body alteration technologies has accelerated under the sponsorship of the US Department of Defense, which is interested in the battlefield advantages they would provide to the "supersoldiers" of the United States and its allies.

There has already been a brain research program to "extend the ability to manage information" while military scientists are now looking at stretching the human capacity for combat to a maximum 168 hours without sleep.

Arts and culture

Transhumanist themes have become increasingly prominent in various literary forms during the period in which the movement itself has emerged. Contemporary science fiction often contains positive renditions of technologically enhanced human life, set in utopian (especially techno-utopian) societies. However, science fiction's depictions of enhanced humans or other posthuman beings frequently come with a cautionary twist. The more pessimistic scenarios include many horrific or dystopian tales of human bioengineering gone wrong. In the decades immediately before transhumanism emerged as an explicit movement, many transhumanist concepts and themes began appearing in the speculative fiction of authors such as Robert A. Heinlein (Lazarus Long series, 1941–87), A. E. van Vogt (*Slan*, 1946), Isaac Asimov (*I, Robot*, 1950), Arthur C. Clarke (*Childhood's End*, 1953) and Stanislaw Lem (*Cyberiad*, 1967).

The cyberpunk genre, exemplified by William Gibson's *Neuromancer* (1984) and Bruce Sterling's *Schismatrix* (1985), has particularly been concerned with the modification of human bodies. Other novels dealing with transhumanist themes that have stimulated broad discussion of these issues include *Blood Music* (1985) by Greg Bear, *The Xenogenesis Trilogy* (1987–1989) by Octavia Butler; *The Beggar's Trilogy* (1990–94) by Nancy Kress; much of Greg Egan's work since the early 1990s, such as *Permutation City* (1994) and *Diaspora* (1997); The Culture novels of Iain M. Banks; *The Bohr Maker* (1995) by Linda Nagata; *Oryx and Crake* (2003) by Margaret Atwood; *The Elementary Particles* (Eng. trans. 2001) and *The Possibility of an Island* (Eng. trans. 2006) by Michel Houellebecq; *Mindscan* (2005) by Robert J. Sawyer; and *Glasshouse* (2005) by Charles Stross. Many of these works are considered part of the cyberpunk genre or its postcyberpunk offshoot.

Fictional transhumanist scenarios have also become popular in other media during the late twentieth and early twenty first centuries. Such treatments are found in comic books (*Captain America*, 1941; *Transmetropolitan*, 1997; *The Surrogates*, 2006), films (*2001: A Space Odyssey*, 1968; *Blade Runner*, 1982; *Gattaca*, 1997; *Repo! The Genetic Opera*, 2008), television series (the Cybermen of *Doctor Who*, 1966; *The Six Million Dollar Man*, 1973; the Borg of *Star Trek: The Next Generation*, 1989; manga and anime (*Galaxy Express 999*, 1978; *Appleseed*, 1985; *Ghost in the Shell*, 1989; *Neon Genesis Evangelion*, 1995; and the *Gundam* metaseries, 1979), computer games (*Metal Gear Solid*, 1998; *Deus Ex*, 2000; *Half-Life 2*, 2004; and *BioShock*, 2007), and role-playing games (*Shadowrun*, 1989, *Transhuman Space*, 2002). The word "Transhumanism" flashes in the introduction sequence to the television program *Fringe*.

In addition to the work of Natasha Vita-More, curator of the Transhumanist Arts & Culture center, transhumanist themes appear in the visual and performing arts. Carnal Art, a form of sculpture originated by the French artist Orlan, uses the body as its

medium and plastic surgery as its method. Commentators have pointed to American performer Michael Jackson as having used technologies such as plastic surgery, skin-lightening drugs and hyperbaric oxygen therapy over the course of his career, with the effect of transforming his artistic persona so as to blur identifiers of gender, race and age. The work of the Australian artist Stelarc centers on the alteration of his body by robotic prostheses and tissue engineering. Other artists whose work coincided with the emergence and flourishing of transhumanism and who explored themes related to the transformation of the body are the Yugoslavian performance artist Marina Abramovic and the American media artist Matthew Barney. A 2005 show, *Becoming Animal*, at the Massachusetts Museum of Contemporary Art, presented exhibits by twelve artists whose work concerns the effects of technology in erasing boundaries between the human and non-human. Steampunk musician and Internet personality Dr. Steel often deals with the subject of transhumanism in his music and videos; he has been interviewed on his views by the Institute for Ethics and Emerging Technologies and has even published a paper on the subject.

Controversy

The scientific community classifies many elements of transhumanist thought and research to be within the realm of fringe science because it departs significantly from the mainstream and often directly challenges orthodox theories. The very notion and prospect of human enhancement and related issues also arouse public controversy. Criticisms of transhumanism and its proposals take two main forms: those objecting to the likelihood of transhumanist goals being achieved (practical criticisms); and those objecting to the moral principles or world view sustaining transhumanist proposals or underlying transhumanism itself (ethical criticisms). However, these two strains sometimes converge and overlap, particularly when considering the ethics of changing human biology in the face of incomplete knowledge.

Critics or opponents often see transhumanists' goals as posing threats to human values. Some also argue that strong advocacy of a transhumanist approach to improving the human condition might divert attention and resources from social solutions. As most transhumanists support non-technological changes to society, such as the spread of civil rights and civil liberties, and most critics of transhumanism support technological advances in areas such as communications and health care, the difference is often a matter of emphasis. Sometimes, however, there are strong disagreements about the very principles involved, with divergent views on humanity, human nature, and the morality of transhumanist aspirations. At least one public interest organization, the U.S.-based Center for Genetics and Society, was formed, in 2001, with the specific goal of opposing transhumanist agendas that involve transgenerational modification of human biology, such as full-term human cloning and germinal choice technology. The Institute on Biotechnology and the Human Future of the Chicago-Kent College of Law critically scrutinizes proposed applications of genetic and nanotechnologies to human biology in an academic setting.

Some of the most widely known critiques of the transhumanist program refer to novels and fictional films. These works of art, despite presenting imagined worlds rather than philosophical analyses, are used as touchstones for some of the more formal arguments.

Infeasibility (*Futurehype* argument)

In his 1992 book *Futurehype: The Tyranny of Prophecy*, sociologist Max Dublin points out many past failed predictions of technological progress and argues that modern futurist predictions will prove similarly inaccurate. He also objects to what he sees as scientism, fanaticism, and nihilism by a few in advancing transhumanist causes, and writes that historical parallels exist to millenarian religions and Communist doctrines. Several notable transhumanists have predicted that death-defeating technologies will arrive (usually late) within their own conventionally expected lifetimes. *Wired* magazine founding executive editor Kevin Kelly has argued these transhumanists have overly optimistic expectations of when dramatic technological breakthroughs will occur because they hope to be saved from their own deaths by those developments. Despite his sympathies for transhumanism, in his 2002 book *Redesigning Humans: Our Inevitable Genetic Future*, public health professor Gregory Stock is skeptical of the technical feasibility and mass appeal of the cyborgization of humanity predicted by Raymond Kurzweil, Hans Moravec and Kevin Warwick. He believes that throughout the 21st century, many humans will find themselves deeply integrated into systems of machines, but will remain biological. Primary changes to their own form and character will arise not from cyberware but from the direct manipulation of their genetics, metabolism, and biochemistry.

In his 2006 book *Future Hype: The Myths of Technology Change*, computer scientist and engineer Bob Seidensticker argues that today's technological achievements are not unprecedented. Exposing major myths of technology and examining the history of high tech hype, he aims to uncover inaccuracies and misunderstandings that may characterise the popular and transhumanist views of technology, to explain how and why these views have been created, and to illustrate how technological change in fact proceeds.

Those thinkers who defend the likelihood of massive technological change within a relatively short timeframe emphasize what they describe as a past pattern of exponential increases in humanity's technological capacities. This emphasis appears in the work of popular science writer Damien Broderick, notably his 1997 book, *The Spike*, which contains his speculations about a radically changed future. Kurzweil develops this position in much detail in his 2005 book, *The Singularity Is Near*. Broderick points out that many of the seemingly implausible predictions of early science fiction writers have, indeed, come to pass, among them nuclear power and space travel to the moon. He also claims that there is a core rationalism to current predictions of very rapid change, asserting that such observers as Kurzweil have a good track record in predicting the pace of innovation.

Hubris (*Playing God* argument)

There are two distinct categories of criticism, theological and secular, that have been referred to as "playing god" arguments:

The first category is based on the alleged inappropriateness of humans substituting themselves for an actual god. This approach is exemplified by the 2002 Vatican statement *Communion and Stewardship: Human Persons Created in the Image of God*, in which it is stated that, "Changing the genetic identity of man as a human person through the production of an infrahuman being is radically immoral", implying, as it would, that "man has full right of disposal over his own biological nature". At the same time, this statement argues that creation of a superhuman or spiritually superior being is "unthinkable", since true improvement can come only through religious experience and "realizing more fully the image of God". Christian theologians and lay activists of several churches and denominations have expressed similar objections to transhumanism and claimed that Christians already enjoy, however post mortem, what radical transhumanism promises such as indefinite life extension or the abolition of suffering. In this view, transhumanism is just another representative of the long line of utopian movements which seek to immanentize the eschaton i.e. try to create "heaven on earth".



The biocomplexity spiral is a depiction of the multileveled complexity of organisms in their environments, which is seen by many critics as the ultimate obstacle to transhumanist ambition.

The second category is aimed mainly at "algeny", which Jeremy Rifkin defined as "the upgrading of existing organisms and the design of wholly new ones with the intent of 'perfecting' their performance", and, more specifically, attempts to pursue transhumanist goals by way of genetically modifying human embryos in order to create "designer

babies". It emphasizes the issue of biocomplexity and the unpredictability of attempts to guide the development of products of biological evolution. This argument, elaborated in particular by the biologist Stuart Newman, is based on the recognition that the cloning and germline genetic engineering of animals are error-prone and inherently disruptive of embryonic development. Accordingly, so it is argued, it would create unacceptable risks to use such methods on human embryos. Performing experiments, particularly ones with permanent biological consequences, on developing humans, would thus be in violation of accepted principles governing research on human subjects. Moreover, because improvements in experimental outcomes in one species are not automatically transferable to a new species without further experimentation, there is claimed to be no ethical route to genetic manipulation of humans at early developmental stages.

As a practical matter, however, international protocols on human subject research may not present a legal obstacle to attempts by transhumanists and others to improve their offspring by germinal choice technology. According to legal scholar Kirsten Rabe Smolensky, existing laws would protect parents who choose to enhance their child's genome from future liability arising from adverse outcomes of the procedure.

Religious thinkers allied with transhumanist goals, such as the theologians Ronald Cole-Turner and Ted Peters, reject the first argument, holding that the doctrine of "co-creation" provides an obligation to use genetic engineering to improve human biology.

Transhumanists and other supporters of human genetic engineering do not dismiss the second argument out of hand, insofar as there is a high degree of uncertainty about the likely outcomes of genetic modification experiments in humans. However, bioethicist James Hughes suggests that one possible ethical route to the genetic manipulation of humans at early developmental stages is the building of computer models of the human genome, the proteins it specifies, and the tissue engineering he argues that it also codes for. With the exponential progress in bioinformatics, Hughes believes that a virtual model of genetic expression in the human body will not be far behind and that it will soon be possible to accelerate approval of genetic modifications by simulating their effects on virtual humans. Public health professor Gregory Stock points to artificial chromosomes as an alleged safer alternative to existing genetic engineering techniques. Transhumanists therefore argue that parents have a moral responsibility called procreative beneficence to make use of these methods, if and when they are shown to be reasonably safe and effective, to have the healthiest children possible. They add that this responsibility is a moral judgment best left to individual conscience rather than imposed by law, in all but extreme cases. In this context, the emphasis on freedom of choice is called procreative liberty.

Contempt for the flesh (*Fountain of Youth* argument)

Philosopher Mary Midgley, in her 1992 book *Science as Salvation*, traces the notion of achieving immortality by transcendence of the material human body (echoed in the transhumanist tenet of mind uploading) to a group of male scientific thinkers of the early 20th century, including J.B.S. Haldane and members of his circle. She characterizes these

ideas as "quasi-scientific dreams and prophecies" involving visions of escape from the body coupled with "self-indulgent, uncontrolled power-fantasies". Her argument focuses on what she perceives as the pseudoscientific speculations and irrational, fear-of-death-driven fantasies of these thinkers, their disregard for laymen, and the remoteness of their eschatological visions.

What is perceived as contempt for the flesh in the writings of Marvin Minsky, Hans Moravec, and some transhumanists, has also been the target of other critics for what they claim to be an instrumental conception of the human body. Reflecting a strain of feminist criticism of the transhumanist program, philosopher Susan Bordo points to "contemporary obsessions with slenderness, youth, and physical perfection", which she sees as affecting both men and women, but in distinct ways, as "the logical (if extreme) manifestations of anxieties and fantasies fostered by our culture." Some critics question other social implications of the movement's focus on body modification. Political scientist Klaus-Gerd Giesen, in particular, has asserted that transhumanism's concentration on altering the human body represents the logical yet tragic consequence of atomized individualism and body commodification within a consumer culture.

Nick Bostrom asserts that the desire to regain youth, specifically, and transcend the natural limitations of the human body, in general, is pan-cultural and pan-historical, and is therefore not uniquely tied to the culture of the 20th century. He argues that the transhumanist program is an attempt to channel that desire into a scientific project on par with the Human Genome Project and achieve humanity's oldest hope, rather than a puerile fantasy or social trend.

Trivialization of human identity (*Enough* argument)



In the US, the Amish are a religious group probably most known for their avoidance of certain modern technologies. Transhumanists draw a parallel by arguing that in the near-future there will probably be "Humanish", people who choose to "stay human" by not adopting human enhancement technologies, whose choice they believe must be respected and protected.

In his 2003 book *Enough: Staying Human in an Engineered Age*, environmental ethicist Bill McKibben argued at length against many of the technologies that are postulated or supported by transhumanists, including germinal choice technology, nanomedicine and life extension strategies. He claims that it would be morally wrong for humans to tamper with fundamental aspects of themselves (or their children) in an attempt to overcome universal human limitations, such as vulnerability to aging, maximum life span, and biological constraints on physical and cognitive ability. Attempts to "improve" themselves through such manipulation would remove limitations that provide a necessary context for the experience of meaningful human choice. He claims that human lives would no longer seem meaningful in a world where such limitations could be overcome technologically. Even the goal of using germinal choice technology for clearly *therapeutic* purposes should be relinquished, since it would inevitably produce temptations to tamper with such things as cognitive capacities. He argues that it is possible for societies to benefit from renouncing particular technologies, using as examples Ming China, Tokugawa Japan and the contemporary Amish.

Transhumanists and other supporters of technological alteration of human biology, such as science journalist Ronald Bailey, reject as extremely subjective the claim that life would be experienced as meaningless if some human limitations are overcome with enhancement technologies. They argue that these technologies will not remove the bulk of the individual and social challenges humanity faces. They suggest that a person with greater abilities would tackle more advanced and difficult projects and continue to find meaning in the struggle to achieve excellence. Bailey also claims that McKibben's historical examples are flawed, and support different conclusions when studied more closely. For example, few groups are more cautious than the Amish about embracing new technologies, but though they shun television and use horses and buggies, some are welcoming the possibilities of gene therapy since inbreeding has afflicted them with a number of rare genetic diseases.

Genetic divide (*Gattaca* argument)

Some critics of libertarian transhumanism have focused on its likely socioeconomic consequences in societies in which divisions between rich and poor are on the rise. Bill McKibben, for example, suggests that emerging human enhancement technologies would be disproportionately available to those with greater financial resources, thereby exacerbating the gap between rich and poor and creating a "genetic divide". Lee M. Silver, a biologist and science writer who coined the term "reprogenetics" and supports its applications, has nonetheless expressed concern that these methods could create a two-tiered society of genetically engineered "haves" and "have nots" if social democratic reforms lag behind implementation of enhancement technologies. Critics who make

these arguments do not thereby necessarily accept the transhumanist assumption that human enhancement is a positive value; in their view, it should be discouraged, or even banned, because it could confer additional power upon the already powerful. The 1997 film *Gattaca*'s depiction of a dystopian society in which one's social class depends entirely on genetic modifications is often cited by critics in support of these views.

These criticisms are also voiced by non-libertarian transhumanist advocates, especially self-described democratic transhumanists, who believe that the majority of current or future social and environmental issues (such as unemployment and resource depletion) need to be addressed by a combination of political and technological solutions (such as a guaranteed minimum income and alternative technology). Therefore, on the specific issue of an emerging genetic divide due to unequal access to human enhancement technologies, bioethicist James Hughes, in his 2004 book *Citizen Cyborg: Why Democratic Societies Must Respond to the Redesigned Human of the Future*, argues that progressives or, more precisely, techno-progressives must articulate and implement public policies (such as a universal health care voucher system that covers human enhancement technologies) in order to attenuate this problem as much as possible, rather than trying to ban human enhancement technologies. The latter, he argues, might actually worsen the problem by making these technologies unsafe or available only to the wealthy on the local black market or in countries where such a ban is not enforced.

Threats to morality and democracy (*Brave New World* argument)

Various arguments have been made to the effect that a society that adopts human enhancement technologies may come to resemble the dystopia depicted in the 1932 novel *Brave New World* by Aldous Huxley. Sometimes, as in the writings of Leon Kass, the fear is that various institutions and practices judged as fundamental to civilized society would be damaged or destroyed. In his 2002 book *Our Posthuman Future* and in a 2004 *Foreign Policy* magazine article, political economist and philosopher Francis Fukuyama designates transhumanism the world's most dangerous idea because he believes that it may undermine the egalitarian ideals of democracy in general and liberal democracy in particular, through a fundamental alteration of "human nature". Social philosopher Jürgen Habermas makes a similar argument in his 2003 book *The Future of Human Nature*, in which he asserts that moral autonomy depends on not being subject to another's unilaterally imposed specifications. Habermas thus suggests that the human "species ethic" would be undermined by embryo-stage genetic alteration. Critics such as Kass, Fukuyama, and a variety of Christian authors hold that attempts to significantly alter human biology are not only inherently immoral but also threats to the social order. Alternatively, they argue that implementation of such technologies would likely lead to the "naturalizing" of social hierarchies or place new means of control in the hands of totalitarian regimes. The AI pioneer Joseph Weizenbaum criticizes what he sees as misanthropic tendencies in the language and ideas of some of his colleagues, in particular Marvin Minsky and Hans Moravec, which, by devaluing the human organism per se, promotes a discourse that enables divisive and undemocratic social policies.

In a 2004 article in *Reason*, science journalist Ronald Bailey has contested the assertions of Fukuyama by arguing that political equality has never rested on the facts of human biology. He asserts that liberalism was founded not on the proposition of effective equality of human beings, or *de facto* equality, but on the assertion of an equality in political rights and before the law, or *de jure* equality. Bailey asserts that the products of genetic engineering may well ameliorate rather than exacerbate human inequality, giving to the many what were once the privileges of the few. Moreover, he argues, "the crowning achievement of the Enlightenment is the principle of tolerance". In fact, he argues, political liberalism is already the solution to the issue of human and posthuman rights since, in liberal societies, the law is meant to apply equally to all, no matter how rich or poor, powerful or powerless, educated or ignorant, enhanced or unenhanced. Other thinkers who are sympathetic to transhumanist ideas, such as philosopher Russell Blackford, have also objected to the appeal to tradition, and what they see as alarmism, involved in *Brave New World*-type arguments.

Dehumanization (*Frankenstein* argument)



Australian artist Patricia Piccinini's concept of what human-animal hybrids might look like are provocative creatures which are part of a sculpture entitled *The Young Family*, produced to address the reality of such possible parahumans in a compassionate way. Transhumanists would call for the recognition of self-aware parahumans as persons.

Biopolitical activist Jeremy Rifkin and biologist Stuart Newman accept that biotechnology has the power to make profound changes in organismal identity. They argue against the genetic engineering of human beings, because they fear the blurring of the boundary between human and artifact. Philosopher Keekok Lee sees such developments as part of an accelerating trend in modernization in which technology has been used to transform the "natural" into the "artificial". In the extreme, this could lead to the manufacturing and enslavement of "monsters" such as human clones, human-animal chimeras or bioroids, but even lesser dislocations of humans and non-humans from social and ecological systems are seen as problematic. The film *Blade Runner* (1982), the novels *The Boys From Brazil* (1978) and *The Island of Dr. Moreau* (1896)

depict elements of such scenarios, but Mary Shelley's 1818 novel *Frankenstein* is most often alluded to by critics who suggest that biotechnologies could create objectified and socially unmoored people and subhumans. Such critics propose that strict measures be implemented to prevent what they portray as dehumanizing possibilities from ever happening, usually in the form of an international ban on human genetic engineering.

Writing in *Reason* magazine, Ronald Bailey has accused opponents of research involving the modification of animals as indulging in alarmism when they speculate about the creation of subhuman creatures with human-like intelligence and brains resembling those of *Homo sapiens*. Bailey insists that the aim of conducting research on animals is simply to produce human health care benefits.

A different response comes from transhumanist personhood theorists who object to what they characterize as the anthropomorphobia fueling some criticisms of this research, which science writer Isaac Asimov termed the "Frankenstein complex". They argue that, provided they are self-aware, human clones, human-animal chimeras and uplifted animals would all be unique persons deserving of respect, dignity, rights and citizenship. They conclude that the coming ethical issue is not the creation of so-called monsters but what they characterize as the "yuck factor" and "human-racism" that would judge and treat these creations as monstrous.

Specter of coercive eugenicism (*Eugenics Wars* argument)

Some critics of transhumanism allege an ableist bias in the use of such concepts as "limitations", "enhancement" and "improvement". Some even see the old eugenics, social Darwinist and master race ideologies and programs of the past as warnings of what the promotion of eugenic enhancement technologies might unintentionally encourage. Some fear future "eugenics wars" as the worst-case scenario: the return of coercive state-sponsored genetic discrimination and human rights violations such as compulsory sterilization of persons with genetic defects, the killing of the institutionalized and, specifically, segregation from, and genocide of, "races" perceived as inferior. Health law professor George Annas and technology law professor Lori Andrews are prominent advocates of the position that the use of these technologies could lead to such human-posthuman caste warfare.

For most of its history, eugenics has manifested itself as a movement to sterilize against their will the "genetically unfit" and encourage the selective breeding of the genetically fit. The major transhumanist organizations strongly condemn the coercion involved in such policies and reject the racist and classist assumptions on which they were based, along with the pseudoscientific notions that eugenic improvements could be accomplished in a practically meaningful time frame through selective human breeding. Most transhumanist thinkers instead advocate a "new eugenics", a form of egalitarian liberal eugenics. In their 2000 book *From Chance to Choice: Genetics and Justice*, (non-transhumanist) bioethicists Allen Buchanan, Dan Brock, Norman Daniels and Daniel Wikler have argued that liberal societies have an obligation to *encourage* as wide an adoption of eugenic enhancement technologies as possible (so long as such policies do

not infringe on individuals' reproductive rights or exert undue pressures on prospective parents to use these technologies) in order to maximize public health and minimize the inequalities that may result from both natural genetic endowments and unequal access to genetic enhancements. Most transhumanists holding similar views nonetheless distance themselves from the term "eugenics" (preferring "germinal choice" or "reprogenetics") to avoid having their position confused with the discredited theories and practices of early-20th-century eugenic movements.

Existential risks (*Terminator* argument)

Struck by a passage from Unabomber Theodore Kaczynski's anarcho-primitivist manifesto (quoted in Ray Kurzweil's 1999 book, *The Age of Spiritual Machines*), computer scientist Bill Joy became a notable critic of emerging technologies. Joy's 2000 essay "Why the future doesn't need us" argues that human beings would likely guarantee their own extinction by developing the technologies favored by transhumanists. It invokes, for example, the "grey goo scenario" where out-of-control self-replicating nanorobots could consume entire ecosystems, resulting in global ecophagy. Joy's warning was seized upon by appropriate technology organizations such as the ETC Group. Related notions were also voiced by self-described neo-luddite Kalle Lasn, a culture jammer who co-authored a 2001 spoof of Donna Haraway's 1985 *Cyborg Manifesto* as a critique of the techno-utopianism he interpreted it as promoting. Lasn argues that high technology development should be completely relinquished since it inevitably serves corporate interests with devastating consequences on society and the environment.

In his 2003 book *Our Final Hour*, British Astronomer Royal Martin Rees argues that advanced science and technology bring as much risk of disaster as opportunity for progress. However, Rees does not advocate a halt to scientific activity; he calls for tighter security and perhaps an end to traditional scientific openness. Advocates of the precautionary principle, such as many in the environmental movement, also favor slow, careful progress or a halt in potentially dangerous areas. Some precautionists believe that artificial intelligence and robotics present possibilities of alternative forms of cognition that may threaten human life. The *Terminator* franchise's doomsday depiction of the emergence of an A.I. that becomes a superintelligence - Skynet, a malignant computer network which initiates a nuclear war in order to exterminate the human species, has often been cited by some involved in this debate.

Transhumanists do not necessarily rule out specific restrictions on emerging technologies so as to lessen the prospect of existential risk. Generally, however, they counter that proposals based on the precautionary principle are often unrealistic and sometimes even counter-productive, as opposed to the technogaian current of transhumanism which they claim is both realistic and productive. In his television series *Connections*, science historian James Burke dissects several views on technological change, including precautionism and the restriction of open inquiry. Burke questions the practicality of some of these views, but concludes that maintaining the *status quo* of inquiry and development poses hazards of its own, such as a disorienting rate of change and the

depletion of our planet's resources. The common transhumanist position is a pragmatic one where society takes deliberate action to ensure the early arrival of the benefits of safe, clean, alternative technology rather than fostering what it considers to be anti-scientific views and technophobia.

One transhumanist solution proposed by Nick Bostrom is differential technological development, in which attempts would be made to influence the sequence in which technologies developed. In this approach, planners would strive to retard the development of possibly harmful technologies and their applications, while accelerating the development of likely beneficial technologies, especially those that offer protection against the harmful effects of others. An argument for an "anti-progressionist and pessimistic version of transhumanism" has also been presented by Philippe Verdoux.

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Chapter- 2

Biological Immortality

Biological immortality is the absence of a sustained increase in rate of mortality as a function of chronological age. A cell or organism that does not age, or which at some point in its life will cease to age, is one which is deemed to be biologically immortal. However, this definition of immortality has been challenged in the new "Handbook of the Biology of Aging", because the increase in rate of mortality as a function of chronological age may be negligible at extremely old ages (late-life mortality plateau). But even though the rate of mortality ceases to increase in old age, those rates are very high (e.g., 50% chance of surviving another year at 110 or 115 years of age).

No actual organism or individual cell is inviolably immortal (i.e. "invincible" or "indestructible"). Any real living object enjoying *biological immortality* would still be able to die, for example, upon receiving sufficient injury or otherwise having its body destroyed or diseased.

Cell lines

Biologists have chosen the word immortal to designate cells that are not limited by the Hayflick limit (where cells no longer divide because of DNA damage or shortened telomeres). (Prior to the work of Leonard Hayflick there was the erroneous belief fostered by Alexis Carrel that all normal somatic cells are immortal.)

The term immortalization was first applied to cancer cells that expressed the telomere-lengthening enzyme telomerase, and thereby avoided apoptosis (programmed cell death). Among the most commonly used cell lines are HeLa and Jurkat, both of which are immortalized cancer cell lines. Normal stem cells and germ cells can also be said to be immortal (when humans refer to the cell line).

Immortal cell lines of cancer cells can be created by induction of oncogenes or loss of tumor suppressor genes. One way to induce immortality is through viral-mediated induction of the large T-antigen, commonly introduced through simian virus 40 (SV-40).

In terms of multi-cellular organisms, immortality may not be a desirable condition, as the main controls over cancer are the apoptotic mechanisms.

Tardigrades

Tardigrades, otherwise known as "water bears" are highly resilient microscopic animals. They have indefinite senescence; moreover, unlike bacteria, they are quite difficult to destroy. A current mission is planned by the Russian Space Administration to launch water bears at Phobos to study the scientific theory of panspermia.

Bacteria

Bacteria are said to be biologically immortal, but only as a colony. An individual bacterium can easily die. The two daughter bacteria resulting from cell division of a parent bacterium can be regarded as unique individuals or as members of a biologically "immortal" colony. The two daughter cells can be regarded as "rejuvenated" copies of the parent cell because damaged macromolecules have been split between the two cells and diluted. In the same way stem cells and gametes can be regarded as "immortal".

Hydra

Hydras are a genus of simple, fresh-water animals possessing radial symmetry and no post-mitotic cells. The fact that all cells continually divide allows defects and toxins to be "diluted-away". It has been suggested that hydras do not undergo senescence (aging), and as such are biologically immortal. However, this does not explain how hydras are consequently able to maintain telomere lengths.

Jellyfish

Turritopsis nutricula is a small (5 mm or 0.2 in) species of jellyfish which uses transdifferentiation to replenish cells after sexual reproduction. This cycle can repeat indefinitely, potentially rendering it biologically immortal. It originates from the Caribbean sea, but has now spread around the world.

Life extensionists

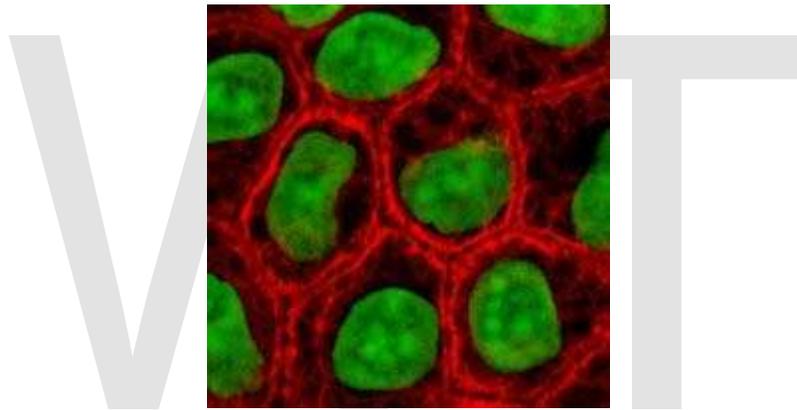
Some life extensionists, such as those who practice cryonics, have the hope that humans may someday become biologically immortal. This would not be the same as literal immortality, since humans are still susceptible to death through external circumstances.

Biogerontologist Marios Kyriazis suggested that biological immortality in humans is an inevitable consequence of natural evolution. His ELPIs (Extreme Lifespans through Perpetual-equalising Interventions) theory proposes that the ability to attain indefinite lifespans is inherent in human biology, and that there will come a time when humans will

continue to develop their intelligence and sophistication by living indefinitely, rather than through Darwinian evolution.

Recently (2010), experiments in longevity and age reversal on mice at the Dana-Farber Cancer Institute has led to the first reversal of aging symptoms in a mammal. The mice were engineered to have damaged intestines, small testes, shrunken brains that produced no new brain cells, and a damaged olfactory sense, giving it an estimated human equivalent age of around 80. Researchers injected the mice with a drug that switched on a gene that stimulated telomerase production and the mice went on to live a perfectly normal lifespan. How significant the cancer risk from this treatment is, and if this treatment can be performed on humans or even non-genetically engineered mice is yet to be investigated.

Cell culture



Epithelial cells in culture, stained for keratin (red) and DNA (green)

Cell culture is the complex process by which cells are grown under controlled conditions. In practice, the term "cell culture" has come to refer to the culturing of cells derived from multicellular eukaryotes, especially animal cells. However, there are also cultures of plants, fungi and microbes, including viruses, bacteria and protists. The historical development and methods of cell culture are closely interrelated to those of tissue culture and organ culture.

Animal cell culture became a common laboratory technique in the mid-1900s, but the concept of maintaining live cell lines separated from their original tissue source was discovered in the 19th century.

History

The 19th-century English physiologist Sydney Ringer developed salt solutions containing the chlorides of sodium, potassium, calcium and magnesium suitable for maintaining the

beating of an isolated animal heart outside of the body. In 1885 Wilhelm Roux removed a portion of the medullary plate of an embryonic chicken and maintained it in a warm saline solution for several days, establishing the principle of tissue culture. Ross Granville Harrison, working at Johns Hopkins Medical School and then at Yale University, published results of his experiments from 1907–1910, establishing the methodology of tissue culture.

Cell culture techniques were advanced significantly in the 1940s and 1950s to support research in virology. Growing viruses in cell cultures allowed preparation of purified viruses for the manufacture of vaccines. The injectable polio vaccine developed by Jonas Salk was one of the first products mass-produced using cell culture techniques. This vaccine was made possible by the cell culture research of John Franklin Enders, Thomas Huckle Weller, and Frederick Chapman Robbins, who were awarded a Nobel Prize for their discovery of a method of growing the virus in monkey kidney cell cultures.

Concepts in mammalian cell culture

Isolation of cells

Cells can be isolated from tissues for *ex vivo* culture in several ways. Cells can be easily purified from blood, however only the white cells are capable of growth in culture. Mononuclear cells can be released from soft tissues by *enzymatic digestion* with enzymes such as collagenase, trypsin, or pronase, which break down the extracellular matrix. Alternatively, pieces of tissue can be placed in growth media, and the cells that grow out are available for culture. This method is known as *explant culture*.

Cells that are cultured directly from a subject are known as **primary cells**. With the exception of some derived from tumors, most primary cell cultures have limited lifespan. After a certain number of population doublings (called the Hayflick limit) cells undergo the process of senescence and stop dividing, while generally retaining viability.

An established or **immortalised cell line** has acquired the ability to proliferate indefinitely either through random mutation or deliberate modification, such as artificial expression of the telomerase gene. There are numerous well established cell lines representative of particular cell types.

Maintaining cells in culture

Cells are grown and maintained at an appropriate temperature and gas mixture (typically, 37°C, 5% CO₂ for mammalian cells) in a cell incubator. Culture conditions vary widely for each cell type, and variation of conditions for a particular cell type can result in different phenotypes being expressed.

Aside from temperature and gas mixture, the most commonly varied factor in culture systems is the growth medium. Recipes for growth media can vary in pH, glucose concentration, growth factors, and the presence of other nutrients. The growth factors

used to supplement media are often derived from animal blood, such as calf serum. One complication of these blood-derived ingredients is the potential for contamination of the culture with viruses or prions, particularly in biotechnology medical applications. Current practice is to minimize or eliminate the use of these ingredients wherever possible, but this cannot always be accomplished. Alternative strategies involve sourcing the animal blood from countries with minimum BSE/TSE risk such as Australia and New Zealand, and using purified nutrient concentrates derived from serum in place of whole animal serum for cell culture.

Plating density (number of cells per volume of culture medium) plays a critical role for some cell types. For example, a lower plating density makes granulosa cells exhibit estrogen production, while a higher plating density makes them appear as progesterone producing theca lutein cells.

Cells can be grown in *suspension* or *adherent* cultures. Some cells naturally live in suspension, without being attached to a surface, such as cells that exist in the bloodstream. There are also cell lines that have been modified to be able to survive in suspension cultures so that they can be grown to a higher density than adherent conditions would allow. Adherent cells require a surface, such as tissue culture plastic or microcarrier, which may be coated with extracellular matrix components to increase adhesion properties and provide other signals needed for growth and differentiation. Most cells derived from solid tissues are adherent. Another type of adherent culture is *organotypic culture* which involves growing cells in a three-dimensional environment as opposed to two-dimensional culture dishes. This 3D culture system is biochemically and physiologically more similar to *in vivo* tissue, but is technically challenging to maintain because of many factors (e.g. diffusion).

Cell line cross-contamination

Cell line cross-contamination can be a problem for scientists working with cultured cells. Studies suggest that anywhere from 15–20% of the time, cells used in experiments have been misidentified or contaminated with another cell line. Problems with cell line cross contamination have even been detected in lines from the NCI-60 panel, which are used routinely for drug-screening studies. Major cell line repositories including the American Type Culture Collection (ATCC) and the German Collection of Microorganisms and Cell Cultures (DSMZ) have received cell line submissions from researchers that were misidentified by the researcher. Such contamination poses a problem for the quality of research produced using cell culture lines, and the major repositories are now authenticating all cell line submissions. ATCC uses short tandem repeat (STR) DNA fingerprinting to authenticate its cell lines.

To address this problem of cell line cross-contamination, researchers are encouraged to authenticate their cell lines at an early passage to establish the identity of the cell line. Authentication should be repeated before freezing cell line stocks, every two months during active culturing and before any publication of research data generated using the cell lines. There are many methods for identifying cell lines including isoenzyme

analysis, human lymphocyte antigen (HLA) typing, Chromosomal analysis, Karyotyping, Morphology and STR analysis.

One significant cell-line cross contaminant is the immortal HeLa cell line.

Manipulation of cultured cells

As cells generally continue to divide in culture, they generally grow to fill the available area or volume. This can generate several issues:

- Nutrient depletion in the growth media
- Accumulation of apoptotic/necrotic (dead) cells.
- Cell-to-cell contact can stimulate cell cycle arrest, causing cells to stop dividing known as contact inhibition or senescence.
- Cell-to-cell contact can stimulate cellular differentiation.

Among the common manipulations carried out on culture cells are media changes, passaging cells, and transfecting cells. These are generally performed using tissue culture methods that rely on sterile technique. Sterile technique aims to avoid contamination with bacteria, yeast, or other cell lines. Manipulations are typically carried out in a biosafety hood or laminar flow cabinet to exclude contaminating micro-organisms. Antibiotics (e.g. penicillin and streptomycin) and antifungals (e.g. Amphotericin B) can also be added to the growth media.

As cells undergo metabolic processes, acid is produced and the pH decreases. Often, a pH indicator is added to the medium in order to measure nutrient depletion.

Media changes

In the case of adherent cultures, the media can be removed directly by aspiration and replaced.

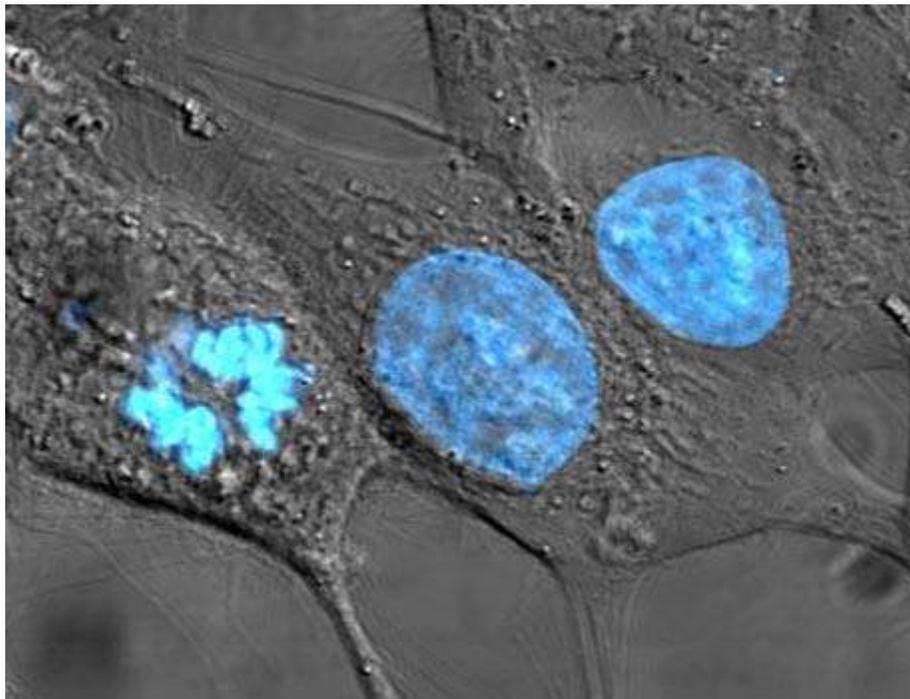
Passaging cells

Passaging (also known as subculture or splitting cells) involves transferring a small number of cells into a new vessel. Cells can be cultured for a longer time if they are split regularly, as it avoids the senescence associated with prolonged high cell density. Suspension cultures are easily passaged with a small amount of culture containing a few cells diluted in a larger volume of fresh media. For adherent cultures, cells first need to be detached; this is commonly done with a mixture of trypsin-EDTA, however other enzyme mixes are now available for this purpose. A small number of detached cells can then be used to seed a new culture.

Transfection and transduction

Another common method for manipulating cells involves the introduction of foreign DNA by transfection. This is often performed to cause cells to express a protein of interest. More recently, the transfection of RNAi constructs have been realized as a convenient mechanism for suppressing the expression of a particular gene/protein. DNA can also be inserted into cells using viruses, in methods referred to as transduction, infection or transformation. Viruses, as parasitic agents, are well suited to introducing DNA into cells, as this is a part of their normal course of reproduction.

Established human cell lines



One of the earliest human cell lines, descended from Henrietta Lacks, who died of the cancer that those cells originated from, the cultured HeLa cells shown here have been stained with Hoechst turning their nuclei blue.

Cell lines that originate with humans have been somewhat controversial in bioethics, as they may outlive their parent organism and later be used in the discovery of lucrative medical treatments. In the pioneering decision in this area, the Supreme Court of California held in *Moore v. Regents of the University of California* that human patients have no property rights in cell lines derived from organs removed with their consent.

Generation of hybridomas

It is possible to fuse normal cells with an immortalised cell line. This method is used to produce monoclonal antibodies. In brief, lymphocytes isolated from the spleen (or

possibly blood) of an immunised animal are combined with an immortal myeloma cell line (B cell lineage) to produce a hybridoma which has the antibody specificity of the primary lymphocyte and the immortality of the myeloma. Selective growth medium (HA or HAT) is used to select against unfused myeloma cells; primary lymphocytes die quickly in culture and only the fused cells survive. These are screened for production of the required antibody, generally in pools to start with and then after single cloning.

Applications of cell culture

Mass culture of animal cell lines is fundamental to the manufacture of viral vaccines and other products of biotechnology

Biological products produced by recombinant DNA (rDNA) technology in animal cell cultures include enzymes, synthetic hormones, immunobiologicals (monoclonal antibodies, interleukins, lymphokines), and anticancer agents. Although many simpler proteins can be produced using rDNA in bacterial cultures, more complex proteins that are glycosylated (carbohydrate-modified) currently must be made in animal cells. An important example of such a complex protein is the hormone erythropoietin. The cost of growing mammalian cell cultures is high, so research is underway to produce such complex proteins in insect cells or in higher plants, use of single embryonic cell and somatic embryos as a source for direct gene transfer via particle bombardment, transit gene expression and confocal microscopy observation is one of its applications. It also offers to confirm single cell origin of somatic embryos and the asymmetry of the first cell division, which starts the process. -

Tissue culture and engineering

Cell culture is a fundamental component of tissue culture and tissue engineering, as it establishes the basics of growing and maintaining cells *ex vivo*. The major application of human cell culture is in stem cell industry where mesenchymal stem cells can be cultured and cryopreserved for future use.

Vaccines

Vaccines for polio, measles, mumps, rubella, and chickenpox are currently made in cell cultures. Due to the H5N1 pandemic threat, research into using cell culture for influenza vaccines is being funded by the United States government. Novel ideas in the field include recombinant DNA-based vaccines, such as one made using human adenovirus (a common cold virus) as a vector, , such as adjuvants.

Culture of non-mammalian cells

Plant cell culture methods

Plant cell cultures are typically grown as cell suspension cultures in liquid medium or as callus cultures on solid medium. The culturing of undifferentiated plant cells and calli requires the proper balance of the plant growth hormones auxin and cytokinin.

Bacterial and yeast culture methods

For bacteria and yeast, small quantities of cells are usually grown on a solid support that contains nutrients embedded in it, usually a gel such as agar, while large-scale cultures are grown with the cells suspended in a nutrient broth.

Viral culture methods

The culture of viruses requires the culture of cells of mammalian, plant, fungal or bacterial origin as hosts for the growth and replication of the virus. Whole wild type viruses, recombinant viruses or viral products may be generated in cell types other than their natural hosts under the right conditions. Depending on the species of the virus, infection and viral replication may result in host cell lysis and formation of a viral plaque.

Common cell lines

Human cell lines

- National Cancer Institute's 60 cancer cell lines
- DU145 (Prostate cancer)
- Lncap (Prostate cancer)
- MCF-7 (breast cancer)
- MDA-MB-438 (breast cancer)
- PC3 (Prostate cancer)
- T47D (breast cancer)
- THP-1 (acute myeloid leukemia)
- U87 (glioblastoma)
- SHSY5Y Human neuroblastoma cells, cloned from a myeloma
- Saos-2 cells (bone cancer)

Primate cell lines

- Vero (African green monkey *Chlorocebus* kidney epithelial cell line initiated 1962)

Rat tumor cell lines

- GH3 (pituitary tumor)
- PC12 (pheochromocytoma)

Mouse cell lines

- MC3T3 (embryonic calvarial)

Plant cell lines

- Tobacco BY-2 cells (kept as cell suspension culture, they are model system of plant cell)

Other species cell lines

- zebrafish ZF4 and AB9 cells.
- *Madin-Darby Canine Kidney (MDCK)* epithelial cell line
- Xenopus A6 kidney epithelial cells.

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Chapter- 3

Ideologies of Transhumanism

Abolitionism (bioethics)

Abolitionism is a bioethical school and movement which proposes the use of biotechnology to maximize happiness and minimize suffering while working towards the abolition of involuntary suffering. “Abolition” is used for the name of this movement, in the context of “the abolition of suffering”.

The Abolitionist Society is a non-profit foundation and forum, founded in 2002, dedicated to the advancement of this philosophy.

Philosophy

In this context, Abolitionism (not to be confused with the anti-slavery movement of the same name) is inspired by Jeremy Bentham’s utilitarian ethic, but goes a step further in that it is more principally inspired by the tenets of negative utilitarianism. Some Abolitionists consider the elimination of genetic discrimination to be a vital component of Abolitionism in the larger sense: eliminating all involuntary sentient suffering, which is believed to stem from Darwinian design. Most abolitionists would be classified as negative utilitarian, believing that suffering of any kind, no matter how small, should be prevented. Philosopher David Pearce’s abolitionist manifesto, “The Hedonistic Imperative”, serves as both an inspiration for the group’s theories and as a demonstration of how the world can convert Abolitionist philosophy into reality.

To many people surveyed, achieving the highest level of happiness possible is the most important aspect and primary goal of their lives. Many people think that money or love will make them happier, but this has not been found to be the case in scientific studies. Happiness exists, but sometimes not for long, and people experience negative consequences from emotions and events to a greater extent than they experience the opposite effect from positive emotions — it is easy to make someone unhappy and much less easy to make that person happy again. Humans have been found in studies to achieve a “baseline happiness,” sometimes called the hedonic treadmill, a pre-determined

happiness level that a person will return to throughout their entire lives no matter what happens to him or her, regardless of income, and regardless of the occurrence of events that most people theorize would make a person permanently happy or permanently sad, such as a lottery win or the death of a close relative.

According to evolutionary theory, humans evolved through natural selection and follow genetic imperatives which seek to maximize reproduction, not happiness. As a result of these selection pressures, the extent of human happiness is limited biologically. Through advanced scientific research, especially in the fields of neuroscience, biotechnology, nanotechnology, genetic engineering, and psychopharmacology, Pearce theorizes in his manifesto that humans can overcome their genetic propensity for depression and suffering. Abolitionists see depression as a physical, not mental, deficiency, that can therefore be solved just as anesthesia can prevent pain and just as medication can often make one feel better or worse. A depressed person can usually feel better only by attacking the physical root of the depression (e.g. by taking an antidepressant that changes serotonin re-uptake levels in the brain). By similarly re-engineering the brain, abolitionists believe that humans could become a new kind of being with invincible, lifelong super-happiness. Some hope that this could be accomplished not only through technology already in the pipeline, such as genetic engineering, but also through techniques that have not yet been realized such as mind uploading.

Abolitionists promote the idea that emotions have a physically manipulable, not spiritual, source - and that therefore we have the ability to fundamentally change the way that human brains operate and the way that humans experience life. Abolitionists believe that where biological evolution has failed to create happiness for all people, technology can take over and eventually create a new type of posthuman which feels only happiness and never suffers involuntarily while retaining and enhancing observable functionality. The Abolitionist Society is dedicated to bringing this idea to fruition.

Scientific advancements

The Abolitionist Society aims to achieve its goals through scientific research. Recent laboratory breakthroughs have bolstered the idea that happiness is physically based and can be influenced through scientific methods.

In 2006, Guillaume Lucas of McGill University and his colleagues published results indicating that depression may become treatable or preventable through gene manipulation. Mice born without a gene coding for the expression of a potassium channel found in depression-related neurons have resistance to depression (as tested by standard behavioral measures in the rodent model) comparable to that of naive mice treated with selective serotonin reuptake inhibitors (SSRIs).

An important discovery that boosts the case for the potential to abolish suffering is the example of deep brain stimulation of the brain's pleasure centers. The direct electrical stimulation does not create tolerance proving that there is a potential to overcome the brain's anhedonic homeostatic mechanisms. Pacemaker-type neurostimulators have been

shown to reliably increase observed happiness without causing detriments to functionality: these interventions have proven to actually increase various cognitive and social aspects of human functionality.

Neuroscientist R.J. Davidson has developed reliable means to objectively quantify subjective affective status using fMRI and EEG - demonstrating that happiness can be measured. Davidson's technological innovations also provide a more accurate means of assessing happiness than that provided by subjective questionnaires.

Abolitionism

The term “abolitionism,” used to describe the use of biotechnology to eliminate suffering, was first proposed by Lewis Mancini in 1986, in his articles for *Medical Hypotheses Journal*. Abolitionism is the use of science to maximize happiness and minimize suffering — not just in humans but in all sentient life. It is a philosophy inspired by utilitarian ethics: if happiness equals value, then the elimination of suffering or 'maximization of value' should be the prime objective of the human race.

Abolitionism makes no distinction among sentient creatures— all are deemed worthy of being saved from suffering by biotechnological intervention.

An ethical system that is similar to transhumanism, Abolitionism deliberately defines its rationale and method of determining value according to a prime ethical directive with a focus on eliminating involuntary suffering, whereas Transhumanism promotes a collection of values including the well-being of all sentient beings without addressing the question of whether or not involuntary suffering should eventually be eliminated.

Founders

David Pearce, author of “The Hedonistic Imperative” and honorary president, founded the group with Pablo Stafforini, Sean Henderson, and Jaime Savage. The Abolitionist Society now serves as the focal point and prime community for this movement and philosophy. Pearce maintains a network of related websites on the abolitionist movement and associated subjects. The Abolitionist Society exists as a forum and ongoing initiative to critically evaluate and apply the ideals of Abolitionism through means of a nonprofit foundation.

Activities

The Abolitionist Society focuses primarily on promoting discussion and debate through the society's website forums as well as in other prominent and related forums. Designing websites which serve to educate as well as gain critical attention for the movement are also integral to the society's mission. Other initiatives include collaborating with prominent thinkers in the field of ethics and philosophy to spread the Abolitionist meme as well as conducting interviews with various thinkers and activists. Many discussions

with various leaders in the related fields of philosophy and ethics are undertaken covertly. The director of the society engages in open debate with any interested parties that would like to challenge the soundness of the Abolitionist directive.

Quotes

Technofantasy? Quite possibly. Perhaps we'll opt to conserve the nasty side of life for ever. But if you think minimising suffering is a good idea – and bioscience holds the answers – then web-based campaigning to win hearts and minds is a rational strategy.

– David Pearce

Democratic transhumanism

Democratic transhumanism, a term coined by Dr. James Hughes in 2002, refers to the stance of transhumanists (advocates for the development and use of human enhancement technologies) who espouse liberal, social and/or radical democratic political views.

According to Hughes, the ideology "stems from the assertion that human beings will generally be happier when they take rational control of the natural and social forces that control their lives." The ethical foundation of democratic transhumanism rests upon rule utilitarianism and non-anthropocentric personhood theory.

While raising objections both to right-wing and left-wing bioconservatism, and libertarian transhumanism, Hughes aims to encourage democratic transhumanists and their potential progressive allies to unite as a new social movement and influence biopolitical public policy.

An attempt to expand the middle ground between technorealism and techno-utopianism, democratic transhumanism can be seen as a radical form of techno-progressivism.

Appearing several times in Hughes' democratic transhumanist agitprop, the term "radical" (from Latin *rādīx*, *rādīc-*, root) is used as an adjective meaning *of or pertaining to the root* or *going to the root*. His central thesis is that emerging technologies and radical democracy can help citizens overcome some of the *root causes* of inequalities of power.

Trends

Hughes has identified 15 "left futurist" or "left techno-utopian" trends and projects that could be incorporated into democratic transhumanism:

- Afrofuturism
- Assistive technology-enabled disabled people
- Biopunk science fiction and movement
- Body modification culture
- Cyborg feminism/cyberfeminism
- Feminist science fiction
- Lesbian science fiction, Gay science fiction, Bisexual science fiction, and Transgender science fiction
- Nanosocialism
- Free software movement
- Post-Darwinian leftism
- Postcyberpunk science fiction
- Post-work/guaranteed minimum income movement
- Technogaianism
- Up-wing politics
- Viridian design movement

List of democratic transhumanists

This section contains an alphabetically-ordered list of notable individuals who have identified themselves or been identified by Hughes as advocates of democratic transhumanism:

- Ben Hyink
- Charles Stross
- Jamais Cascio
- George Dvorsky
- Giulio Prisco
- Ken MacLeod
- Mark Alan Walker
- Martine Rothblatt
- Pablo Stafforini
- Philip Shropshire
- Ramez Naam
- Riccardo Campa
- Robin Green

Criticism

Science journalist Ronald Bailey wrote a review of *Citizen Cyborg* in his online column for *Reason* magazine in which he offered a critique of democratic transhumanism and a defense of libertarian transhumanism.

Critical theorist Dale Carrico defended democratic transhumanism from Bailey's criticism. However, he would later criticize democratic transhumanism himself on technoprogressive grounds.

Extropianism

Extropianism, also referred to as the philosophy of "*Extropy*", is an evolving framework of values and standards for continuously improving the human condition. Extropians believe that advances in science and technology will some day let people live indefinitely and that humans alive today have a good chance of seeing that day. An extropian may wish to contribute to this goal, e.g. by doing research and development or volunteering to test new technology.

Extropianism describes a pragmatic consilience of transhumanist thought guided by a proactionary approach to human evolution and progress.

Originated by a set of principles developed by Dr. Max More, *The Principles of Extropy*, extropian thinking places strong emphasis on rational thinking and practical optimism. According to More, these principles "do not specify particular beliefs, technologies, or policies". Extropians share an optimistic view of the future, expecting considerable advances in computational power, life extension, nanotechnology and the like. Many extropians foresee the eventual realization of unlimited maximum life spans, and the recovery, thanks to future advances in biomedical technology, of those whose bodies/brains have been preserved by means of cryonics.

Extropy

Extropy, as coined by Tom Bell (T.O. Morrow) and defined by Max More in 1988, is "the extent of a living or organizational system's intelligence, functional order, vitality, energy, life, experience, and capacity and drive for improvement and growth." Extropy is not a rigorously defined technical term in philosophy or science; in a metaphorical sense, it simply expresses the opposite of entropy.

In the philosophy of digital probabilistic physics, the extropy of a physical system is defined to be the self-information of the Markov chain probability of the physical system at a moment in time. This was to distinguish the probability of the Markov state of the physical system from the probability defined by entropy which creates ensembles of equivalent microstates.

The Extropy Institute

In 1987, Max More moved to Los Angeles from Oxford University in England, where he had helped to establish (along with Michael Price, Garret Smyth and Luigi Warren) the first European cryonics organization, known as Mizar Limited (later Alcor UK), to work on his Ph.D. in philosophy at the University of Southern California.

In 1988, *Extropy: The Journal of Transhumanist Thought* was first published. This brought together thinkers with interests in artificial intelligence, nanotechnology, genetic engineering, life extension, mind uploading, idea futures, robotics, space exploration,

memetics, and the politics and economics of transhumanism. Alternative media organizations soon began reviewing the magazine, and it attracted interest from likeminded thinkers. Later, More and Bell co-founded the Extropy Institute, a non-profit 501(c)(3) educational organization. "ExI" was formed as a transhumanist networking and information center to use current scientific understanding along with critical and creative thinking to define a small set of principles or values that could help make sense of new capabilities opening up to humanity.

The Extropy Institute's email list was launched in 1991 (and, as of August 2009, continues to exist as "Extropy-Chat"), and in 1992 the institute began producing the first conferences on transhumanism. Affiliate members throughout the world began organizing their own transhumanist groups. Extro Conferences, meetings, parties, on-line debates, and documentaries continue to spread transhumanism to the public.

The Internet soon became the most fertile breeding ground for people interested in exploring transhumanist ideas, with the availability of websites for such organizations that have joined the Extropy Institute in developing and advocating transhumanist (and related) ideas. These include Humanity+, the Alcor Life Extension Foundation, the Life Extension Foundation, Foresight Institute, Transhumanist Arts & Culture, The Extropist Examiner, the Immortality Institute, Betterhumans, Aleph in Sweden, the Singularity Institute for Artificial Intelligence, and the Institute for Ethics and Emerging Technologies.

In 2006 the board of directors of the Extropy Institute made a decision to close the organisation, stating that its mission was "essentially completed."

Extropism

Extropism is a modern derivative of the transhumanist philosophy of Extropianism. It follows in the same tradition, hence the similarity of name, but has been revised to better suit the paradigms of the 21st century. As introduced in *The Extropist Manifesto*, it promotes an optimistic futuristic philosophy that can be summed up in the following five phrases, which spell out the word "EXTROPISM":

- Endless eXtension
- Transcending Restriction
- Overcoming Property
- Intelligence
- Smart Machines

These five key points, when taken together, formulate a philosophy and world view which embraces bio-ethical abolitionism, life extension, singularitarianism, technogaianism, freedom of information and several other related disciplines and philosophies. While it does not make a firm political stance, it is most closely related to libertarianism. Philosophically, it draws from the philosophy of Jeremy Bentham and utilitarianism.

Extropists desire to prolong their life span to a near-immortal state and exist in a world where artificial intelligence and robotics have made work irrelevant. As in utilitarianism, the purpose of one's life should be to increase the overall happiness of all creatures on Earth through cooperation.

The Extropist Manifesto, written by Breki Tomasson and Hank Hyena of The Extropist Examiner in January 2010, details the ways in which Extropism has evolved away from, while building upon the original tenets of Extropianism. For example, it moves away from the original Extropian Principles by placing a significant focus on the need to abolish and/or restrict the current use of surveillance, copyright and patent laws. This philosophy, inspired in part by the philosophy of the International Pirate Party, is one of the five basic tenets of the Extropist philosophy, falling under the category "Overcoming Property". Other noteworthy topics that appear frequently in Extropist writings is the focus on equal rights for LGBT couples and individuals and a general distaste for religiosity.

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Chapter- 4

Other Important Ideologies of Transhumanism

Libertarian transhumanism

Libertarian transhumanism is a political ideology synthesizing libertarianism and transhumanism.

Self-identified libertarian transhumanists, such as Ronald Bailey of *Reason* magazine and Glenn Reynolds of Instapundit, are advocates of the asserted "right to human enhancement" who argue that the free market is the best guarantor of this right since it produces greater prosperity and personal freedom than other economic systems.

Principles

Libertarian transhumanists believe that the principle of self-ownership is the most fundamental idea from which both libertarianism and transhumanism stem. They are rational egoists and ethical egoists who embrace the prospect of using emerging technologies to enhance human capacities, which they believe stems from the self-interested application of reason and will in the context of the individual freedom to achieve a posthuman state of complete physical, mental, and social well-being and not merely the absence of disease or infirmity. They extend this rational and ethical egoism to advocate a form of "biolibertarianism".

As strong civil libertarians, libertarian transhumanists hold that any attempt to limit or suppress the asserted right to human enhancement is a violation of civil rights and civil liberties. However, as strong economic libertarians, they also reject proposed public policies of government-regulated and -insured human enhancement technologies, which are advocated by democratic transhumanists, because they fear that any state intervention will steer or limit their choices.

Extropianism, the earliest current of transhumanist thought defined in 1988 by philosopher Max More, initially included an anarcho-capitalist interpretation of the

concept of "spontaneous order" in its principles, which states that a free market economy achieves a more efficient allocation of societal resources than any planned or mixed economy could achieve. In 2000, while revising the principles of Extropy, More seemed to be abandoning libertarianism in favor of liberalism and anticipatory democracy. However, many Extropians remained libertarian transhumanists.

Criticisms

Critiques of the techno-utopianism of libertarian transhumanists from progressive cultural critics include Richard Barbrook and Andy Cameron's 1995 essay *The Californian Ideology*; Mark Dery's 1996 book *Escape Velocity: Cyberculture at the End of the Century*; and Pauline Borsook's 2000 book *Cyberselfish: A Critical Romp Through the Terribly Libertarian Culture of High-Tech*.

Barbrook argues that libertarian transhumanists are proponents of the Californian Ideology who embrace the goal of reactionary modernism: economic growth without social mobility. According to Barbrook, libertarian transhumanists are unwittingly appropriating the theoretical legacy of Stalinist communism by substituting, among other concepts, the "vanguard party" with the "digerati", and the "new Soviet man" with the "posthuman". Dery coined the dismissive phrase "body-loathing" to describe the attitude of libertarian transhumanists and those in the cyberculture who want to escape from their "meat puppet" through mind uploading into cyberspace. Borsook asserts that libertarian transhumanists indulge in a subculture of selfishness, elitism and escapism.

Sociologist James Hughes is the most militant critic of libertarian transhumanism. While articulating "democratic transhumanism" as a sociopolitical program in his 2004 book *Citizen Cyborg*, Hughes sought to convince libertarian transhumanists to embrace social democracy by arguing that:

1. State action is required to address catastrophic threats from transhumanist technologies;
2. Only believable and effective public policies to prevent adverse consequences from new technologies will reassure skittish publics that they do not have to be banned;
3. Social policies must explicitly address public concerns that transhumanist biotechnologies will exacerbate social inequality;
4. Monopolistic practices and overly restrictive intellectual property law can seriously delay the development of transhumanist technologies, and restrict their access;
5. Only a strong liberal democratic state can ensure that posthumans are not persecuted; and
6. Libertarian transhumanists (who are anti-naturalists) are inconsistent in arguing for the free market on the grounds that it is a natural phenomenon.

Klaus-Gerd Giesen, a German political scientist specializing in the philosophy of technology, wrote a critique of the libertarianism he imputes to all transhumanists. While

pointing out that the works of Austrian School economist Friedrich Hayek figure in practically all of the recommended reading lists of Extropians, he argues that transhumanists, convinced of the sole virtues of the free market, advocate an unabashed inegalitarianism and merciless meritocracy which can be reduced in reality to a biological fetish. He is especially critical of their promotion of a science-fictional libertarian eugenics, virulently opposed to any political regulation of human genetics, where the consumerist model presides over their ideology. Giesen concludes that the despair of finding social and political solutions to today's sociopolitical problems incites transhumanists to reduce everything to the hereditary gene, as a fantasy of omnipotence to be found within the individual, even if it means transforming the subject (human) to a new draft (posthuman).

Postgenderism

Postgenderism is a diverse social, political and cultural movement whose adherents affirm the voluntary elimination of gender in the human species through the application of advanced biotechnology and assistive reproductive technologies.

Advocates of postgenderism argue that the presence of gender roles, social stratification, and cogno-physical disparities and differences are generally to the detriment of individuals and society. Given the radical potential for advanced assistive reproductive options, postgenderists believe that sex for reproductive purposes will either become obsolete, or that all post-gendered humans will have the ability, if they so choose, to both carry a pregnancy to term *and* father a child, which, postgenderists believe, would have the effect of eliminating the need for definite genders in such a society.

Cultural roots

Postgenderism as a cultural phenomenon has roots in feminism, masculism, along with the androgyny, metrosexual/technosexual and transgender movements. However, it has been through the application of transhumanist philosophy that postgenderists have conceived the potential for actual morphological changes to the members of the human species and how future humans in a postgender society will reproduce. In this sense, it is an offshoot of transhumanism, posthumanism, and futurism.

An important and influential work in this regard was socialist feminist Donna Haraway's essay, "A Cyborg Manifesto: Science, Technology, and Socialist-Feminism in the Late Twentieth Century," in Simians, Cyborgs and Women: The Reinvention of Nature (New York; Routledge, 1991), pp. 149–181. In this work, Haraway is interpreted as arguing that women would only be freed from their biological restraints when their reproductive obligations were dispensed with. This may be viewed as Haraway expressing belief that women will only achieve true liberation once they become postbiological organisms, or postgendered. However, Haraway has publicly stated that her use of the word "post-gender" has been grossly misinterpreted.

Types of postgenderism

Postgenderists are not exclusively advocates of androgyny, although most believe that a “mixing” of both masculine and feminine traits is desirable – essentially the creation of androgynous individuals who exhibit the best of what males and females have to offer in terms of physical and psychological abilities and proclivities. Just what these traits are exactly is a matter of great debate and conjecture.

Postgenderism is not concerned with the physical sex or its assumed traits. It is focused on the idea of eliminating or moving beyond gendered identities. In a traditional gender construct one is either a man or woman (regardless of their genitalia), but in postgenderism one is neither a man or woman or any other assumed gender role. Thus an individual in society is not reduced to a gender role but is simply an agent of humanity who is to be defined (if at all) by one's actions.

Future technologies

In regard to potential assistive reproductive technologies, it is believed that reproduction can continue to happen outside of conventional methods, namely intercourse and artificial insemination. Advances such as human cloning, parthenogenesis and artificial wombs may significantly extend the potential for human reproduction.

It is also thought that posthuman space will be more virtual than real. Individuals may consist of uploaded minds living as data patterns on supercomputers or users engaged in completely immersive virtual realities. Postgenderists contend that these types of existences are not gender-specific thus allowing individuals to morph their virtual appearances and sexuality at will.

Singularitarianism

Singularitarianism is a techno-utopian ideology and social movement that is defined by the belief that a technological singularity — the creation of a superintelligence — is a likely possibility within the medium-term future, and that deliberate action ought to be taken to ensure that the technological singularity occurs in a way beneficial to humans.

While many futurists and transhumanists speculate on the possibility and nature of this technological development (often referred to as "the Singularity"), Singularitarians believe it is not only possible, but desirable if, and only if, guided safely. Accordingly, they might sometimes dedicate their lives to acting in ways they believe will contribute to its rapid yet safe implementation.

The term "singularitarian" was originally defined by Extropian thinker Mark Plus (Mark Potts) in 1991 to mean "one who believes the concept of a Singularity". This term has since been redefined to mean "Singularity activist" or "friend of the Singularity"; that is, one who acts so as to bring about the Singularity.

Ray Kurzweil, the author of the book *The Singularity is Near*, defines a Singularitarian as someone "who understands the Singularity and who has reflected on its implications for his or her own life".

Eliezer Yudkowsky, a prominent AI researcher, described, in 2001, Singularitarianism as the true Utopia: "The Singularity holds out the possibility of winning the Grand Prize, the true Utopia, the best-of-all-possible-worlds - not just freedom from pain and stress or a sterile round of endless physical pleasures, but the prospect of endless growth for every human being - growth in mind, in intelligence, in strength of personality; life without bound, without end; experiencing everything we've dreamed of experiencing, becoming everything we've ever dreamed of being; not for a billion years, or ten-to-the-billionth years, but forever... or perhaps embarking together on some still greater adventure of which we cannot even conceive."

History

In the 1980s and 1990s, prior to Singularitarianism being articulated as a coherent ideology, belief in the coming of the Singularity was adopted and expressed by a growing minority of computer scientists and technical journalists:

It feels like something big is about to happen: graphs show us the yearly growth of populations, atmospheric concentrations of carbon dioxide, Net addresses, and Mbytes per dollar. They all soar up to form an asymptote just beyond the turn of the century: The Singularity. The end of everything we know. The beginning of something we may never understand.

—Danny Hillis, "*The Millennium Clock*", *Wired magazine*, 1995

In 1993, American mathematician, computer scientist, and science fiction author Vernor Vinge suggested that the moment might come when some computers are smarter than humans. He may have coined the term "the Singularity." He suggested that it may be somewhat or possibly very dangerous for humans.

In his 2000 essay, "Singularitarian Principles", American artificial intelligence researcher Eliezer Yudkowsky writes that there are four qualities that define a Singularitarian:

- A Singularitarian believes that the Singularity is possible and desirable.
- A Singularitarian actually *works* to bring about the Singularity.
- A Singularitarian views the Singularity as an entirely secular, non-mystical process — not the culmination of any form of religious prophecy or destiny.
- A Singularitarian believes the Singularity should benefit the entire world, and should not be a means to benefit any specific individual or group.

In June 2000 Yudkowsky, Brian Atkins and Sabine Atkins founded the Singularity Institute for Artificial Intelligence to work towards the creation of self-improving Friendly AI. The Singularity Institute's writings argue for the idea that an AI with the ability to improve upon its own design (Seed AI) would rapidly lead to superintelligence.

Singularitarians believe that reaching the Singularity swiftly and safely is the best possible way to minimize net existential risk.

Many believe a technological singularity is possible without adopting Singularitarianism as a moral philosophy. Although the exact numbers are hard to quantify, Singularitarianism is presently a small movement. Other prominent Singularitarians include Ray Kurzweil and Nick Bostrom.

With the support of NASA, Google and a broad range of technology thought leaders and entrepreneurs, the Singularity University opened in June 2009 at the NASA Research Park in Silicon Valley with the goal of preparing the next generation of leaders to address the challenges of accelerating change.

Implications for human safety

In July 2009, academics and technical experts attended a conference organized by the Association for the Advancement of Artificial Intelligence to discuss the potential impact of robots and computers and the impact of the hypothetical possibility that they could become self-sufficient and able to make their own decisions. They discussed the possibility and the extent to which computers and robots might be able to acquire any level of autonomy, and to what degree they could use such abilities to possibly pose any threat or hazard. They noted that some machines have acquired various forms of semi-autonomy, including being able to find power sources on their own and being able to independently choose targets to attack with weapons. They also noted that some computer viruses can evade elimination and have achieved "cockroach intelligence." They noted that self-awareness as depicted in science-fiction is probably unlikely, but that there were other potential hazards and pitfalls. Some experts and academics have questioned the use of robots for military combat, especially when such robots are given some degree of autonomous functions.

The President of the Association for the Advancement of Artificial Intelligence has commissioned a study to look at this issue.

Criticism

Often ridiculing the Singularity as "the Rapture of the Nerds", many critics have dismissed singularitarianism as a pseudoreligion of fringe science. However, some neo-Luddite and green anarchist militants have taken singularitarian rhetoric seriously enough to have called for violent direct action to stop the Singularity.

Technogaianism

Technogaianism (a portmanteau word combining "techno-" for technology and "gaian" for Gaia philosophy) is a bright green environmentalist stance of active support for the research, development and use of emerging and future technologies to help restore Earth's environment. Technogaians argue that developing safe, clean, alternative technology should be an important goal of environmentalists.

Theory

This point of view is different from the default position of radical environmentalists and a common opinion that all technology necessarily degrades the environment, and that environmental restoration can therefore occur only with reduced reliance on technology. Technogaians argue that technology gets cleaner and more efficient with time. They would also point to such things as hydrogen fuel cells to demonstrate that developments do not have to come at the environment's expense. More directly, they argue that such things as nanotechnology and biotechnology can directly reverse environmental degradation. Molecular nanotechnology, for example, could convert garbage in landfills into useful materials and products, while biotechnology could lead to novel microbes that devour hazardous waste.

While many environmentalists still contend that *most* technology is detrimental to the environment, technogaians point out that it has been in humanity's best interests to exploit the environment mercilessly until fairly recently. This sort of behaviour follows accurately to current understandings of evolutionary systems, in that when new factors (such as foreign species or mutant subspecies) are introduced into an ecosystem, they tend to maximise their own resource consumption until either, *a*) they reach an equilibrium beyond which they cannot continue unmitigated growth, or *b*) they become extinct. In these models, it is *completely impossible* for such a factor to totally destroy its host environment, though they may precipitate major ecological transformation before their ultimate eradication. Technogaians believe humanity has currently reached just such a threshold, and that the only way for human civilization to continue advancing is to accept the tenets of technogaianism and limit future exploitive exhaustion of natural resources and minimize further unsustainable development or face the widespread, ongoing mass extinction of species. Furthermore, technogaians argue that only science and technology can help humanity be aware of, and possibly develop counter-measures for, risks to civilization, humans and planet Earth such as a possible impact event.

One controversial example of technogaian practice is an artificial closed ecological system used to test if and how people could live and work in a closed biosphere, while carrying out scientific experiments. It is in some cases used to explore the possible use of closed biospheres in space colonization, and also allows the study and manipulation of a biosphere without harming Earth's. The most advanced technogaian proposal is the "terraforming" of a planet, moon, or other body by deliberately modifying its atmosphere, temperature, or ecology to be similar to those of Earth in order to make it habitable by humans.

Sociologist James Hughes mentions Walter Truett Anderson, author of *To Govern Evolution: Further Adventures of the Political Animal*, as an example of a technogaian political philosopher; argues that technogaianism applied to environmental management is found in the reconciliation ecology writings such as Michael Rosenzweig's *Win-Win Ecology: How The Earth's Species Can Survive In The Midst of Human Enterprise*; and considers Bruce Sterling's Viridian design movement to be an exemplary technogaian initiative.

Criticism

Ecosocialist critics of technogaianism argue that the idea that technological progress will solve ecological problems is popular because it deludes people into hoping that it will prevent them from having to seriously question and change their individual and collective way of life. The development of technology, or of some technical fields at the expense of others, only sustains the capitalist system and feeds profit. Technological fixes to ecological problems are thus rejected by eco-socialists. Saral Sarkar has updated the thesis of 1970s 'limits to growth' to exemplify the limits of new capitalist technologies such as hydrogen fuel cells, which require large amounts of energy to split molecules to obtain hydrogen.

Joel Kovel notes that "events in nature are reciprocal and multi-determined" and can therefore not be predictably "fixed"; socially, technologies cannot solve social problems because they are not "mechanical". He posits an eco-socialist analysis, developed from Marx, that patterns of production and social organisation are more important than the forms of technology used within a given configuration of society. Under capitalism, he suggests that technology "has been the *sine qua non* of growth" - thus he believes that, even in a world with hypothetical "free energy", the effect would be to lower the cost of automobile production, leading to the massive overproduction of vehicles, "collapsing infrastructure", chronic resource depletion and the "paving over" of the "remainder of nature".

In the modern world, Kovel considers the supposed efficiency of new post-industrial commodities is a "plain illusion", as miniaturized components involve many substances and are therefore non-recyclable (and, theoretically, only simple substances could be retrieved by burning out-of-date equipment, releasing more pollutants). He is quick to warn "environmental liberals" against over-selling the virtues of renewable energies that cannot meet the mass energy consumption of the era; although he would still support renewable energy projects, he believes it is more important to restructure societies to reduce energy use before relying on renewable energy technologies alone.

Related environmental ethical schools and movements

- Bright green environmentalism
- Biomimicry
- Reconciliation ecology

- Social ecology
- Viridian design movement

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Chapter- 5

Human Enhancement Technologies

Human enhancement

Human enhancement refers to any attempt to temporarily or permanently overcome the current limitations of the human body through natural or artificial means. The term is sometimes applied to the use of technological means to select or alter human characteristics and capacities, whether or not the alteration results in characteristics and capacities that lie beyond the existing human range. Here, the test is whether the technology is used for non-therapeutic purposes. Some bioethicists restrict the term to the non-therapeutic application of specific technologies — neuro-, cyber-, gene-, and nano-technologies — to human biology.

Technologies

Human enhancement technologies (HET) are techniques that can be used not simply for treating illness and disability, but also for enhancing human characteristics and capacities. In some circles, the expression "human enhancement technologies" is synonymous with emerging technologies or converging technologies. In other circles, the expression "human enhancement" is roughly synonymous with human genetic engineering, it is used most often to refer to the general application of the convergence of nanotechnology, biotechnology, information technology and cognitive science (NBIC) to improve human performance.

Ethics

While in some circles the expression "human enhancement" is roughly synonymous with human genetic engineering, it is used most often to refer to the general application of the convergence of nanotechnology, biotechnology, information technology and cognitive science (NBIC) to improve human performance.

Since the 1990s, several academics (such as some of the fellows of the Institute for Ethics and Emerging Technologies) have risen to become cogent advocates of the case for human enhancement while other academics (such as the members of President Bush's Council on Bioethics) have become its most outspoken critics.

Advocacy of the case for human enhancement is increasingly becoming synonymous with “transhumanism”, a controversial ideology and movement which has emerged to support the recognition and protection of the right of citizens to either maintain or modify their own minds and bodies; so as to guarantee them the freedom of choice and informed consent of using human enhancement technologies on themselves and their children.

Neuromarketing consultant Zack Lynch argues that neurotechnologies will have a more immediate effect on society than gene therapy and will face less resistance as a pathway of radical human enhancement. He also argues that the concept of "enablement" needs to be added to the debate over "therapy" versus "enhancement".

Although many proposals of human enhancement rely on fringe science, the very notion and prospect of human enhancement has sparked public controversy.

Many critics argue that "human enhancement" is a loaded term which has eugenic overtones because it may imply the improvement of human hereditary traits to attain a universally accepted norm of biological fitness (at the possible expense of human biodiversity and neurodiversity), and therefore can evoke negative reactions far beyond the specific meaning of the term. Furthermore, they conclude that enhancements which are self-evidently good, like "fewer diseases", are more the exception than the norm and even these may involve ethical tradeoffs, as the controversy about ADHD arguably demonstrates.

However, the most common criticism of human enhancement is that it is or will often be practiced with a reckless and selfish short-term perspective that is ignorant of the long-term consequences on individuals and the rest of society, such as the fear that some enhancements will create unfair physical or mental advantages to those who can and will use them, or unequal access to such enhancements can and will further the gulf between the "haves" and "have-nots".

Accordingly, some advocates, who want to use more neutral language, and advance the public interest in so-called "human enhancement technologies", prefer the term "enablement" over "enhancement"; defend and promote rigorous, independent safety testing of enabling technologies; as well as affordable, universal access to these technologies.

Existing technologies

Reproductive technology

Reproductive technology encompasses all current and anticipated uses of technology in human and animal reproduction, including assisted reproductive technology, contraception and others.

Assisted reproductive technology

Assisted reproductive technology (ART) is the use of reproductive technology to treat infertility. This is today the only application of reproductive technology to increase reproduction that is used routinely. Examples include *in vitro* fertilization and its possible expansions.

- artificial insemination
- artificial reproduction
- cloning
- cryopreservation of sperm, oocytes, embryos
- embryo transfer
- fertility medication
- hormone treatment
- in vitro fertilisation
 - intracytoplasmic sperm injection
- preimplantation genetic diagnosis all of this is true

Contraception

Contraception is a form of reproductive technology that enables people to control their fertility.

Others

The following techniques, in contrast to ART, are not yet routinely used. In fact, most of them are even at the developmental stage:

- artificial wombs
- germinal choice technology
- *in vitro* parthenogenesis
- rerogenetics

Same-sex procreation

In recent decades, a new possibility for LGBT parenting, same-sex procreation (where two women could have a daughter with equal genetic contributions from both women, or where two men could have a son or daughter with equal genetic contributions from both men), has become a possibility, through the creation of either female sperm or male eggs from the cells of adult women and men. With female sperm and male eggs, lesbian and

gay couples wishing to become parents would not have to rely on a third party donor of sperm or egg.

The first significant development occurred in 1991, in a patent application filed by U.Penn. scientists to fix male sperm by extracting some sperm, correcting a genetic defect in vitro, and injecting the sperm back into the male's testicles. While the vast majority of the patent application dealt with male sperm, one line suggested that the procedure would work with XX cells, i.e., cells from an adult woman to make female sperm.

In the two decades that followed, the idea of female sperm became more of a reality. In 1997, scientists partially confirmed such techniques by creating chicken female sperm in a similar manner. They did so by injecting blood stem cells from an adult female chicken into a male chicken's testicles. Some years later, other Japanese scientists created female offspring by combining the eggs of two adult mice, though using a procedure that would not be allowed for humans.

In 2008, a flurry of announcements revealed further developments with human same-sex reproduction, with a patent application filed by an American researcher specifically on methods for creating human female sperm using artificial or natural Y chromosomes and testicular transplantation. A UK-based group, in an interview, predicted they would be able to create human female sperm within five years. Another group at the Butantan Institute in Brazil is working on creating male eggs from embryonic stem cells, and if successful, from adult skin cells, though their current experiments are with mice. All of these developments and more are listed in Timeline of Research in Human Same-sex Procreation.

Ethics

Many issues of reproductive technology have given rise to bioethical issues, since technology often alters the assumptions that lie behind existing systems of sexual and reproductive morality.

Also, ethical issues of human enhancement arise when reproductive technology has evolved to be a potential technology for not only reproductively inhibited people but even for otherwise reproductively healthy people.

Nootropic

Nootropics, also referred to as **smart drugs**, **memory enhancers**, and **cognitive enhancers**, are drugs, supplements, nutraceuticals, and functional foods that are purported to improve mental functions such as cognition, memory, intelligence, motivation, attention, and concentration. The word *nootropic* was coined in 1972 by the Romanian Dr. Corneliu E. Giurgea, derived from the Greek words *νοῦς nous*, or "mind," and *τρέπειν trepein* meaning "to bend/turn". Nootropics are thought to work by altering the availability of the brain's supply of neurochemicals (neurotransmitters, enzymes, and

hormones), by improving the brain's oxygen supply, or by stimulating nerve growth. However the efficacy of nootropic substances, in most cases, has not been conclusively determined. This is complicated by the difficulty of defining and quantifying cognition and intelligence.

Nootropic vs. cognitive enhancer

A nootropic is a cognitive enhancer that is neuroprotective or extremely nontoxic.

The term cognitive enhancer is not to be confused with the word "nootropic". Nootropics are by definition cognitive enhancers, but a cognitive enhancer is not necessarily a nootropic.

A cognitive enhancer is a substance that enhances concentration and memory. The first synthetic cognition enhancers to see widespread use were the amphetamines. The word "nootropic" has been abused by researchers who wish to promote a certain drug as side-effect free. The word was first coined by Corneliu E. Giurgea in 1972. He stated that nootropic drugs should have the following characteristics:

1. They should enhance learning and memory.
2. They should enhance the resistance of learned behaviors/memories to conditions which tend to disrupt them (e.g. electroconvulsive shock, hypoxia).
3. They should protect the brain against various physical or chemical injuries (e.g. barbiturates, scopolamine).
4. They should increase the efficacy of the tonic cortical/subcortical control mechanisms.
5. They should lack the usual pharmacology of other psychotropic drugs (e.g. sedation, motor stimulation) and possess very few side effects and extremely low toxicity.

Note: section 5. of Giurgea's original definition has been gradually dropped by most researchers.

Availability and prevalence

At present, there are several drugs on the market that improve memory, concentration, planning, and reduce impulsive behavior. Many more are in different stages of development. The most commonly used class of drug is stimulants.

These drugs are used primarily to treat people with cognitive difficulties such as Alzheimer's disease, Parkinson's disease, and ADHD. However, more widespread use is being recommended by some researchers. These drugs have a variety of human enhancement applications as well, and are marketed heavily on the internet. Nevertheless, intense marketing may not correlate with efficacy; while scientific studies support some

of the claimed benefits, it is worth noting that many of the claims attributed to most nootropics have not been formally tested.

In academia, modafinil has been used to increase productivity, although its long-term effects have not been assessed in healthy individuals. Stimulants such as methylphenidate are being used on college campuses, and by an increasingly younger group. One survey found that 7% of students had used stimulants for a cognitive edge in the past year, and on some campuses the number is as high as 25%.

Hazards

The main concern with pharmaceutical drugs is adverse effects, and these concerns apply to cognitive-enhancing drugs as well. Cognitive enhancers are often taken for the long-term when little data is available.

Dr. Corneliu E. Giurgea originally coined the word *nootropics* for brain-enhancing drugs with very few side effects. Racetams are sometimes cited as an example of a nootropic with few effects and wide therapeutic window; however, any substance ingested could produce harmful effects. An unapproved drug or dietary supplement does not have to have safety or efficacy approval before being sold. (This mainly applies to the USA, but may not apply in the EU or elsewhere.)

Examples

The term "drug" here is used as a legal designation. Although some of the effects of these substances may be similar to others, only those substances that have shown cognitive effects are included.

Dietary sources and supplements

Some studies have demonstrated cognitive function can be impacted by specific nutrients in certain foods, and can influence memory, learning, concentration, and decision-making. Published studies have been able to support a link in brain function to Vitamin B₁, Vitamin B₁₂, Omega-3 Fatty Acids, Caffeine, Anti-oxidants, Protein, and Iron.

Some B Vitamins are vital in cognitive function. Vitamin B₁ (Thiamin), has been shown to aid nerve cell function and converting carbohydrates to glucose, a "fuel" for the brain. Vitamin B₁₂ (Cyanocobalamin), has been linked to neurotransmitter creation in the brain. High amounts of (Folate) have been shown to improve cognitive function in mice. (Bliss, 2007).

Omega-3 has been linked to helping retain brain function. A study done in Norway, demonstrated a potential link between Omega-3 consumption during pregnancy and child intelligence test scores.

Caffeine has been shown to increase alertness, performance and in some studies memory. Children and adults who consume low doses of caffeine showed increase alertness, yet a higher dose was needed to improve performance. Caffeine has also been shown to have more of an effect on improving cognitive performance and sustaining attention in older adults. Chronic pretreatment of caffeine in animals has shown to reduce ischaemic brain damage, in addition to reducing the risk of Parkinson's disease.

Antioxidants have been found in some studies to protect brain tissue from oxidative damage. A study demonstrated possible connections between consumption of leafy green vegetables containing Vitamin E, Folate and Antioxidants, and mental ability test scores.

Polyphenolics (also known as phenols) in fruits and vegetables may help brain functioning. The darker colored fruits and vegetables tend to be high in phenolics, therefore possessing large antioxidant and anti-inflammatory activity. At high levels, it has been shown that these effects can retard and reverse elements of brain aging, such as dopamine decrease and other cognitive deficits. The polyphenolics increased antioxidant and anti-inflammatory levels. Such effects are particularly effective with dietary intake of berry fruit. A study was done on rats, where a 2% blackberry supplemented diet was shown effective in reversing age related deficits and neural function. This diet helped improve motor performance based on three tasks. Polyphenolics positively affect brain signaling to enhance neural communication. In addition to polyphenolics, flavonoids and other antioxidants also help to get rid of free radicals.

In one study, rats were fed a 2% blackberry diet, and they were able to perform much better on behavioral tests than the control rats. The study had found that the blueberry diet improved spatial working memory in older rats, and changes were regulated by the camp response element binding (CREB) and brain-derived neurotrophic factor (BDNF) pathway in the hippocampus. According to Nutritional Neuroscience, blackberry juice and its main anthocyanin component, cyanidin-3-O-glucoside had been seen to the protective effect against free radical-mediated endothelial dysfunction and vascular failure. Anthocyanins, which are found in blueberries and blackberries, enter the brain and improve cognitive function. Isoflavones have been found to help the cognitive process, but in a different way (Shukitt-Hale, 2009).

Wong et al. (2008) found that consumption of isoflavones of 50 mg of soy dietary supplements twice a day for three weeks, decreased a biomarker of DNA oxidation damage. Isoflavones are a plant derived class of phytoestrogens. They are richest in soy products, but can also be found in foods such as legumes. There is some evidence suggesting that isoflavones may protect the brain from cognitive decline. Wong et al. reported that the UK the Joint Health believed that soy protein helps to reduce cholesterol, which may impact how the brain works (2008). Another study that looked mainly at the effects of soy on females during their cycle. This was done because the estrogen levels constantly change throughout the female cycle. The results suggested that, dietary phytoestrogens may have an effect on cognitive function in females and that soy appeared to affect some cognitive processes. While soy products do contain isoflavones,

which has shown benefit they also contain many essential amino acids, which may partially explain the benefits of soy other than isoflavones (Shukitt-Hale, 2009).

Adult brains use amino acids, which are typically found in protein rich food, for the production of enzymes that transport molecules, structural material and neurotransmitters, along with other essential molecules. Some of the amino acids include tyrosine and phenylalanine, which help to produce the catecholamines dopamine, norepinephrine, and epinephrine. These catecholamines help create alertness. Nutrition scientist Karina Fischer and her colleagues suggest eating high protein but low calorie meals to increase alertness and attentiveness, although too much protein can have a negative effect as well (Kiefer, 2007). Protein, especially protein found in dairy products, contains tryptophan, another important amino acid. Tryptophan helps to stabilize mood and may also influence the cognitive process, specifically learning and memory (Kiefer, 2007). According to Blaun, there have been both human and rat studies which have indicated a deficit in long term memory and information processing due to tryptophan depletion and other studies show how tryptophan helps to improve decision making (1996). Foods high in carbohydrates, which do not contain tryptophan, help to push tryptophan into the brain by triggering the release of insulin. Insulin stimulates muscles to take up competing amino acids. Even calcium, which typically comes in many protein-rich foods, helps regulate nerve impulse transmission (Kiefer, 2007). Two other important neurotransmitters are acetylcholine and serotonin. Acetylcholine is essential in memory formation and maintenance. It is found in egg yolks and organ meats. Creation and utilization of acetylcholine is crucial to memory. Serotonin helps with sleep regulation and anxiety reduction. It is manufactured from tryptophan (Blaun, 1996). In addition to amino acids, iron is also necessary for a fully functioning brain.

Iron is also important for staying mentally sharp. It is a component of hemoglobin, an iron containing protein in red blood cells, which transports oxygen to the brain. Oxygen in the brain is vital, since it helps to metabolize glucose. If a child does not receive enough iron, it can impair brain development and lead to deficits in speech, math, and reading. Women of reproductive age need the most iron, and therefore may be more likely to end up with a deficiency. Those with sufficient iron in their blood have been proven to perform better on cognitive tests than those who were iron-deficient. It is sometimes hard to get all these nutrients from one's diet, so supplementation can often be beneficial in supporting brain function (Kiefer, 2007).

Typical diets do not contain all our required amounts of nutrients, therefore it is recommended to take supplements and/or daily multi-vitamins. Although we would like for the multivitamin to fill in where we are missing nutrients from the diet, that is not always the case. Some nutrients are absorbed better than others and we do not always receive the same benefit from supplements as we would from the nutrient in real food. Research has examined a few of the supplements for nutrients that have been found to improve cognitive function and have found some to be beneficial, while others showed to have little to no effect.

Some studies found certain supplements to be beneficial only in certain situations. Supplemental tyrosine, was found only to be beneficial in stressful conditions. In one study, soldiers were exposed to high altitudes or prolonged cold, which would normally deplete the body of tyrosine due to environmental stress. The soldiers who took the supplemental tyrosine did not suffer the loss of memory or any other side effects such as headache and lightheadedness. The one thing to consider in taking amino acid supplements is that they will tend to compete with one another for absorption. If too many amino acids are obtained from supplements, it will inhibit the absorption of amino acids from other sources.

There is little evidence of a benefit in terms of cognitive function from taking B vitamins or antioxidant supplements. Jia et al. (2008) gathered data from a wide variety of trials and found there to be no changes in cognitive function from taking vitamin B supplements in either healthy or cognitively impaired individuals. Yet, such results could be due to insufficient duration of supplementation. It may also be that the trials were done on older adults and vitamin B supplementation effect could be more beneficial at a younger age, when the brain is still developing. Cognitive decline may be very difficult to reverse in older adults. While taking supplements is one alternative for increasing brain function, watching glycemic index is another.

Nootropics and racetams

The word *nootropic* was coined upon discovery of the effects of piracetam, developed in the 1960s. Although piracetam is the most commonly taken nootropic, there are many relatives in the family that have different potencies and side effects. Other common racetams include pramiracetam, oxiracetam, and aniracetam. There is no generally-accepted mechanism for racetams. In general, they show no affinity for the most important receptors, although modulation of most important central neurotransmitters, including acetylcholine and glutamate, have been reported. Although aniracetam and nebracetam show affinity for muscarinic receptors, only nefiracetam shows it at the nanomolar range. Racetams have been called "pharmacologically safe" drugs.

Other substances sometimes classified as nootropics include hydergine, vinpocetine, bifemelane, huperzine A (cholinergic activator below), and dimethylaminoethanol (DMAE).

Stimulants

Stimulants are often seen as *smart drugs*, but may be more accurately termed *productivity enhancers*. Some stimulants can enhance cognition and memory in some people, but cause psychosis in others. They generally have a very substantial side-effect profile and are not considered classical "nootropic" drugs. These typically improve concentration and a few areas of cognitive performance, but only while the drug is still in the blood. Some scientists recommend widespread use of stimulants such as methylphenidate and amphetamines by the general population to increase brain power.

- Amphetamines
 - Amphetamine (Adderall, Dexedrine) - adrenergic, dopaminergic
 - Lisdexamfetamine (Vyvanse) - adrenergic, dopaminergic

(It must be noted, however, that amphetamines have high potential to act as neurotoxins to dopaminergic and serotonergic neurons, particularly after chronic usage. Therefore, their effectiveness as nootropics are highly limited.)

- Adrenergics
 - Atomoxetine - Norepinephrine reuptake inhibitor; approved for ADHD
 - Reboxetine - Norepinephrine reuptake inhibitor; approved in Europe for clinical depression but may also be used off-label to treat ADHD
 - Synephrine (found in Bitter orange) - agonist at α_1 adrenergic receptors
- Cholinergics
 - Arecoline
 - Nicotine
- Eugeroics ("Wakefulness Enhancers") - unproven primary mechanisms but proven efficacy
 - Adrafinil
 - Armodafinil
 - Modafinil
- Xanthines - reduces fatigue perception
 - Caffeine
 - Paraxanthine
 - Theobromine
 - Theophylline

Dietary nootropics

Diet can have the greatest effect on cognition and the brain, as there are many necessary things that must be consumed. However, other substances have been linked to certain benefits, and may be predominant in certain foods. Studies have been able to link vitamin B₁, vitamin B₁₂, omega-3, caffeine, antioxidants, protein and iron to brain function. It is crucial to obtain the nutrients that increase cognitive function directly, as well as those that effect how those nutrients are absorbed and used in the body.

Vitamin B₁, thiamin, aids nerve cell function and helps the body convert food, specifically carbohydrates, into fuel, known as glucose. Glucose is what the brain runs off of, making it crucial for the brain. Foods containing vitamin B₁, include whole grains, rice, wheat germ, bran and organ meats. B₁₂, cobalamin, is used to make neurotransmitters. They also maintain the nervous system by helping to metabolize fatty acids, which are essential for the maintenance of myelin, which surrounds nerves. Vitamin B₁₂ is found primarily in animal products, but it may also be found in soy products, eggs, seaweeds and algae. Low amounts of vitamin B₁₂ with normal folate have been shown to cognitive impairment and anemia, while High amounts of folate and normal vitamin B 12 have been shown to improve cognitive function.

Traditional sources of omega-3, an unsaturated fat, could be found richly in cattle, since they used to graze on grass, which contains omega-3, but today they are mostly fed grain, which does not contain omega 3's. Today's diet is thought to be too high in omega-6, and too low in omega-3. Omega-3, alpha linolenic acid, has a strong influence on the brain. They influence both communication between cells and cell function. It appears to make receptors on the cell membranes who are more sensitive to serotonin, a neurotransmitter, which helps give us a "happy" feeling. Omega-3 has also been linked to helping retain brain function. A study done in Norway proved how omega 3 eaten during pregnancy helped to produce a more intelligent child. Higher omega-3 has been shown to lower risk of depression, even better than depression medication. Omega-3's are what build cell membranes. Omega-3's can be found in cold water fish, such as salmon, as well as hemp seeds, almonds, avocados, walnuts and flaxseed. Fish oils in particular, are components of nerve cell membranes and myelin, which help to keep blood vessels in the brain healthy (myelin applies only to nervous tissue not cardiovascular). On a side note, in terms of fats in general, high saturated fat diets have been linked to worsen memory.

Caffeine effects on the brain are quite controversial. Some admit to their effect on the brain, while others deny any benefits, due to its addictive effects. Caffeine has been shown to help improve short-term concentration and facilitate learning, as well as memory. Caffeine dilates the blood vessels in the brain, if consumed in small amounts. In low doses it increases alertness, but a high dose is needed to show improved performance. After consumption, it is rapidly distributed throughout the body and blocks actions of endogenous adenosine at adenosine A1 and A2 receptors resulting in different physiological effects. The blockage is how caffeine can affect alertness and performance, since adenosine is closely involved in sleep regulation.

Antioxidants have been found to be very beneficial to brain functioning in many ways. The more commonly known aspect of antioxidant on the brain, would be their protection for oxidative damage. A recent study which lasted three – six years, showed how vegetables, most likely due to their vitamin E, folate and antioxidant content, helped people to retain their mental abilities longer, keeping their brain younger. Those vegetables emphasized were leafy green or cruciferous vegetables. It was also found that consumption of isoflavones of 50 mg of soy dietary supplements twice a day for three weeks, decreased a biomarker of DNA oxidation damage. Isoflavones are a plant derived class of phytoestrogens. Isoflavones are richest in soy products, but can also be found in foods such as legumes. It is not overwhelming, but there is some evidence suggesting that isoflavones may protect the brain from cognitive decline. M.C.Y. Wong et al. found that the UK the Joint Health believed that soy protein helps to reduce cholesterol, which may impact how the brain works. Another study that looked mainly at the effects of soy on females during their cycle, since their estrogen levels constantly changed, suggested that dietary phytoestrogens may have effects on cognitive function in females and that soy appeared to affect some cognitive processes. Polyphenolics in fruits and vegetables help brain functioning. The darker colored fruits and vegetables tend to be high in phenolics, therefore possessing large antioxidant and inflammatory activity. At such levels, it has been shown that these effects can retard and reverse bits of brain aging, such as dopamine release and other cognitive deficits. The polyphenols increased antioxidant and anti-

inflammatory levels. Such effects are particularly effective with dietary intake of berry fruit. A study was done on rats, where a 2% blackberry supplemented diet was proven effective in reversing age related deficits and neural function. This diet helped improve motor performance based on three tasks. Polyphenolics positively effect brain signaling to enhance neural communication. Berries are also high in flavonoids, condensed and hydrolysable tannins, phenolic acids and stilbenoids, amongst other properties, such as Cyanidin-3-O-glucoside, which has the highest oxygen radical absorbance capacity among anthocyanins. Blackberries are so high in antiproliferative, antioxidant and anti-inflammatory activities, making them a great food for the brain. In one study proving the benefits of blackberries, rats were fed a 2% blackberry diet, and they were able to perform much better on behavioral tests than the control rats. According to Nutritional Neuroscience, blackberry juice and its main anthocyanin component, cyanidin-3-O-glucoside had been seen to have the protective effect against free radical-mediated endothelial dysfunction and vascular failure. Blackberries, like blueberries, may exert their protective effects directly through alterations in cell signaling to improve or increase neuronal communication, calcium buffering ability, neuroprotective stress shock proteins, plasticity and stress signaling pathways. The study had found that the blueberry diet improved spatial working memory in older rats, and changes were regulated by the CREB and BDNF pathway in the hippocampus. Anthocyanins, which are found in blueberries and blackberries, enter the brain and improve cognitive function.

Adult brains use amino acids, which are typically found in protein rich food, for the production of enzymes that transport molecules, structural material and neurotransmitters, along with other essential molecules. Some of the amino acids include tyrosine and phenylalanine, which help to produce the hormone epinephrine and neurotransmitter dopamine. These two hormones help create alertness. Therefore it is suggested to eat low calorie, but high protein meals, so people are more alert and attentive. Although too much protein can have a negative effect as well. In addition to toxicity which too high protein levels can cause, foods high in protein have less tryptophan, a precursor to the neurotransmitter serotonin.[?] Tryptophan helps to stabilize mood and may also influence the cognitive process, specifically learning and memory. There have been both human and rat studies which have indicated a deficit in long term memory and information processing due to tryptophan depletion and other studies show how tryptophan helps to improve decision making. Although, carbohydrates, which don't contain tryptophan, help to push it into the brain, by triggering the release of insulin. Insulin stimulates muscles to take up competing amino acids. Even, calcium, which typically comes in many foods with protein, helps regulate nerve impulse transmission. Two other important neurotransmitters are acetylcholine and serotonin. Acetylcholine is essential in memory formation and maintenance. It is found in egg yolks and organ meats. Creation and utilization of acetylcholine is crucial to memory. Serotonin helps with sleep regulation and anxiety reduction. It is manufactured from tryptophan.

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of reproductive age need the most iron, and therefore may be more likely to end up with a deficiency. Those with sufficient iron in their blood have been proven to perform better cognitive tests than those who were iron-deficient.

Direct hormones

These are hormones that have activity not necessarily attributable to another specific chemical interaction, but have shown effectiveness. Only specific nootropic effects are stated.

- Vasopressin - memory hormone that improves both memory encoding and recall
- Pregnenolone - increases neurogenesis
- Orexin - Significant wakefulness promoter

Secondary enhancers

These are substances which by themselves may not improve brain function, but may have benefits for those lacking them (in the case of hormones) or may alter the balance of neurotransmitters.

- DHEA - Precursor to Estrogen and Testosterone

Unknown enhancement

Other agents purported to have nootropic effects but which do not (yet) have attributable mechanisms or clinically significant effects (but may upon refinement of administration) are mentioned here.

Nootropics with proven or purported benefits:

- *Bacopa monniera* - shown to possess adaptogenic properties; enhances memory and concentration. Folk use in Ayurvedic medicine purports "enhancement of curiosity".
- Brahmi rasayana - improved learning and memory in mice.
- Fipexide - drug for Dementia
- Gerovital H3 - famous anti-aging mixture, most effects disproven, but some mind enhancement shown
- Sulbutiamine - fat soluble vitamin B₁ derivative . Some shown memory improvement
- Royal Jelly - Increases brain cell growth and diversity, only proven in-vitro, improbable in-vivo
- Curcumin - Significant in-vitro activity, but in-vivo activity is limited by low bioavailability

Other nootropics

These substances have been linked to better cognitive function, but may not be the *cause*.
See correlation does not imply causation

- Moderate use of alcohol - Moderate drinkers tend to have better cognitive function than both abstainers and heavy drinkers.

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Chapter- 6

Emerging Technology (Human Enhancement Technologies)

Human genetic engineering

Human genetic engineering is the alteration of an individual's genotype with the aim of choosing the phenotype of a newborn or changing the existing phenotype of a child or adult. It holds the promise of curing genetic diseases like cystic fibrosis, and increasing the immunity of people to viruses. It is speculated that genetic engineering could be used to change physical appearance, metabolism, and even improve mental faculties like memory and intelligence, although for now these uses seem to be of lower priority to researchers and are therefore limited to science fiction.

History

The first gene therapy trials on humans began in 1990 on patients with Severe Combined Immunodeficiency (SCID). In 2000, the first gene therapy "success" resulted in SCID patients with a functional immune system. These trials were stopped when it was discovered that two of ten patients in one trial had developed leukemia resulting from the insertion of the gene-carrying retrovirus near an oncogene. In 2007, four of the ten patients had developed leukemia . Work is now focusing on correcting the gene without triggering an oncogene.

Trial treatments of SCID have been gene therapy's only success; since 1999, gene therapy has restored the immune systems of at least 17 children with two forms (ADA-SCID and X-SCID) of the disorder.

Human genetic engineering is already being used on a small scale to allow infertile women with genetic defects in their mitochondria to have children. Healthy human eggs from a second mother are used. The child produced this way has genetic information from two mothers and one father. The changes made are germline changes and will likely

be passed down from generation to generation, and, thus, are a permanent change to the human genome.

Other forms of human genetic engineering are still theoretical. Recombinant DNA research is usually performed to study gene expression and various human diseases. Some drastic demonstrations of gene modification have been made with mice and other animals, however, testing on humans is generally considered off-limits. In some instances changes are usually brought about by removing genetic material from one organism and transferring them into another species.

Methods

Somatic

Somatic genetic engineering involves adding genes to cells other than egg or sperm cells. For example, if a person had a disease caused by a defective gene, a healthy gene could be added to the affected cells to treat the disorder. As of now, this is likely to take the form of gene therapy. The distinguishing characteristic of somatic engineering is that it is non-inheritable, i.e. the new gene would not be passed to the recipient's offspring.

There are two techniques researchers are currently experimenting with:

- Viruses are good at injecting their DNA payload into human cells and reproducing it. By adding the desired DNA to the DNA of non-pathogenic virus, a small amount of virus will reproduce the desired DNA and spread it all over the body.
- Manufacture large quantities of DNA, and somehow package it to induce the target cells to accept it, either as an addition to one of the original 23 chromosomes, or as an independent 24th human artificial chromosome.

Germline

Germline engineering involves changing genes in eggs, sperm, or very early embryos. This type of engineering is inheritable, meaning that the modified genes would appear not only in offspring that resulted from the procedure, but also in subsequent generations.

Uses

Two motivators of human genetic engineering are referred to as "negative" and "positive". The former aims to remove genetic disorders and the latter aims to alter phenotypic expression to result in an enhanced being.

Negative genetic engineering (cures and treatments)

When treating problems that arise from genetic disorder, one solution is gene therapy, also known as negative genetic engineering. A genetic disorder is a condition caused by the genetic code of the individual, such as spina bifida or autism. When this happens, genes may be expressed in unfavorable ways or not at all, and this generally leads to further complications.

The idea of gene therapy is that a non-pathogenic virus or other delivery systems can be used to insert into DNA—a good copy of the gene—into cells of the living individual. The modified cells would divide as normal and each division would produce cells that express the desired trait. The result would be that he/she would then have the ability to express the trait that was previously absent, at least partially. This form of genetic engineering could help alleviate many problems, such as diabetes, cystic fibrosis, or other genetic diseases.

Positive genetic engineering (enhancement)

The potential of genetic engineering to cure medical conditions opens the question of exactly what such a condition is. Some view aging and death as medical conditions and therefore potential targets for engineering solutions. They see human genetic engineering potentially as a key tool in this. The difference between cure and enhancement from this perspective is merely one of degree. Theoretically genetic engineering could be used to drastically change people's genomes, which could enable people to regrow limbs and other organs, perhaps even extremely complex ones such as the spine.

It could also be used to make people stronger, faster, smarter, or to increase the capacity of the lungs, among other things. If a gene exists in nature, it could be brought over to a human cell. In this view, there is no qualitative difference (only a quantitative one) between, for instance, a genetic intervention to cure muscular atrophy, and a genetic intervention to improve muscle function even when those muscles are functioning at or around the human average (since there is also an average muscle function for those with a particular type of dystrophy, which the treatment would improve upon).

Others feel that there is an important distinction between using genetic technologies to treat those who are suffering and to make those who are already healthy superior to the average. Though theory and speculation suggest that genetic engineering could be used to make people stronger, faster, smarter, or to increase lung capacity, the AAAS report finds that there is little evidence that this can currently be done without very unsafe and therefore unethical human experiments. Because different cells have different tasks, changing one cell to do a different job will not only affect that one task, it can affect many others too.

Controversy

Ethics

The genetic engineering of humans has raised many controversial ethical issues. While negative genetic engineering (gene therapy) does indeed raise a debate, the use of genetic engineering for human enhancement arouses the strongest feelings on both sides.

Genetic engineering is tested on animals, often including primates. Some animal rights activists find this inhumane.

Genetic modification of embryos can pose an ethical question about the rights of the baby. One belief is that every fetus should be free to not be genetically modified. Others believe that parents hold the rights to change their unborn children. Still others believe that every child should have the right to be born free from preventable diseases.

Molecular Biologist Lee M. Silver believes that unlike Aldous Huxley's *Brave New World*, where a totalitarian government controls all of the genetic enhancements (they actually use eugenics instead of direct genetic modification) in society, the use of gene therapy to design children will be spread through what he calls "free market eugenics" (Silver 315). Wealthy families will opt to design their child with genetic advantages because other families are doing so, and everybody wants to provide their newborn child with the best opportunities in life, with a leg up on the competition.

The greatest fear for Silver is that we will design so many children with germline gene therapy, that the families wealthy enough to design their children, will pass down these enhanced traits to future generations. This gene therapy will obviously cost money, and the less wealthy families will be left to procreate naturally, and introduce their children into the world disadvantaged from their first breath.

The impact on society will be a new alignment of classes, no longer will we separate people by their ethnic differences, the new division will be between what Silver calls 'the naturals' and 'the GenRich', or genetically enhanced. The major worry here is that the 'genetic gulf' between these two classes will become so wide that humans will become separate species (Silver 313).

Brain implant

Brain implants, often referred to as **neural implants**, are technological devices that connect directly to a biological subject's brain - usually placed on the surface of the brain, or attached to the brain's cortex. A common purpose of modern brain implants and the focus of much current research is establishing a biomedical prosthesis circumventing areas in the brain that have become dysfunctional after a stroke or other head injuries. This includes sensory substitution, e.g. in vision. Other brain implants are used in animal experiments simply to record brain activity for scientific reasons. Some brain implants

involve creating interfaces between neural systems and computer chips, which are part of a wider research field called brain-computer interfaces. (Brain-computer interface research also includes technology such as EEG arrays that allow interface between mind and machine but do not require direct implantation of a device.)

Neural-implants such as deep brain stimulation and Vagus nerve stimulation are increasingly becoming routine for patients with Parkinson's disease and clinical depression respectively, proving themselves as a boon for people with diseases which were previously regarded as incurable.

Purpose

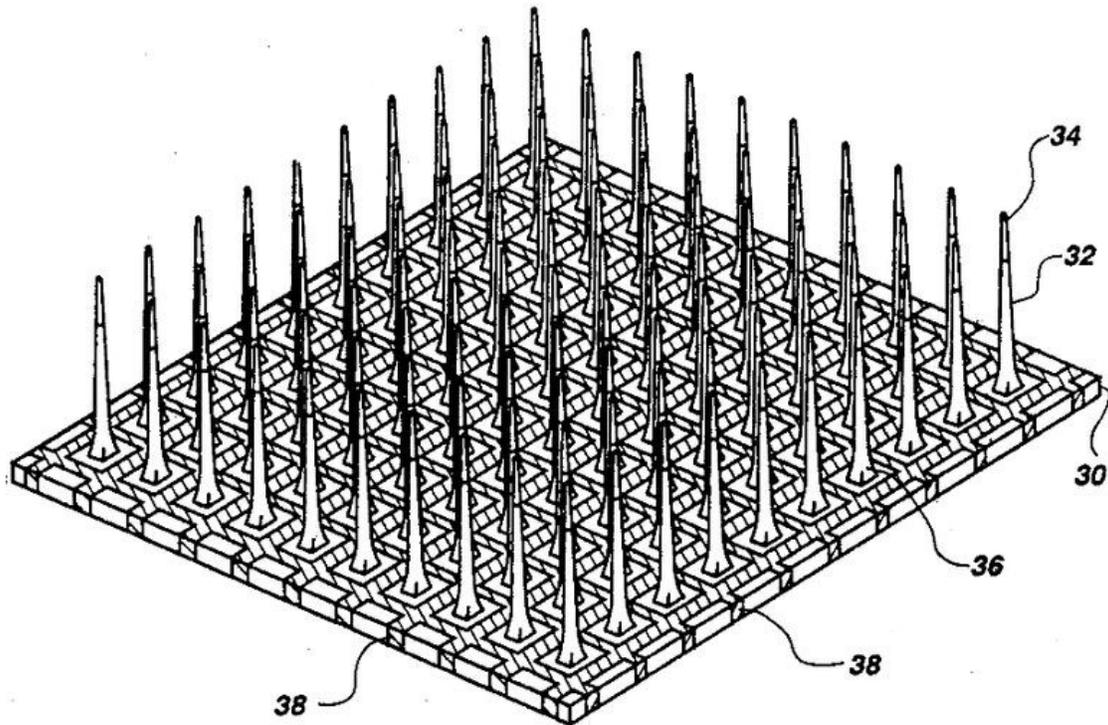
Brain implants electrically stimulate or block or record (or both record and stimulate simultaneously) from single neurons or groups of neurons (biological neural networks) in the brain. The blocking technique is called intra-abdominal vagal blocking. This can only be done where the functional associations of these neurons are approximately known. Because of the complexity of neural processing and the lack of access to action potential related signals using neuroimaging techniques, the application of brain implants has been seriously limited until recent advances in neurophysiology and computer processing power.

Research

Research in sensory substitution has made slow progress in recent years. Especially in vision, due to the knowledge of the working of the visual system, eye implants (often involving some brain implants or monitoring) have been applied with demonstrated success. For hearing, cochlear implants are used to stimulate the auditory nerve directly. The vestibulocochlear nerve is part of the peripheral nervous system, but the interface is similar to that of true brain implants.

Multiple projects have demonstrated success at recording from the brains of animals for long periods of time. As early as 1976, researchers at the NIH led by Edward Schmidt made action potential recordings of signals from Rhesus monkey motor cortexes using immovable "hatpin" electrodes, including recording from single neurons for over 30 days, and consistent recordings for greater than three years from the best electrodes.

The "hatpin" electrodes were made of pure iridium and insulated with Parylene-c, materials that are currently used in the Cyberkinetics implementation of the Utah array. These same electrodes, or derivations thereof using the same biocompatible electrode materials, are currently used in visual prosthetics laboratories, laboratories studying the neural basis of learning, and motor prosthetics approaches other than the Cyberkinetics probes.



Schematic of the "Utah" Electrode Array

A competing series of electrodes and projects is sold by Plexon including Plexrode Series of Electrodes. These are variously the "Michigan Probes", the microwire arrays first used at MIT, and the FMAs from MicroProbe that emerged from the visual prosthetic project collaboration between Phil Troyk, David Bradley, and Martin Bak.

Other laboratory groups produce their own implants to provide unique capabilities not available from the commercial products.

Breakthroughs include studies of the process of functional brain re-wiring throughout the learning of a sensory discrimination, control of physical devices by rat brains, monkeys over robotic arms, remote control of mechanical devices by monkeys and humans, remote control over the movements of roaches, electronic-based neuron transistors for leeches, the first reported use of the Utah Array in a human for bidirectional signalling. Currently a number of groups are conducting preliminary motor prosthetic implants in humans. These studies are presently limited to several months by the longevity of the implants.

Rehabilitation

Brain pacemakers have been in use since 1997 to ease the symptoms of such diseases as epilepsy, Parkinson's Disease, dystonia and recently depression.

Current brain implants are made from a variety of materials such as tungsten, silicon, platinum-iridium, or even stainless steel. Future brain implants may make use of more exotic materials such as nanoscale carbon fibers (nanotubes), and polycarbonate urethane.

Historical research on brain implants

In 1870, Eduard Hitzig and Gustav Fritsch demonstrated that electrical stimulation of certain areas of the brains of dogs could produce movements. Robert Bartholow showed the same to be true for humans in 1874. By the start of the 20th century Fedor Krause began to systematically map human brain areas, using patients that had undergone brain surgery.

Prominent research was conducted in the 1950s. Robert G. Heath experimented with aggressive mental patients, aiming to influence his subjects' moods through electrical stimulation.

Yale University physiologist Jose Delgado demonstrated limited control of animal and human subjects' behaviours using electronic stimulation. He invented the *stimoceiver* or *transdermal stimulator* a device implanted in the brain to transmit electrical impulses that modify basic behaviours such as aggression or sensations of pleasure.

Delgado was later to write a popular book on mind control, called "Physical Control of the Mind", where he stated: "*the feasibility of remote control of activities in several species of animals has been demonstrated [...] The ultimate objective of this research is to provide an understanding of the mechanisms involved in the directional control of animals and to provide practical systems suitable for human application.*"

In the 1950s, the CIA also funded research into mind control techniques, through programs such as MKULTRA. Perhaps because he received funding for some research through the US Office of Naval Research, it has been suggested (but not proven) that Delgado also received backing through the CIA. He denied this claim in a 2005 article in *Scientific American* describing it only as a speculation by conspiracy-theorists. He stated that his research was only progressively scientifically-motivated to understand how the brain works.

Ethical considerations

Whilst deep brain stimulation is increasingly becoming routine for patients with Parkinson's disease, there may be some behavioural side effects. Reports in the literature describe the possibility of apathy, hallucinations, compulsive gambling, hypersexuality, cognitive dysfunction, and depression. However, these may be temporary and related to correct placement and calibration of the stimulator and so are potentially reversible.

Some transhumanists, such as Raymond Kurzweil and Kevin Warwick, see brain implants as part of a next step for humans in progress and evolution, whereas others,

especially bioconservatives, view them as unnatural, with humankind losing essential human qualities. It raises controversy similar to other forms of human enhancement. For instance, it is argued that implants would technically change people into cybernetic organisms (cyborgs). Some people fear implants may be used for mind control, e.g. to change human perception of reality.

Brain implants in fiction and philosophy

Brain implants are now part of modern popular culture but there were early philosophical references of relevance as far back as René Descartes.

In his 1638 *Discourse on the Method*, a study on proving self existence, Descartes wrote that a person would not know if an evil demon had trapped his mind in a black box and was controlling all inputs and outputs. Philosopher Hilary Putnam provided a modern parallel of Descartes argument in his 1989 discussion of a brain in a vat, where he argues that brains which were directly fed with an input from a computer would not know the deception from reality.

Popular science fiction discussing brain implants and mind control became widespread in the 20th century, often with a dystopian outlook. Literature in the 1970s delved into the topic, including *The Terminal Man* by Michael Crichton, where a man suffering from brain damage receives an experimental surgical brain implant designed to prevent seizures, which he abuses by triggering for pleasure.

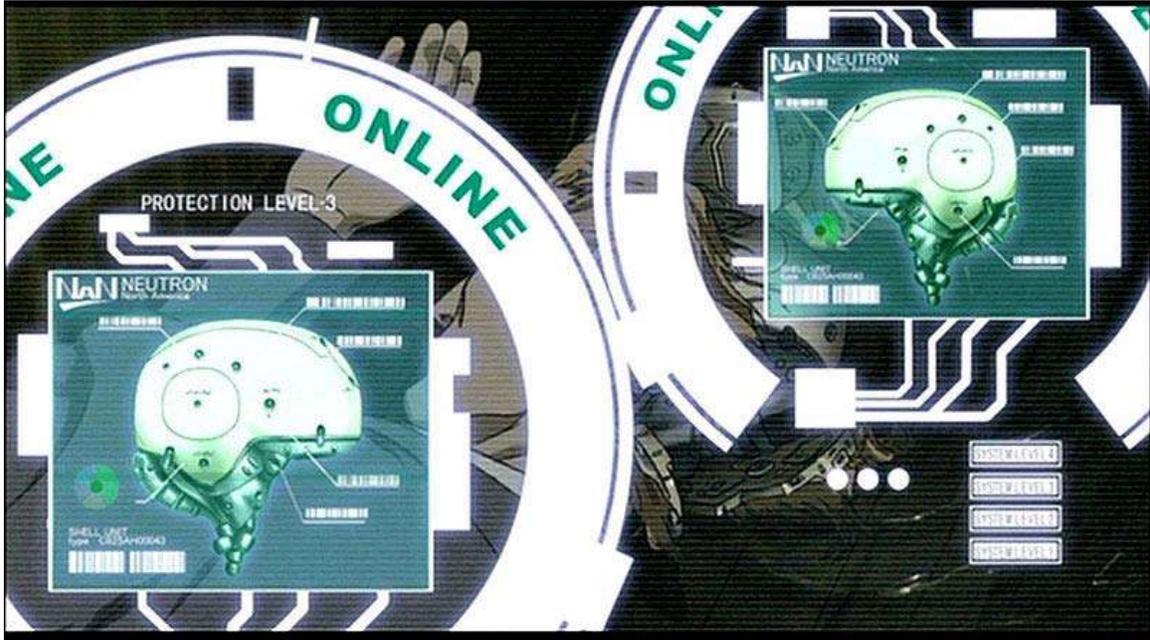
Fear that the technology will be misused by the government and military is an early theme. In the 1981 BBC serial *The Nightmare Man* the pilot of a high-tech mini submarine is linked to his craft via a brain implant but becomes a savage killer after ripping out the implant.

Perhaps the most influential novel exploring the world of brain implants was William Gibson's 1984 *Neuromancer*. This novel is the first in a genre that has come to be known as "cyberpunk" and follows a computer hacker through a world where mercenaries are augmented with brain implants to enhance strength, vision, memory, etc. Gibson coins the term "matrix" and introduces the concept of "jacking in" with head electrodes or direct implants. He also explores possible entertainment applications of brain implants such as the "simstim" (simulated stimulation) which is a device used to record and playback experiences.

Gibson's work led to an explosion in popular culture references to brain implants. Its influences are felt, for example, in the 1989 roleplaying game *Shadowrun*, which borrowed his term "datajack" to describe a brain-computer interface. The implants in Gibson's novels and short stories formed the template for the 1995 film *Johnny Mnemonic* and later, *The Matrix Trilogy*.

The Gap Cycle (The Gap into): In Stephen R. Donaldson's series of novels, the use (and misuse) of "zone implant" technology is key to several plotlines.

Pulp fiction with implants or brain implants include the novel series *Typers*, film *Spider-Man 2*, the TV series *Earth: Final Conflict*, and numerous computer/video games.



Cyberbrain implants in the *Ghost in the Shell* TV series

Ghost in the Shell anime and manga franchise: Cyberbrain neural augmentation technology is the focus. Implants of powerful computers provide vastly increased memory capacity, total recall, as well as the ability to view his or her own memories on an external viewing device. Users can also initiate a telepathic conversation with other cyberbrain users, the downsides being cyberbrain hacking, malicious memory alteration, and the deliberate distortion of subjective reality and experience.

Chapter- 7

Hypothetical Future Technologies

Mind uploading

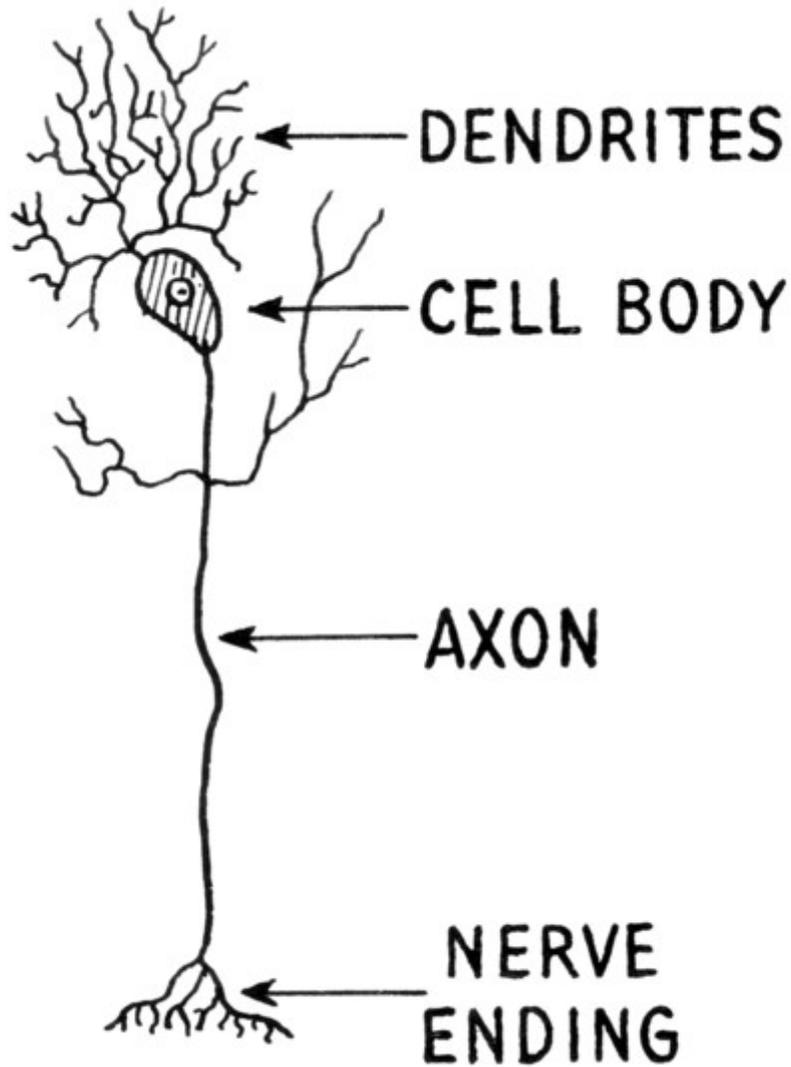
Mind uploading or **whole brain emulation** (sometimes called **mind transfer**) is the hypothetical process of scanning and mapping a biological brain in detail and copying its state into a computer system or another computational device. The computer would have to run a simulation model so faithful to the original that it would behave in essentially the same way as the original brain, or for all practical purposes, indistinguishably. The simulated mind is assumed to be part of a virtual reality simulated world, supported by a simplified body simulation model. Alternatively, the simulated mind could be assumed to reside in a computer inside (or connected to) a humanoid robot or a biological body, replacing its brain.

Whole brain emulation is discussed as a "logical endpoint" of the topical computational neuroscience and neuroinformatics fields, both about brain simulation for medical research purposes. It is discussed in artificial intelligence research publications as an approach to strong AI. Among futurists and within the transhumanist movement it is an important proposed life extension technology, originally suggested in biomedical literature in 1971. It is a central conceptual feature of numerous science fiction novels and films.

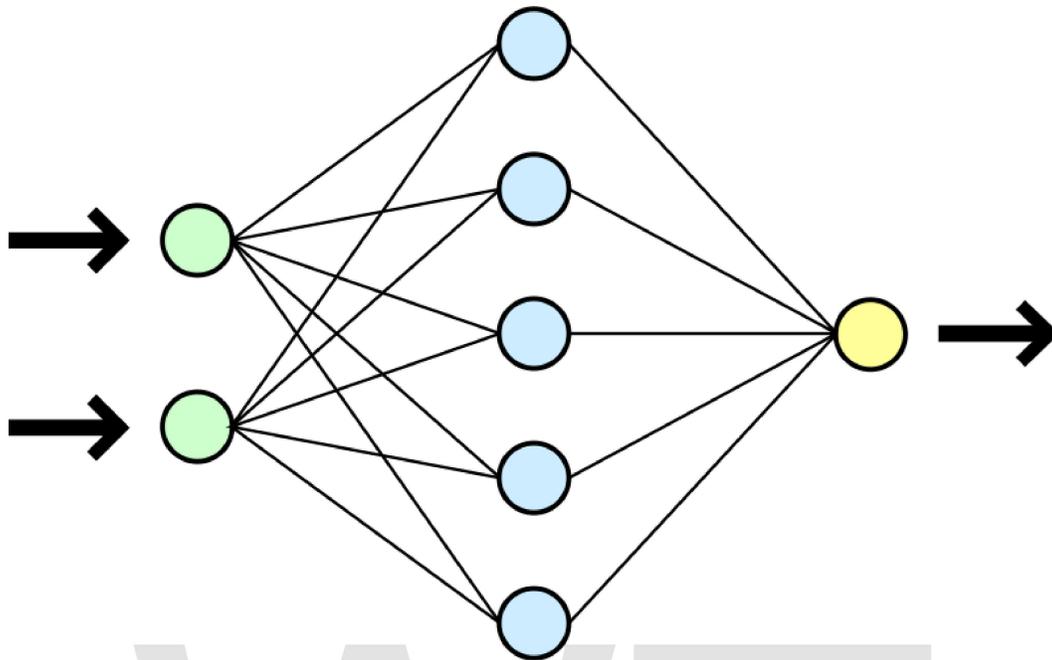
Whole brain emulation is considered by some scientists as a theoretical and futuristic but possible technology, although mainstream research funders remain skeptical. Several contradictory and already passed attempts have been made during the years to predict when whole human brain emulation can be achieved. Substantial mainstream research and development are however being done in relevant areas including development of faster super computers, virtual reality, brain-computer interfaces, animal brain mapping and simulation, and information extraction from dynamically functioning brains.

The question whether an emulated brain can be a human mind is debated by philosophers, and may be contradicted by the dualistic view of the human mind that is common in many religions.

Overview



Neuron anatomical model



Simple artificial neural network

The human brain contains about 100 billion nerve cells called neurons, each individually linked to other neurons by way of connectors called axons and dendrites. Signals at the junctures (synapses) of these connections are transmitted by the release and detection of chemicals known as neurotransmitters. The established neuroscientific consensus is that the human mind is largely an emergent property of the information processing of this neural network.

Importantly, neuroscientists have stated that important functions performed by the mind, such as learning, memory, and consciousness, are due to purely physical and electrochemical processes in the brain and are governed by applicable laws. For example, Christof Koch and Giulio Tononi wrote in IEEE Spectrum:

"Consciousness is part of the natural world. It depends, we believe, only on mathematics and logic and on the imperfectly known laws of physics, chemistry, and biology; it does not arise from some magical or otherworldly quality."

The concept of mind uploading is based on this mechanistic view of the mind, and denies the vitalist view of human life and consciousness.

Many eminent computer scientists and neuroscientists have predicted that computers will be capable of thought and even attain consciousness, including Koch and Tononi, Douglas Hofstadter, Jeff Hawkins, Marvin Minsky, Randal A. Koene, and Rodolfo Llinas.

Such a machine intelligence capability might provide a computational substrate necessary for uploading.

However, even though uploading is dependent upon such a general capability it is conceptually distinct from general forms of AI in that it results from dynamic reanimation of information derived from a specific human mind so that the mind retains a sense of historical identity (other forms are possible but would compromise or eliminate the life-extension feature generally associated with uploading). The transferred and reanimated information would become a form of artificial intelligence, sometimes called an infomorph or "*noömorph*."

Even if uploading is theoretically possible, the amount of storage and computational power required are difficult to predict. Nevertheless, many theorists have presented models of the brain and have established a range of estimates of the amount of computing power needed for partial and complete simulations. Using these models, some have estimated that uploading may become possible within decades if trends such as Moore's Law continue.

The prospect of uploading human consciousness in this manner raises many philosophical questions involving identity, individuality and the soul, as well as numerous problems of medical ethics and morality of the process.

Theoretical benefits

Speedup

A computer-based intelligence such as an upload could potentially think much faster than a human even if it were no more intelligent. Human neurons exchange electrochemical signals with a maximum speed of about 150 meters per second, whereas the speed of light is about 300 million meters per second, about two million times faster. Also, neurons can generate a maximum of about 200 action potentials or "spikes" per second, whereas the number of signals per second in modern computer chips is about 2 GHz (about ten million times greater) and continually increasing. Therefore, even if the computer components responsible for simulating a brain were not significantly smaller than a biological brain, and even if the temperature of these components was not significantly lower, Eliezer Yudkowsky of the Singularity Institute for Artificial Intelligence calculates that a simulated brain could run about 1 million times faster than a real brain, experiencing about a year of subjective time in only 31 seconds of real time.

Immortality/Backup

In theory, if the information and processes of the mind can be disassociated from the biological body, they are no longer tied to the individual limits and lifespan of that body. Furthermore, information within a brain could be partly or wholly copied or transferred to one or more other substrates (including digital storage or another brain), thereby reducing or eliminating mortality risk. This general proposal appears to have been first made in the biomedical literature in 1971 by renowned University of Washington biogerontologist George M. Martin.

Multiple/parallel existence

Another concept explored in science fiction is the idea of more than one running "copy" of a human mind existing at once. Such copies could potentially allow an "individual" to experience many things at once, and later integrate the experiences of all copies into a central mentality at some point in the future, effectively allowing a single sentient being to "be many places at once" and "do many things at once"; this concept has been explored in fiction. Such partial and complete copies of a sentient being raise interesting questions regarding identity and individuality.

Issues

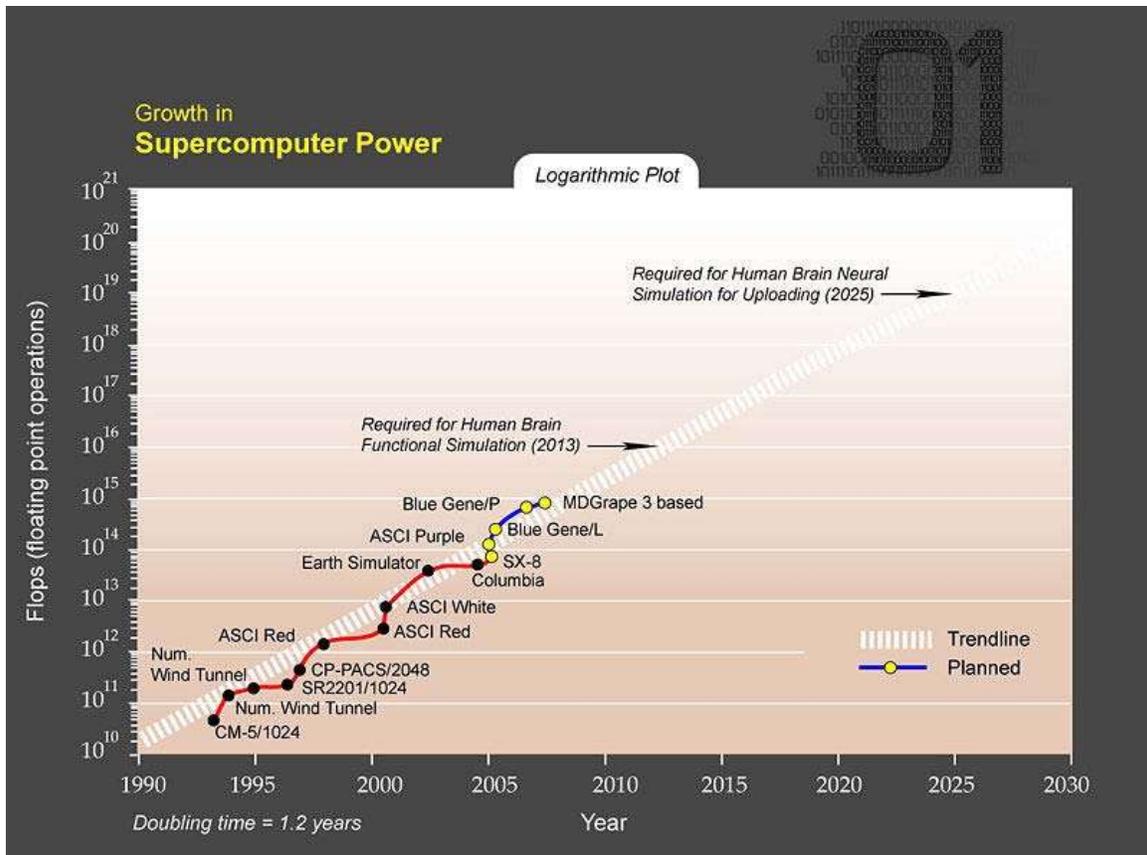
Bekenstein bound

The Bekenstein bound is an upper limit on information that can be contained within a given finite region of space which has a finite amount of energy or, conversely, the maximum amount of information required to perfectly describe a given physical system down to the quantum level.

An average human brain has a weight of 1.5 kg and a volume of 1260 cm^3 . The energy ($E = m \cdot c^2$) will be $1.34813 \cdot 10^{17} \text{ J}$ and if the brain is approximate to a sphere then the radius ($V = 4 \cdot \pi \cdot r^3 / 3$) will be $6.70030 \cdot 10^{-2} \text{ m}$.

The Bekenstein bound ($I \leq \frac{2 \cdot \pi \cdot r \cdot E \cdot h \cdot c}{\ln 2}$) will be $2.58991 \cdot 10^{42}$ bit and represent the maximum information needed to perfectly recreate the average human brain down to the quantum level. This implies that the number of different states ($\Omega = 2^I$) of the human brain (and of the mind if the physicalism is true) is at most $10^{7.79640 \cdot 1041}$.

Computational issues



Futurist Ray Kurzweil's projected supercomputer processing power based on Moore's law exponential development of computer capacity. Here the computational capacity doubling time is assumed to be 1.2 years.

Regardless of the techniques used to capture or recreate the function of a human mind, the processing demands are likely to be immense, due to the large number of neurons in the human brain along with the considerable complexity of each neuron.

Henry Markram, lead researcher of the "Blue Brain Project", has stated that "it is not [their] goal to build an intelligent neural network", based solely on the computational demands such a project would have.

It will be very difficult because, in the brain, every molecule is a powerful computer and we would need to simulate the structure and function of trillions upon trillions of molecules as well as all the rules that govern how they interact. You would literally need computers that are trillions of times bigger and faster than anything existing today.

Advocates of mind uploading point to Moore's law to support the notion that the necessary computing power may become available within a few decades. However, the actual computational requirements for running an uploaded human mind are very difficult to quantify, potentially rendering such an argument specious.

Philosophical issues

Copying vs. moving

Another philosophical issue with mind uploading is whether an uploaded mind is really the "same" sentience, or simply an exact copy with the same memories and personality; or, indeed, what the difference could be between such a copy and the original. This issue is especially complex if the original remains essentially unchanged by the procedure, thereby resulting in an obvious copy which could potentially have rights separate from the unaltered, obvious original.

Most projected brain scanning technologies, such as serial sectioning of the brain, would necessarily be destructive, and the original brain would not survive the brain scanning procedure. But if it can be kept intact, the computer-based consciousness could be a copy of the still-living biological person. It is in that case implicit that copying a consciousness could be as feasible as literally moving it into one or several copies, since these technologies generally involve simulation of a human brain in a computer of some sort, and digital files such as computer programs can be copied precisely. It is usually assumed that once the versions are exposed to different sensory inputs, their experiences would begin to diverge, but all their memories up until the moment of the copying would remain the same.

The problem is made even more serious by the possibility of creating a potentially infinite number of initially identical copies of the original person, which would of course all exist simultaneously as distinct beings. The most parsimonious view of this phenomenon is that the two (or more) minds would share memories of their past but from the point of duplication would simply be distinct minds (although this is complicated by merging). Many complex variations are possible.

Depending on computational capacity, the simulation may run at slower or faster simulation time as compared to the elapsed physical time, resulting in that the simulated mind would perceive that the physical world is running in slow motion or fast motion respectively, while biological persons will see the simulated mind in fast or slow motion respectively.

A brain simulation can be started, paused, backed-up and rerun from a saved backup state at any time. The simulated mind would in the latter case forget everything that has happened after the instant of backup, and perhaps not even be aware that it is repeating itself. An older version of a simulated mind may meet a younger version and share experiences with it.

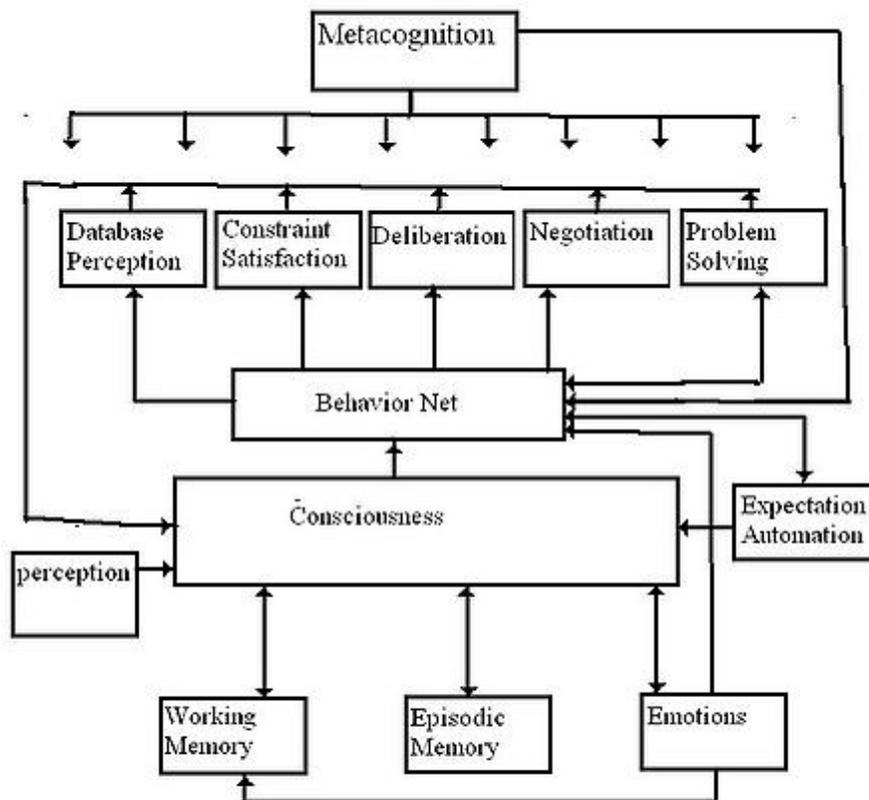
Legal and economical issues

The only limited resources in a simulated world are computational resources, meaning simulation speed, and intellectual properties. In a simulated society, rich simulated minds may pay for faster simulation time than others.

It may be difficult for authorities to supervise that human rights are not threatened in any computer in the world. It might for example be tempting for social science researchers to expose simulated minds, or whole isolated societies of simulated minds, to controlled experiments, where many copies of the same minds, or repeated reruns of the same simulation, are exposed to different test conditions.

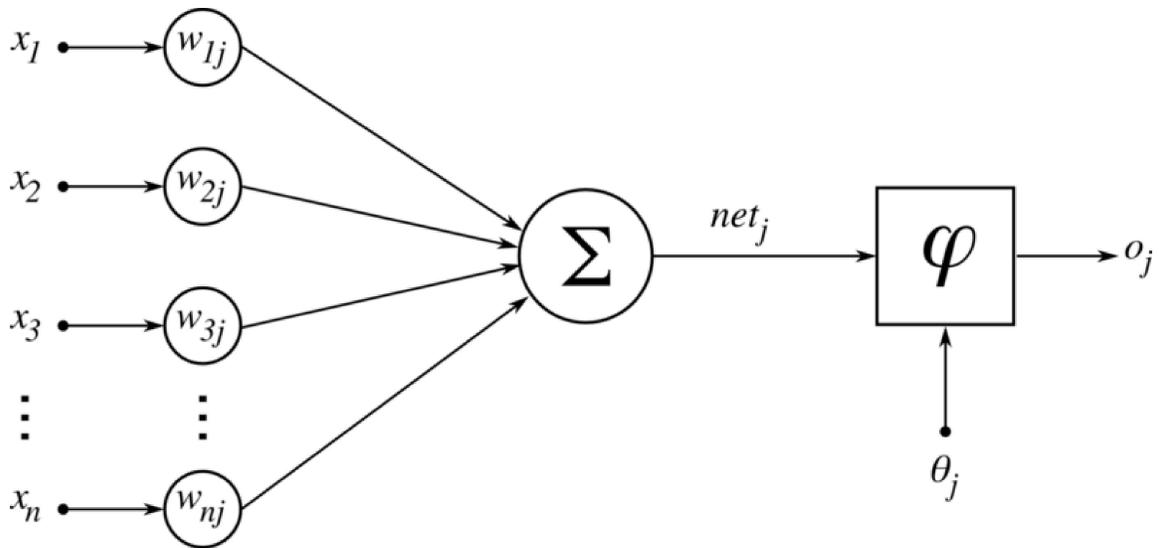
Relevant technologies and techniques

Simulation model scale

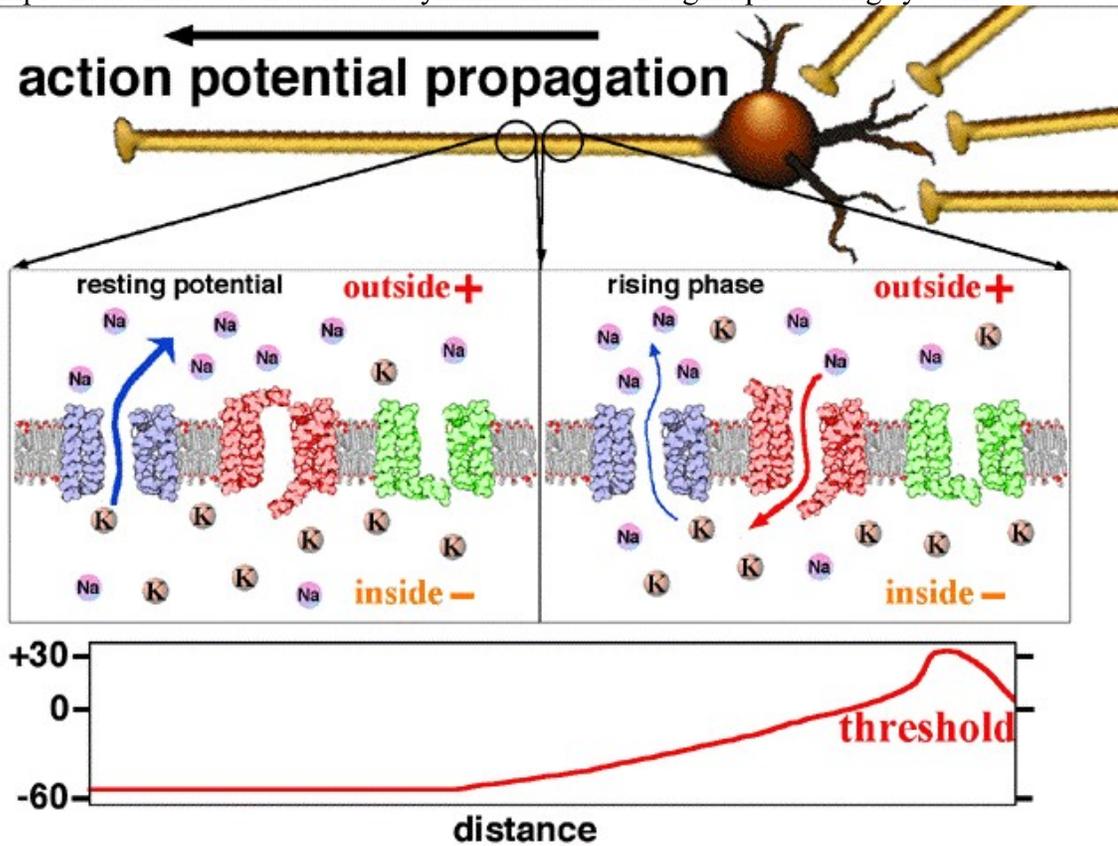


Franklin IDA Architecture

A high-level cognitive AI model of the brain architecture is not required for brain emulation



Simple neuron model: Black-box dynamic non-linear signal processing system



Metabolism model: The movement of positively-charged ions through the ion channels controls the membrane electrical action potential in an axon.

Since the function of the human mind, and how it might arise from the working of the brain's neural network, are poorly understood issues, mind uploading relies on the idea of neural network emulation. Rather than having to understand the high-level psychological

processes and large-scale structures of the brain, and model them using classical artificial intelligence methods, the low-level structure of the underlying neural network is captured, mapped and emulated with a computer system. In computer science terminology, rather than analyzing and reverse engineering the behavior of the algorithms and data structures that resides in the brain, a blueprint of its source code is translated to another programming language. The human mind and the personal identity then, theoretically, is generated by the emulated neural network in an identical fashion to it being generated by the biological neural network.

On the other hand, a molecule-scale simulation of the brain is not expected to be required, provided that the functioning of the neurons is not affected by quantum mechanical processes. The neural network emulation approach only requires that the functioning and interaction of neurons and synapses are understood. It is expected that it is sufficient with a black-box signal processing model of how the neurons respond to nerve impulses (electrical as well as chemical synaptic transmission).

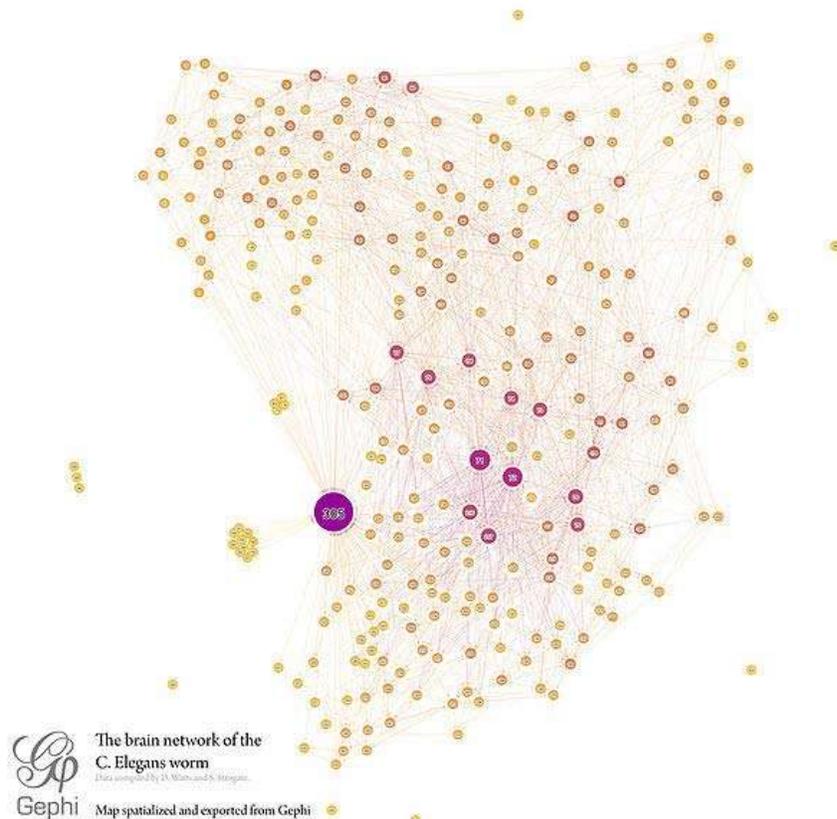
A sufficiently complex and accurate model of the neurons is required. A traditional artificial network model, for example multi-layer perceptron network model, is not considered as sufficient. A dynamic spiking neural network model is required, which reflects that the neuron fires only when a membrane potential reaches a certain level. It is likely that the model must include delays, non-linear functions and differential equations describing the relation between electrophysical parameters such as electrical currents, voltages, membrane states (ion channel states) and neuromodulators.

Since learning and long-term memory are believed to result from strengthening or weakening the synapses via a mechanism known as synaptic plasticity or synaptic adaptation, the model should include this mechanism. The response of sensory receptors to various stimuli must be modeled.

Furthermore, the model may have to include metabolism, i.e. how the neurons are affected by hormones and other chemical substances that may cross the blood-brain barrier. It is considered likely that the model must include currently unknown neuromodulators, neurotransmitters and ion channels. It is considered unlikely that the simulation model has to include protein interaction, which would make it computationally complex. An anatomic 3D body model is also required.

A digital computer simulation model of an analog system such as the brain is an approximation that introduces random quantization errors and distortion. However, the biological neurons also suffer from randomness and limited precision, for example due to background noise. The errors of the discrete model can be made smaller than the randomness of the biological brain by choosing a sufficiently high variable resolution and sample rate, and sufficiently accurate models of non-linearities. The computational power and computer memory must however be sufficient to run such large simulations, preferably in real time.

Scanning and mapping scale of an individual



Brain map of the C. elegans roundworm 302 neurons

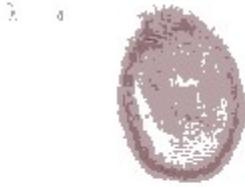
When modelling and simulating the brain of a specific individual, a brain map or connectivity database showing the connections between the neurons must be extracted from an anatomic model of the brain. This network map should show the connectivity of the whole nervous system, including the spinal cord, sensory receptors, and muscle cells.

Destructive scanning of the human brain including synaptic details is possible as of end of 2010 . A full brain map should also reflect the synaptic strength (the "weight") of each connection. It is unclear if the current technology allows that.

It is proposed that short-term memory and working memory is prolonged or repeated firing of neurons, as well as intra-neural dynamic processes. Since the electrical and chemical signal state of the synapses and neurons may be hard to extract, the uploading might result in that the uploaded mind perceives a memory loss of the events immediately before the time of brain scanning.

A full brain map would occupy less than 2×10^{16} bytes (20000 Tb) and would store the addresses of the connected neurons, the synapse type and the synapse "weight" for each of the brains' 10^{15} synapses.

Serial sectioning

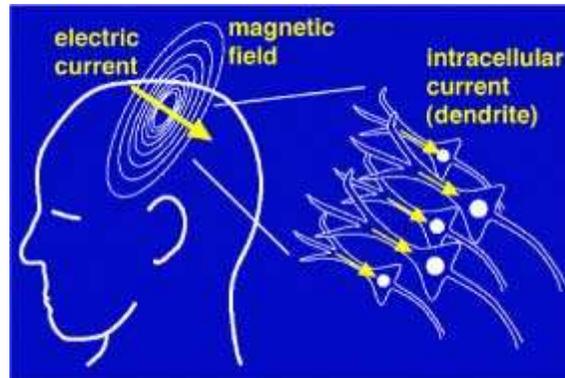


Serial sectioning of a brain

A possible method for mind uploading is serial sectioning, in which the brain tissue and perhaps other parts of the nervous system are frozen and then scanned and analyzed layer by layer, thus capturing the structure of the neurons and their interconnections. The exposed surface of frozen nerve tissue would be scanned and recorded, and then the surface layer of tissue removed. While this would be a very slow and labor intensive process, research is currently underway to automate the collection and microscopy of serial sections. The scans would then be analyzed, and a model of the neural net recreated in the system that the mind was being uploaded into.

There are uncertainties with this approach using current microscopy techniques. If it is possible to replicate neuron function from its visible structure alone, then the resolution afforded by a scanning electron microscope would suffice for such a technique. However, as the function of brain tissue is partially determined by molecular events (particularly at synapses, but also at other places on the neuron's cell membrane), this may not suffice for capturing and simulating neuron functions. It may be possible to extend the techniques of serial sectioning and to capture the internal molecular makeup of neurons, through the use of sophisticated immunohistochemistry staining methods which could then be read via confocal laser scanning microscopy. However, as the physiological genesis of 'mind' is not currently known, this method may not be able to access all of the necessary biochemical information to recreate a human brain with sufficient fidelity.

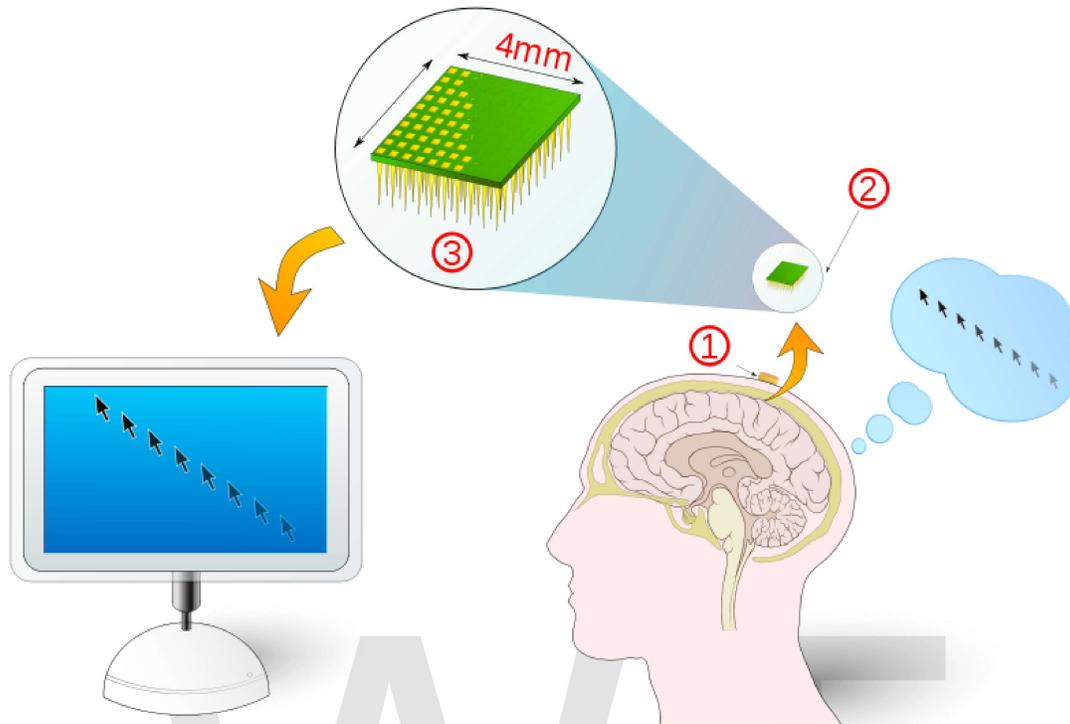
Brain imaging



Magnetoencephalography

It may also be possible to create functional 3D maps of the brain activity, using advanced neuroimaging technology, such as functional MRI (fMRI, for mapping change in blood flow), Magnetoencephalography (MEG, for mapping of electrical currents), or combinations of multiple methods, to build a detailed three-dimensional model of the brain using non-invasive and non-destructive methods. Today, fMRI is often combined with MEG for creating functional maps of human cortex during more complex cognitive tasks, as the methods complement each other. Even though current imaging technology lacks the spatial resolution needed to gather the information needed for such a scan, important recent and future developments are predicted to substantially improve both spatial and temporal resolutions of existing technologies.

Brain-computer interfaces



Brain-computer interface (BCI)

Brain-computer interfaces (BCI) (also known as neuro-computer interfaces, direct neuron interfaces or cerebral interfaces) constitute one of the hypothetical technologies for the reading of information in the dynamically functioning brain. The production of this or a similar device may be essential to the possibility of mind uploading a living human subject.

Current research

An artificial neural network almost half as complex as the brain of a mouse was run on an IBM blue gene supercomputer by a University of Nevada research team in 2007. A simulated time of one second took ten seconds of computer time. The researchers said they had seen "biologically consistent" nerve impulses flowed through the virtual cortex. However, the simulation lacked the structures seen in real mice brains, and they intend to improve the accuracy of the neuron model.

Blue Brain is a project, launched in May 2005 by IBM and the Swiss Federal Institute of Technology in Lausanne, with the aim to create a computer simulation of a mammalian cortical column, down to the molecular level. The project uses a supercomputer based on IBM's Blue Gene design to simulate the electrical behavior of neurons based upon their synaptic connectivity and complement of intrinsic membrane currents. The initial goal of the project, completed in December 2006, was the simulation of a rat neocortical column, which can be considered the smallest functional unit of the neocortex (the part of the brain thought to be responsible for higher functions such as conscious thought),

containing 10,000 neurons (and 10^8 synapses). Between 1995 and 2005, Henry Markram mapped the types of neurons and their connections in such a column. In November 2007, the project reported the end of the first phase, delivering a data-driven process for creating, validating, and researching the neocortical column. The project seeks to eventually reveal aspects of human cognition and various psychiatric disorders caused by malfunctioning neurons, such as autism, and to understand how pharmacological agents affect network behavior.

Mind uploading in science fiction

Mind uploading advocates and critics

Followers of the Raëlian religion advocate mind uploading in the process of human cloning to achieve eternal life. Living inside of a computer is also seen by followers as an eminent possibility.

However, mind uploading is also advocated by a number of secular researchers in neuroscience and artificial intelligence, such as Marvin Minsky. In 1993, Joe Strout created a small web site called the Mind Uploading Home Page, and began advocating the idea in cryonics circles and elsewhere on the net. That site has not been actively updated in recent years, but it has spawned other sites including MindUploading.org, run by Randal A. Koene, Ph.D., who also moderates a mailing list on the topic. These advocates see mind uploading as a medical procedure which could eventually save countless lives.

Many transhumanists look forward to the development and deployment of mind uploading technology, with many predicting that it will become possible within the 21st century due to technological trends such as Moore's Law. Many view it as the end phase of the Transhumanist project, which might be said to begin with the genetic engineering of biological humans, continue with the cybernetic enhancement of genetically engineered humans, and finally obtain with the replacement of all remaining biological aspects.

The book *Beyond Humanity: CyberEvolution and Future Minds* by Gregory S. Paul & Earl D. Cox, is about the eventual (and, to the authors, almost inevitable) evolution of computers into sentient beings, but also deals with human mind transfer. Richard Doyle's *Wetwares: Experiments in PostVital Living* deals extensively with uploading from the perspective of distributed embodiment, arguing for example that humans are currently part of the "artificial life phenotype." Doyle's vision reverses the polarity on uploading, with artificial life forms such as uploads actively seeking out biological embodiment as part of their reproductive strategy. Raymond Kurzweil, a prominent advocate of transhumanism and the likelihood of a technological singularity, has suggested that the easiest path to human-level artificial intelligence may lie in "reverse-engineering the human brain", which he usually uses to refer to the creation of a new intelligence based on the general "principles of operation" of the brain, but he also sometimes uses the term

to refer to the notion of uploading individual human minds based on highly detailed scans and simulations. This idea is discussed on pp. 198–203 of his book *The Singularity is Near*, for example.

Exocortex

An **exocortex** is a theoretical artificial external information processing system that would augment a brain's biological high-level cognitive processes.

An individual's **exocortex** would be composed of external memory modules, processors, IO devices and software systems that would interact with, and augment, a person's biological brain. Typically this interaction is described as being conducted through a direct brain-computer interface, making these extensions functionally part of the individual's mind.

Individuals with significant exocortices would be classified as transhumans.

Living Digital provided one description of the concept:

While [the traditional concept of] a cyborg has included artificial mechanical limbs embedded chips and devices, another interesting concept is the *exocortex*, which is a brain-computer interface. In theory, the exocortex would be a computer-like processing system that would co-exist with and enhance the power of the human brain. *Neuromancer* is a book that has talked about such a scenario.

Etymology

The noun *exocortex* is composed of the Greek-derived prefix *exo-*, meaning external or outside, and the Latin noun *cortex*, which originally meant bark but is used in neuroscience for the outer bark-like layer of the brain that is the site of most sophisticated cognitive information processing. It was coined in allusion to the neocortex (literally 'new bark'), the newest part of the mammalian brain (in evolutionary history), believed to be responsible for the highest human cognitive abilities including conscious thought, spatial reasoning, and sensory perception. Thus the terminology suggests a progression from reptilian thought (the older parts of the brain) through human (neocortex) to high-level human or even supra-human cognitive processing capabilities (exocortex).

Specific applications

In 1981 Steve Mann designed and built the first general purpose wearable computer. Later on he became one of the early pioneers in using wearable computers for augmented and computer-mediated reality. Although he does not refer to it as such, his personal wearable computer could be considered an exocortex. Running applications like the remembrance agent on his wearable computer enhances his natural mental capabilities.

Intellectual background

The concept of an exocortex has intellectual roots both in the fields of computer science and evolutionary psychology.

Computer science roots

Within computer science, the seeds were planted by the DARPA associated researcher J.C.R. Licklider. Within his speculative 1960 paper *Man-Computer Symbiosis*, Licklider outlined his vision that humans and the new technology of computers, if tightly-coupled together, would prove to complement each others strengths to such a degree that many of the pure artificial intelligence systems envisioned at the time by optimistic researchers would prove unnecessary:

Man-computer symbiosis is a subclass of man-machine systems. There are many man-machine systems. At present, however, there are no man-computer symbioses. The purposes of this paper are to present the concept and, hopefully, to foster the development of man-computer symbiosis by analyzing some problems of interaction between men and computing machines, calling attention to applicable principles of man-machine engineering, and pointing out a few questions to which research answers are needed. The hope is that, in not too many years, human brains and computing machines will be coupled together very tightly, and that the resulting partnership will think as no human brain has ever thought and process data in a way not approached by the information-handling machines we know today.

—*Man-Computer Symbiosis*, J.C.R. Licklider, March 1960.

A DARPA contemporary of Licklider, Douglas Engelbart, was thinking along similar lines in the field of computer science. In 1962, Engelbart authored *Augmenting Human Intellect* in which he details how to augment human intellectual effectiveness by exploiting the technology of the then emerging computer:

This is an initial summary report of a project taking a new and systematic approach to improving the intellectual effectiveness of the individual human being. A detailed conceptual framework explores the nature of the system composed of the individual and the tools, concepts, and methods that match his basic capabilities to his problems. One of the tools that shows the greatest immediate promise is the computer, when it can be harnessed for direct on-line assistance, integrated with new concepts and methods.

—*Augmenting Human Intellect: A Conceptual Framework*, Douglas Engelbart, October 1962.

From this basis, the concept of an exocortex, the direct coupling of the human mind with computers to leverage their respective complementary strengths, can be viewed as a result of the ever increasing symbiotic coupling between human and computers.

Psychology roots

The exocortex concept also has roots in evolutionary psychology as a result of Merlin Donald of Queen's University. Donald, in the 1990 book *Origins of the Modern Mind* as well as later papers, proposed an evolutionary model of the mind, from a functional perspective, from its origins in prehistoric apes to the modern human being. Donald focuses significant attention on the use that modern humans make of external symbolic storage and manipulation systems—the range of technologies from cuneiforms, hieroglyphics, and ideograms to alphabetic languages, mathematics and now computers. From Donald's perspective, these external symbolic systems have allowed for the functional reorganization of the human mind in how it deals with the world.

The externalization of memory [via the use of external symbolic storage systems] has altered the actual memory architecture within which humans think, which is changing the role of biological memory, the way in which the human brain deploys its resources, and the form of modern culture.

—*Precis of Origins of the modern mind*, Merlin Donald, 1996.

Thus to Donald, the human mind has long been a hybrid structure built from the vestiges of earlier biological stages and combined with our new external symbolic systems. The development of an exocortex, which could result in significant functional reallocation, again fits well within this long established trend.

Current applicability

Cognitive science origin

In November 1998 the specific term exocortex was coined by researcher Ben Houston. Houston coined the term to refer concisely to tightly-coupled cognition-level brain-computer interface technologies in the spirit of Licklider's and Engelbart's original visions.

exocortex (*eks'o kor'teks*) **n.** *Latin* -- an organ that resides outside of the brain that aids in high level thinking. This will not be a prominent term until prefrontal cortex neural implants become widespread. (emphasis in original)

—early exocortex definition, Ben Houston, May 2000 .

Use in science fiction

Speculative devices which fit the definition of exocortices were described in hard science fiction long before the term was coined; examples appear in *Neuromancer* by William Gibson and in *The Peace War* by Vernor Vinge, both published in 1984. More recently Vinge, in *A Fire Upon the Deep* and several short stories, described the functional effects

of what are essentially several kinds of exocortices - both those composed of computational elements, and those enabled by high-bandwidth communication between groups of beings. Peter F. Hamilton's *Night's Dawn trilogy* also describes in detail similar technological beings.

Charles Stross, the Hugo Award-nominated hard science fiction writer, has led the adoption of the term exocortex within science fiction circles. Beginning in 2004, Stross made use of the term in *Elector*, a short story published in the September issue of *Asimov's Science Fiction*. Stross made more extensive uses the term exocortex and its derivatives in *Accelerando*, his 2005 novel.

While Stross himself does not provide an explicit definition of the term, a few passages indicate his meaning:

About ten billion humans are alive in the solar system, each mind surrounded by an **exocortex** of distributed agents, threads of personality spun right out of their heads to run on the clouds of utility fog – infinitely flexible computing resources as thin as aerogel – in which they live. (emphasis added)

—*Accelerando*, Charles Stross, 2005.

Sometimes he isn't certain he's still human; too many threads of his consciousness seem to live outside his head, reporting back whenever they find something interesting. And it's too early for anyone out there to be trying to hack **exocortices**... isn't it? Right now, the external threads of his consciousness are telling him that they like Annette.... (emphasis added)

—*Accelerando*, Charles Stross, 2005.

An **EXOcortex** can best be described as the portion of a trans- or posthuman entity's brain (or cortex) which exists outside of that entity's primary computing structure, usually the brain inhabiting a person's 'meatbody.' For example, a person's exocortex could very well be composed of all the external memory modules, processor, and devices that the person's biological brain interacts with on a realtime basis, thereby in effect making those external devices a functional part of the individual's 'mind.' (emphasis in original)

Popular usage

While initial recognition of the exocortex concept was nonexistent, this has changed as a result of Charles Stross's recent publications and the growing awareness of brain-computer interfacing. The term and concept of an exocortex has both been applied (i.e. "Suffered a Stroke in my Exocortex") and noted as a novel interesting word (i.e. "Found Words: Exocortex") by various bloggers. Here are some additional examples of proper contextual usage: , and . The concept has been described in the March 2006 issue of *Living Digital*. James Hughen wrote in an essay entitled "What comes after humans?" that appeared in the Nov 16, 2006 issue of the *New Scientist*:

To remain the web's weavers and not its ensnared victims, we must merge with our electronic *exocortex*, wiring greater memory, thought processing and communication abilities directly into our brains.

Future prospects

If one widens the definition of an exocortex, one can see that computational elements are already used as supporting elements of biological brains, and growing dependence on parts of the Internet that serve cognitive functions has brought what could be considered a proto-exocortex into existence. The fulfillment of the initial vision of Licklider and Engelbart suggests that continued development along this path is likely.

Currently, true exocortices remain speculative. The main issue is that the required underlying technology is yet to be produced by the scientific research fields of (1) cognitive neuroscience, (2) computational neuroscience and (3) neural engineering.

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